PROCEEDINGS

OF THE

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PROCEEDINGS

OF THE

AMERICAN ACADEMY

OF

ARTS AND SCIENCES.

VOL. XXII.

PAPERS READ BEFORE THE ACADEMY.

I.

OBSERVATIONS OF THE MEAN RIGHT ASCENSION OF CERTAIN POLAR STARS, MADE AT THE FIELD MEMORIAL OBSERVATORY OF WILLIAMS COLLEGE, AND REDUCED TO THE EPOCH 1884.0.

By Truman Henry Safford.

Presented April 14, 1886.

The observations here presented were made mostly in 1884; a few earlier were not before reduced, for reasons of convenience; and a very few later, in 1885, are here added for completeness' sake.

The latter portion of the observations of 1884, not here given, and those of 1885, are in progress of reduction to 1885.0, and will be offered to the Academy later. The present series includes right ascensions only, as with the instrument here employed it is not convenient to observe both co-ordinates of so close polars at the same time. The region in which I am at present working allows this simultaneous observation. The declinations of the stars here given are readily observed along with both right ascensions and declinations of the stars now taken.

The series of which this work is a part was begun in 1882, at the Field Memorial Observatory of Williams College. The results of 1882–83 are given in the Proceedings, Vol. XIX. pp. 324–352. My intention was and is to carry it over a pretty extensive region of the heavens, taking in from time to time stars needing observation, and those only. This condition, it is true, offers a wide range of choice; but the attempt is made to avoid needless duplication of the work of others. A previous series of right ascensions, which I observed in 1862–66 at Cambridge, was not found superfluous.

Both then and now I have been impressed with certain deficiencies in our fundamental catalogues, as, indeed, have other astronomers. These deficiencies are not the fault of those who have constructed the catalogues, but arise from the lack of foresight in the astronomers of the last century. Our fundamental and secondary places are perfectly good and sure, taken as a whole, for 1865 or thereabouts; but in many cases accurate proper motions are lacking to bring them up to the present epoch. Stars which Bradley observed with sufficient completeness about 1755 can be accurately brought up by proper motions derived from his observations.

But Bradley could not foresee what observers would need a century or more after his decease; and omitted to provide us all the materials we now need, especially in this polar region. The next set of observers — Piazzi, Groombridge, etc. — did not employ stellar observations for the correction of their instruments, but meridian marks; and depended upon occasional adjustments, overlooking the tendency now so well known of instruments to crawl away from their adjustments through molecular strains connected with change of temperature. Consequently, when Bradley, 1755, fails us, the observations of Struve, beginning in 1814, are the first which really come up to Bradley's standard.

So that in my use of the best fundamental catalogue now existing, that of the Astronomische Gesellschaft, I have thought it safest to begin by excluding for instrumental corrections all stars whose proper motions do not essentially depend upon Bradley, or upon Struve and later observers. This excludes quite a number of the right ascensions even of the Hauptsterne; as well those whose errors Professor Rogers and Mr. Chandler have detected, as those which, equally uncertain *a priori*, are approximately correct by compensation of errors. In their places I have substituted a number of closer polars whose right ascensions are thoroughly well determined by modern observations, and whose proper motions are also accurately known. In collecting modern observations, my own Harvard catalogue of 1865, and the work since done there by Professor Rogers, as well as the Williamstown observations, have been added to the ordinary catalogues; and I have sought out and reduced the single Pulcova observations made in this region by Winnecke and Gromadski between 1858 and 1869.

The right ascensions so obtained are amply sufficient both in quantity and quality to replace the excluded "Hauptsterne," although not quite equal to the latter for their own proper epoch, 1865. The greater nearness of these stars to the pole in certain right-ascensions renders them better for instrumental errors than, for example, such as γ Ursæ Minoris, whose right ascension is both uncertain and erroneous at the present time; and in fact better than ζ Ursæ Minoris, which is some degrees nearer, equally uncertain, but actually not quite so much in error, so far as I can judge.

It has not been yet necessary to employ any stars whose right ascensions are not given in one or more ephemerides; so that the following corrections to the apparent places of these ephemerides are currently employed to bring the instrumental corrections into harmony with the Pulcova system, as modified by Auwers.

Two of Auwers's right ascensions are also corrected; Draconis 1 H., as stated in my previous paper; and 76 Draconis, in consequence of an error of sign in the proper motion, which has been since corrected in the Jahrbuch.

		s.	s.	
Groombridge 944	American Ephemeris	—0.38	—0.011	(t — 1885)
Camelopardali 25 H.	American Ephemeris	—0.58	—0.008	(t — 1885)
Groombridge 1119	Connaissance des Temps	+6.1	+0.32	(t — 1885)
Draconis 1 H.	Berliner Jahrbuch	+0.26	+0.0097	(t — 1885)
Bradley 1672	Conn. des Temps	+1.6	+0.063	(t — 1885)
Camelopardali 32 H.	American Ephemeris	—0.30	—0.009	(t — 1885)
Groombridge 2283	Conn. des Temps	—2.2	—0.089	(t — 1885)
Bradley 2701	Montsouris Ephemeris	+0.2	+0.008	(t — 1885)
76 Draconis	B. J. (to 1886 inclusive)	+0.366	+0.0282	(t — 1885)
Groombridge 3548	Conn. des Temps	—0.76	—0.017	(t — 1885)
Cephei 32 H.	Montsouris Ephemeris	0.		
Cephei 39 H.	Conn. des Temps	0.		

In extending my scheme southward, I have, as will be seen, inserted the doubtful Hauptsterne, and all the Zusatzsterne, so far as my zone now goes, into my working list. The doubt refers almost exclusively to right ascension; hence this co-ordinate will be determined, while at present the catalogue declination is used to find the equator-point.

During the present year I hope to begin a series of experiments with the Rittenhouse* collimator, for the purpose of showing how far

* It seems to be certain that our countryman, David Rittenhouse, was the first to employ an object-glass of small curvature with a meridian mark in its focus. It is quite possible that this application preceded that of an ordinary telescope as a collimator; but the latter is practically a different instrument.

I can depend upon the stability of the soil in the Observatory grounds. This collimator has an object-glass of five inches in diameter mounted upon a pier south of the circle; on the same pier are Y's for the other collimator, and the object-glass is between them, but can be turned down so that the telescope of two and one half inches' aperture can be placed in the Y's over it. The telescope, which has pivots and a level, is usually placed upon the north collimator pier, which has Y's, but no object-glass.

In the ordinary position, then, we have two collimators which can be set upon each other; the focal mark is one hundred Paris feet south of the five-inch object-glass, and the north collimator has an excellent micrometer.

When the north collimator telescope is transferred to the south Y's, it can be used with its level for the determination of the horizontal point, as well as in its usual position.

The whole arrangement is ingenious, original, and economical, and admirably adapted to an observatory whose means are insufficient for strictly primary work, while, with the addition of a few not very expensive auxiliaries, it can be readily adapted to primary work. The object-glass and eye-piece are interchangeable, a requirement which I should always make for any fixed instrument, (I believe the Repsolds always construct their large instruments so,) and there is no difficulty whatever in observing the nadir whenever we please.

But at present I have no intention of attempting a strictly primary catalogue; enough such catalogues are now in course of construction, and I need only to take care that the casual errors of the primary catalogue which I employ do not become systematic errors in my results. Of this there is some danger when the Jahrbuch in its present condition is employed without discriminating between well and ill determined polars, — that is, without reading Professor Auwers's memoir.

The general arrangement of the tables which follow is like that in my previous paper, Vol. XIX. of the Proceedings, pages 324–352. The mean right ascensions are given in two different ways, according as their places are or are not given in one of the great ephemerides. In the former case the datum of each observation is the correction to the ephemeris; and the mean right ascensions for 1884.0 are obtained by applying to that given in the ephemeris the mean of these corrections. For other stars no proper motions are here applied.

As the observations reduced to 1885.0 will soon follow these, I have thought it needless to form a catalogue of mean right ascensions for this paper.

MEAN RIGHT ASCENSIONS FOR 1884.0.

Results of Separate Observations.

Groombridge 67.

	h. m. s.
1884, May 2 s. p.	0 24 50.18
3 s. p.	51.04
24 s. p.	50.30
28 s. p.	50.03
Nov. 21	50.65
22	51.38
29	50.27
Dec. 2	50.64
Mean A. R. 1884.0	0 24 50.561

Radcliffe 134.

	h. m. s.
1884, Dec. 2	0 28 32.22
4	32.50
29	32.33
30	32.52
Mean A. R. 1884.0	0 28 32.392

Schwerd 43.

	h. m. s.
1884, Nov. 15	0 51 13.42
22	13.76
29	13.49
Dec. 2	13.44
Mean A. R. 1884.0	0 51 13.528

Bradley 95.

	h. m. s.
1882, Oct. 20	0 56 46.11
1884, Jan. 10	46.75
12	46.58
17	47.01
Mean A. R. 1884.0	0 56 46.612

Radcliffe 378.

	h. m. s.
1884, May 28 s. p.	1 8 37.05
Nov. 15	36.81
29	37.03
Dec. 2	36.91
4	36.27
Mean A. R. 1884.0	1 8 36.814

Bradley 402.

	h. m. s.
1883, June 22 s. p.	3 5 2.12
23 s. p.	2.20
1884, June 26 s. p.	2.64
July 3 s. p.	3.29
7 s. p.	2.82
10 s. p.	2.80
Mean A. R. 1884.0	3 5 2.645

Groombridge 848.

		s.
1884, July 18 s. p.	B. J.	+0.04
21 s. p.		+0.00
22 s. p.		+0.10
25 s. p.		—0.09
	Mean	+0.012
	B. J.	14.581
	h. m.	s.
Mean A. R. 1884.0	4 33	14.593

Radcliffe 1272.

	h. m. s.
1884, July 9 s. p.	4 40 28.13
10 s. p.	28.49
11 s. p.	28.23
15 s. p.	28.03
Mean A. R. 1884.0	4 40 28.220

Radcliffe 1311.

	h. m. s.
1884, July 21 s. p.	4 50 48.17
22 s. p.	48.22
25 s. p.	47.34
26 s. p.	47.98
Mean A. R. 1884.0	4 50 47.928

Groombridge 966.

		s.
1884, July 18 s. p.	B. J.	+0.04
22 s. p.		+0.45*
25 s. p.		+0.04
28 s. p.		—0.13
	Mean	+0.100
	B. J.	13.185
	h. m.	s.
Mean A. R. 1884.0	5 24	13.285

* The observation of July 22 seems anomalous; but no error can be found in the wires or reductions. The air was thick, and the star probably faint and tremulous.

MEAN RIGHT ASCENSIONS FOR 1884.0. — *Continued.*

Groombridge 944.

			s.
1884, Feb. 1		A. E.	—0.72
15			—0.71
July 18	s. p.		—0.03
21	s. p.		—0.17
22	s. p.		+0.11
25	s. p.		—0.40
Aug. 14	s. p.		—0.06
16	s. p.		—0.18
18	s. p.		—0.18
		Mean	—0.260
		A. E.	56.518
		h. m.	s.
Mean A. R. 1884.0		5 24	56.258

Groombridge 956.

		h. m.	s.
1883, Aug. 14	s. p.	5 29	32.75
21	s. p.		33.27
22	s. p.		33.02
1884, July 21	s. p.		33.43
25	s. p.		33.56
28	s. p.		33.73
30	s. p.		33.29
Mean A. R. 1884.0		5 29	33.293

Groombridge 1004.

		h. m.	s.
1884, Feb. 1		6 0	55.19
15			55.81
July 30	s. p.		55.85
Aug. 2	s. p.		55.48
14	s. p.		54.84
15	s. p.		54.68
Mean A. R. 1884.0		6 0	55.308

Camelopardali 23 H.

		s.
1884, Feb. 1	B. J.	—0.35
15		—0.33
Mar. 4		—0.21
18		—0.04
22		—0.18
	Mean	—0.222
	B. J. 1884.0	24.996
	h. m.	s.
Mean A. R. 1884.0	6 26	24.774

Camelopardali 25 H.

		s.
1884, Feb. 15	A. E.	—0.37
Mar. 4		—0.82
18		—0.96
22		—0.78
	Mean	—0.732
	A. E.	36.827
	h. m.	s.
Mean A. R. 1884.0	7 6	36.095

Schwerd 406.

	h. m.	s.
1884, Feb. 15	7 9	26.92
Mar. 4		26.25
18		26.67
22		26.70
25		26.62
Mean A. R. 1884.0	7 9	26.632

Groombridge 1278.

	h. m.	s.
1884, Feb. 15	7 13	28.81
Mar. 4		28.47
18		28.61
22		28.76
25		28.73
Mean A. R. 1884.0	7 13	28.676

Groombridge 1119.

		s.
1884, Mar. 15	C. des T.	+6.46
18		+6.76
22		+4.26
25		+4.45
	Mean	+5.482
	C. des T.	48.39
	h. m.	s.
Mean A. R. 1884.0	7 39	53.872

Radcliffe 2020.

		h. m.	s.
1884, Mar. 22		7 47	5.39
25			5.86
Aug. 27	s. p.		6.02
Sept. 2	s. p.		5.89
Mean A. R. 1884.0		7 47	5.790

MEAN RIGHT ASCENSIONS FOR 1884.0. — *Continued.*

GROOMBRIDGE 1391.

	h.	m.	s.
1884, Mar. 15	8	1	59.07
18			58.63
25			59.19
31			58.99
Mean A. R. 1884.0	8	1	58.970

RADCLIFFE 2162.

	h	m.	s.
1884, Sept. 2 s. p.	8	31	46.05
5 s. p.			45.61
9 s. p.			45.51
17 s. p.			45.93
Mean A. R. 1884.0	8	31	45.775

GROOMBRIDGE 1463.

	h.	m.	s.
1883, Apr. 13	8	38	25.06
14			25.75
Oct. 5 s. p.			25.47
1884, Mar. 25			25.21
31			25.29
Sept. 9 s. p.			25.04
12 s. p.			25.45
17 s. p.			25.72
18 s. p.			25.72
Mean A. R. 1884.0	8	38	25.412

RADCLIFFE 2189.

	h.	m.	s.
1884, Sept. 5 s. p.	8	42	23.62
9 s. p.			23.58
12 s. p.			23.92
17 s. p.			24.21
Mean A. R. 1884.0	8	42	23.832

RADCLIFFE 2368.

	h.	m.	s.
1884, Nov. 10 s. p.	9	39	9.86
21 s. p.			9.85
22 s. p.			10.39
24 s. p.			9.61
Mean A. R. 1884.0	9	39	9.928

SCHWERD 587.

	h.	m.	s.
1884, Apr. 22	9	44	48.90
23			48.82
26			49.39
Nov. 10 s. p.			49.43
Mean A. R. 1884.0	9	44	49.135

SCHWERD 609.

	h.	m.	s.
1883, Mar. 22	9	57	18.01
Apr. 14			17.91
17			17.96
1884, Apr. 22			18.08
23			17.83
26			17.86
Nov. 10 s. p.			18.12
21 s. p.			17.99
24 s. p.			18.03
Dec. 2 s. p.			18.08
Mean A. R. 1884.0	9	57	17.987*

RADCLIFFE 2407.

	h.	m.	s.
1884, Oct. 24 s. p.	9	58	33.37
Nov. 10 s. p.			34.45
21 s. p.			32.82
Mean A. R. 1884.0	9	58	33.547

RADCLIFFE 2459.

	h.	m.	s.
1883, Oct. 17 s. p.	10	9	30.44
1884, Apr. 22			29.88
25			29.54
26			29.83
Nov. 10 s. p.			30.07
21 s. p.			29.86
24 s. p.			29.86
Dec. 2 s. p.			29.54
Mean A. R. 1884.0	10	9	29.878

BRADLEY 1458.

	h.	m.	s.
1883, Dec. 6 s. p.	10	31	58.49
1884, Apr. 23			58.43
26			58.80
30			58.43
May 2			58.61
Nov. 8 s. p.			58.75
Dec. 2 s. p.			58.74
4 s. p.			58.70
Mean A. R. 1884.0	10	31	58.619

RADCLIFFE 2612.

	h.	m.	s.
1884, Apr. 26	11	0	19.94
May 2			19.37
3			18.91
Nov. 14 s. p.			19.20
15 s. p.			18.89
Mean A. R. 1884.0	11	0	19.262

* A single observation of 1884 Nov. 22 s. p. gives 1 s. more than the mean of these ten; it was rejected, because at the time a workman was hammering loudly in the observing room, and a miscount of 1 s. may easily have taken place.

MEAN RIGHT ASCENSIONS FOR 1884.0. — *Continued.*

SCHWERD 665.

	h.	m.	s.
1884, May 2	11	0	43.96
Nov. 8 s. p.			44.23
14 s. p.			43.50
15 s. p.			43.83
Mean A. R. 1884.0	11	0	43.880

RADCLIFFE 2684.

	h.	m.	s.
1884, Nov. 8 s. p.	11	22	52.02
14 s. p.			51.85
15 s. p.			52.10
21 s. p.			52.50
Mean A. R. 1884.0	11	22	52.118

GROOMBRIDGE 1782.

	h.	m.	s.
1884, Apr. 23	11	23	37.02
26			37.31
May 2			37.03
3			36.94
Nov. 14 s. p.			36.80
15 s. p.			36.84
21 s. p.			37.02
Dec. 29 s. p.			37.31
Mean A. R. 1884.0	11	23	37.034

RADCLIFFE 2705.

	h.	m.	s.
1884, Apr. 26	11	26	44.91
May 2			45.36
3			44.63
Nov. 21 s. p.			45.06
Dec. 30 s. p.			45.94
Mean A. R. 1884.0	11	26	45.180

RADCLIFFE 2738.

	h.	m.	s.
1884, Nov. 15 s. p.	11	38	51.44
21 s. p.			51.85
29 s. p.			51.99
Dec. 26 s. p.			50.78
Mean A. R. 1884.0	11	38	51.515

GROOMBRIDGE 1845.

	h.	m.	s.
1883, Oct. 20 s. p.	11	54	13.73
Nov. 21 s. p.			13.11
1884, Apr. 30			13.44
May 2			13.71
3			13.58
24			13.97
Nov. 21 s. p.			14.08
22 s. p.			13.57
29 s. p.			13.63
Dec. 25 s. p.			13.62
Mean A. R. 1884.0	11	54	13.644

GROOMBRIDGE 1850.

	h.	m.	s.
1884, Apr. 30	11	58	52.71
May 2			53.57
3			53.70
24			54.07
28			54.15
Nov. 14 s. p.			52.66*
21 s. p.			53.71
Mean A. R. 1884.0	11	58	53.510

GROOMBRIDGE 1858 = BRADLEY 3241.

	h.	m.	s.
1884, Nov. 14 s. p.	12	5	45.30
15 s. p.			45.77
21 s. p.			45.72
22 s. p.			45.53
29 s. p.			45.87
Mean A. R. 1884.0	12	5	45.638

BRADLEY 1642 (following of two stars).

	h.	m.	s.
1884, Nov. 29 s. p.	12	11	9.46
Dec. 2 s. p.			9.41
4 s. p.			9.58
29 s. p.			9.71
Mean A. R. 1884.0	12	11	9.540

BRADLEY 1672.

		s.
1884, Apr. 30	C. des T.	+1.01
May 2		+1.70
3		+0.31
24		+1.76
	Mean	+1.195
	C. des T.	18.33
	h. m.	s.
Mean A. R. 1884.0	12 14	19.525

* A large political meeting was going on in the neighborhood, with great uproar.

MEAN RIGHT ASCENSIONS FOR 1884.0. — *Continued.*

Groombridge 1879.

	h.	m.	s.
1884, Nov. 8 s. p.	12	15	57.31
14 s. p.			56.82
21 s. p.			56.52
22 s. p.			56.62
Mean A. R. 1884.0	12	15	56.818

Groombridge 1909.

	h.	m.	s.
1882, Nov. 21 s. p.	12	30	36.45
1883, May 17			35.67
1884, May 2			36.25
3			36.39
24			36.33
28			36.35
Nov. 8 s. p.			36.17
21 s. p.			36.61
22 s. p.			36.91
29 s. p.			36.45
Mean A. R. 1884.0	12	30	36.358

Schwerd 750.

	h.	m.	s.
1884, Nov. 21 s. p.	12	33	37.52
22 s. p.			38.21
29 s. p.			37.58
Dec. 2 s. p.			37.29
Mean A. R. 1884.0	12	33	37.650

Schwerd 752.

	h.	m.	s.
1883, Nov. 7 s. p.	12	34	38.02
Dec. 6 s. p.			37.66
29 s. p.			37.72
1884, Nov. 8 s. p.			38.99
Mean A. R. 1884.0	12	34	38.098

Groombridge 1923.

	h.	m.	s.
1884, May 24	12	37	33.93
28			33.75
Nov. 8 s. p.			34.11
14 s. p.			34.07
Mean A. R. 1884.0	12	37	33.965

Groombridge 1927.

	h.	m.	s.
1884, May 24	12	41	29.37
Nov. 8 s. p.			29.63
Mean A. R. 1884.0	12	41	29.500

Schwerd 761.

	h.	m.	s.
1884, Nov. 14 s. p.	12	41	53.46
15 s. p.			53.44
21 s. p.			53.86
22 s. p.			53.59
Mean A. R. 1884.0	12	41	53.588

Fedorenko 2201.

	h.	m.	s.
1884, Nov. 15 s. p.	12	58	24.65
21 s. p. [½ wt.]			25.12
Dec. 2 s. p.			24.56
4 s. p.			25.03
Mean A. R. 1884.0	12	58	24.800

Groombridge 2006.

	h.	m.	s.
1884, June 7	13	6	57.42
Mean A. R. 1884.0	13	6	57.420

Groombridge 1977.

	h.	m.	s.
1884, May 28	13	11	24.01
30			24.28
June 7			24.12
13			24.13
Nov. 15 s. p.			24.34
1885, Jan. 14 s. p.			24.27
19 s. p.			24.37
Mean A. R. 1884.0	13	11	24.217

Schwerd 806.

	h.	m.	s.
1884, June 7	13	42	23.28
13			23.58
17			23.61
18			23.51
Mean A. R. 1884.0	13	42	23.495

Groombridge 2063.

	h.	m.	s.
1884, June 7	13	45	41.92
13			42.09
17			42.14
18			41.88
Mean A. R. 1884.0	13	45	42.008

MEAN RIGHT ASCENSIONS FOR 1884.0. — *Continued.*

Schwerd 812.

	h.	m.	s.
1884, June 7	13	50	5.18
13			4.86
17			4.95
18			4.77
Mean A. R. 1884.0	13	50	4.940

Schwerd 817.

	h.	m.	s.
1884, June 13	13	52	35.99
17			36.26
18			36.74
1885, June 9			36.43
Mean A. R. 1884.0	13	52	36.355

Groombridge 2099.

	h.	m.	s.
1884, June 7	14	1	21.82
13			20.73
17			21.32
18			21.77
Mean A. R. 1884.0	14	1	21.410

5 Ursæ Minoris.

		s.
1884, June 7	A. E.	—0.03
13		+0.04
17		+0.01
18		+0.18
	Mean	+0.050
	A. E.	46.958
	h. m.	s.
Mean A. R. 1884.0	14 27	47.008

Schwerd 853.

	h.	m.	s.
1882, Dec. 12 s. p.	14	36	52.09
1883, June 14			51.91
25			52.39
1884, June 13			52.32
17			52.32
18			52.54
21			52.83
Mean A. R. 1884.0	14	36	52.343

Groombridge 2210.

	h.	m.	s.
1884, June 18	14	52	41.11
26			40.94
July 10			41.43
Mean A. R. 1884.0	14	52	41.160

Groombridge 2196.

	h.	m.	s.
1884, June 18	14	58	13.90
21			14.03
26			13.67
July 3			13.31
Dec. 30 s. p.			13.96
Mean A. R. 1884.0	14	58	13.774

Groombridge 2213.

	h.	m.	s.
1884, June 18	15	3	27.30
26			27.18
Dec. 30 s. p.			26.89
Mean A. R. 1884.0	15	3	27.123

Groombridge 2283.

		s.
1884, June 18	C. des T.	—1.00
26		—2.41
July 7		—1.20
9		—1.77
	Mean	—1.595
	C. des T.	0.52
	h. m.	s.
Mean A. R. 1884.0	15 14	58.925

Schwerd 916.

	h.	m.	s.
1884, June 18	15	27	38.79
26			38.47
July 7			38.94
9			38.55
Mean A. R. 1884.0	15	27	38.688

θ Ursæ Minoris.

	h	m.	s.
1883, July 18	15	34	53.15
20			52.94
23			52 59
1884, June 26			52.63
July 7			52.67
9			52.71
10			52.76
Mean A. R. 1884.0	15	34	52.779

MEAN RIGHT ASCENSIONS FOR 1884.0. — *Continued.*

GROOMBRIDGE 2286.

	h. m. s.
1883, Jan. 18 s. p.	15 39 33.34
Feb. 12 s. p.	33.20
1884, June 18	33 87
July 7	33.85
9	34.10
10	33.83
Dec. 30 s. p.	34.11
1885, Jan. 8 s. p.	34.28
Mean A. R. 1884.0	15 39 33.822

RADCLIFFE 3523.

	h. m. s.
1884, Jan. 12 s. p.	16 0 35.09
26 s. p. [½ wt.]	34.76
July 11	35.34
15	35.57
18	35.02
21	36.14
1885, Jan. 14 s. p.	35.02
31 s. p.	34.52
Mean A. R. 1884.0	16 0 35.211

GROOMBRIDGE 2320.

		s.
1883, July 20	A. E.	+0.22
24		+0.38
1884, July 9		+0.38
10		+0.21
15		+0.33
22		+0.47
	Mean	+0.332
	A. E.	0.350
		h. m. s.
Mean A. R. 1884.0		16 6 0.682

19 URSÆ MINORIS.

		s.
1884, July 7	B. J.	+0.21
9		—0.24
10		—0.14
11		+0.16
	Mean	—0.002
	B. J.	8.574
		h. m. s.
Mean A. R. 1884.0		16 14 8.572

SCHWERD 963.

	h. m. s.
1884, July 7	16 8 37.87
9	38.24
10	38.04
11	38.19
Mean A. R. 1884.0	16 8 38.085

20 URSÆ MINORIS.

	h. m. s.
1884, July 18	16 15 28.00
21	27.88
25	27.90
26	27.95
Mean A. R. 1884.0	16 15 27.932

η URSÆ MINORIS.

		s.
1884, July 7	A.E.(Suppl.)	+0.01
9		+0.13
10		—0.12
11		+0.05
	Mean	+0.018
	A. E.	54.388
		h. m. s.
Mean A. R. 1884.0		16 20 54.406

GROOMBRIDGE 2347.

	h. m. s.
1884, July 18	16 22 4.77
21	4 82
22	4.93
25	4.82
Mean A. R. 1884.0	16 22 4.835

A DRACONIS.

		s.
1884, July 7	B. J.	+0.07
9		+0 08
10		—0.14
11		+0.20
	Mean	+0.052
	B. J.	12.737
		h. m. s.
Mean A. R. 1884.0		16 28 12.789

GROOMBRIDGE 2372.

	h. m. s.
1884, July 7	16 32 12.77
9	12.85
10	12.49
11	12.91
Mean A. R. 1884.0	16 32 12.755

MEAN RIGHT ASCENSIONS FOR 1884.0. — *Continued.*

Groombridge 2373.

		h.	m.	s.
1884, July 7	B. J.			+0.13
9				—0.03
10				—0.24
11				+0.28
	Mean			+0.035
	B. J.			38.894
Mean A. R. 1884.0		16	35	38.929

Schwerd 992.

	h.	m.	s.
1884, July 18	16	44	30.07
21			30.05
22			29.90
25			30.00
Mean A. R. 1884.0	16	44	30.005

Groombridge 2391.

	h.	m.	s.
1884, July 18	16	48	16.94
22			16.69
25			17.02
26			16.86
Mean A. R. 1884.0	16	48	16.878

Radcliffe 3685.

	h.	m.	s.
1884, July 18	17	1	48.44
21			48.85
22			48.91
25			48.75
Mean A. R. 1884.0	17	1	48.738

f Draconis.

		h.	m.	s.
1884, July 30	B. J.			+0.23
Aug. 2				+0.14
14				+0.07
18				—0.11
	Mean			+0.082
	B. J.			25.697
Mean A. R. 1884.0		17	32	25.779

Radcliffe 3749.

	h.	m.	s.
1884, July 21	17	31	35.45
22			35.49
25			35.71
28			35.70
Mean A. R. 1884.0	17	31	35.588

Groombridge 2476.

	h.	m.	s.
1884, July 21	17	34	54.39
22			54.29
28			54.38
30			54.40
Mean A. R. 1884.0	17	34	54.365

ω Draconis.

		h.	m.	s.
1884, Aug. 2	B. J.			—0.07
14				+0.04
15				0.00
18				—0.15
	Mean			—0.045
	B. J.			37.893
Mean A. R. 1884.0		17	37	37.848

Radcliffe 3798.

	h.	m.	s.
1883, Feb. 13 s. p.	17	38	26.77
Mar. 1 s. p.			25.95
5 s. p.			26.57
Aug. 14			27.15
21			26.99
22			26.24
1884, July 18			26.98
21			26.80
25			26 57
28			26.07
Mean A. R. 1884.0	17	38	26.609

35 Draconis.

		h.	m.	s.
1884, July 28	B. J.			—0.03
30				+0.14
Aug. 16				—0.08
18				—0.11
23				+0.24
	Mean			+0.032
	B. J.			38.592
Mean A. R. 1884.0		17	54	38.624

Groombridge 2548.

	h.	m.	s.
1883, Aug. 14	18	4	21.44
21			21.89
1884, Aug. 2			21.75
15			22.14
18			20.60
Mean A. R. 1884.0	18	4	21.564

MEAN RIGHT ASCENSIONS FOR 1884.0. — *Concluded.*

RADCLIFFE 3900.

	h.	m.	s.
1884, July 30	18	10	8.03
Aug. 2			7.54
14			7.66
15			7.98
Mean A. R. 1884.0	18	10	7.802

RADCLIFFE 3903.

	h.	m.	s.
1884, Aug. 16	18	11	14.79
18			14.38
20			15.22
23			14.87
Mean A. R. 1884.0	18	11	14.815

RADCLIFFE 3921.

	h.	m.	s.
1883, Aug. 14	18	11	3.81
1884, Aug. 16			4.46
18			3.74
19			4.13
Mean A. R. 1884.0	18	11	4.035

φ DRACONIS.

		s.
1884, Aug. 28	B. J.	—0.02
Sept. 1		+0.03
2		—0.05
4		+0.11
	Mean	+0.018
	B. J.	25.235
	h. m.	s.
Mean A. R. 1884.0	18 22	25.253

SCHWERD 1094.

	h.	m.	s.
1883, Aug. 14	18	24	57.55
1884, Aug. 19			57.76
20			57.89
23 [½ wt.]			58.02
27			57.90
Mean A. R. 1884.0	18	24	57.802

GROOMBRIDGE 2655.

		s.
1883, Aug. 14	B. J.	—0.12
1884, July 30		+0.07
Aug. 14		—0.13
15		+0.11
16		0.00
	Mean	—0.014
	B. J.	20.928
	h. m.	s.
Mean A. R. 1884.0	18 35	20.914

GROOMBRIDGE 2708.

	h.	m.	s.
1884, Aug. 18	18	38	36.47
19			36.73
20			37.06
27			36.23
Mean A. R. 1884.0	18	38	36.622

RADCLIFFE 4165.

	h.	m.	s.
1884, Aug. 18	18	53	48.33
27			48.20
28			48.56
Sept. 2			48.22
Mean A. R. 1884.0	18	53	48.328

RADCLIFFE 4253.

	h.	m.	s.
1884, Feb. 15 s. p.	19	6	19.06
Mar. 4 s. p.			19.67
25 s. p.			20.16
Mean A. R. 1884.0	19	6	19.630

SCHWERD 1139.

	h.	m.	s.
1884, Mar. 22 s. p.	19	6	21.59
25 s. p.			22.15
Aug. 18			21.97
19			22.00
27			21.71
28			22.32
Mean A. R. 1884.0	19	6	21.957

RADCLIFFE 4313.

	h.	m.	s.
1884, Feb. 15 s. p.	19	16	43.35
Mar. 4 s. p.			44.08
22 s. p.			44.17
25 s. p.			43.83
Mean A. R. 1884.0	19	16	43.858

CEPHEI 39 H. s. p.

		s.
1884, Apr. 22	C. des T.	—0.03
23		+0.07
26		—0.31
30		—0.60
	Mean	—0.218
	C. des T.	50.26
	h. m.	s.
Mean A. R. 1884.0	23 27	50.042

II.

THUNDER-STORMS IN NEW ENGLAND IN THE SUMMER OF 1885.

By William Morris Davis.

Presented June 16, 1886.

The observation of thunder-storms was taken as a special subject of investigation by the New England Meteorological Society during the summer of 1885. The considerable expense of the work was lessened by effective assistance from the Chief Signal Officer, U. S. Army, and the remainder was borne by a grant from the Bache fund of the National Academy. By taking advantage of all available opportunities, offers of aid were received from about five hundred volunteers in various parts of New England, and about three hundred of these maintained their interest in the work through the summer, and sent in their records with considerable regularity. The Society is greatly indebted to these observers for their persevering assistance. As success in the work depended entirely on the enlistment of a well-distributed body of observers, effort was made to secure an equal representation of different districts, but not with as much success as it is to be hoped will attend a second season's campaign. Several districts, such as northeastern Connecticut and southeastern Massachusetts, were almost without observers; while only central and eastern Massachusetts were pretty well covered with stations. The results here stated are therefore in many ways to be regarded as preliminary to those that a more complete investigation may yield in the current year.

The correspondence with volunteer observers during the summer months, the care of the records as received, and the preliminary tabulation and charting of the observations, have been in the hands of Mr. O. N. Oswell, of the U. S. Signal Service, whose careful work has been, from the beginning of this investigation, an essential in its continuance. Mr. H. Helm Clayton, now observer at the Blue Hill Meteorological Observatory, has also given valued assistance in charting certain storms. But even with so much effective help, a long delay in presenting this statement of our last summer's work has been unavoidable. The discouraging effects of the delay may, however, be more than counterbalanced, if the report reaches our observers at the opening of another thunder-storm season, and, by pointing out the value of the work done last year, encourages them to still further efforts in a second campaign. These efforts should be of two kinds. First, the enlistment of new volunteers in neighboring towns; it is hoped that our observers will take care — will indeed take pride in seeing that no large district remains unrepresented on our lists. Second, in giving special attention to certain questions which are mentioned in the following pages as needing well-directed, discriminate observation for their decision; among these, the growth and motions of the storm-clouds, whether observed near at hand or on the distant horizon, may be named as of the first importance.

It is worth while to state here that one of the most serious difficulties that we have had to contend with is the lack of belief in the importance of trivial observations. Many observers have expressed some misgivings as to the value of their work, because they had only light rain and faint thunder to report; and some persons seem really to have been discouraged even to the point of giving up their records, because they were not favored with any violent storms. It would take but a short time to convince all these observers that very simple records in many cases possess the especial interest of marking the beginning, end, or border of violent storms, without which it would be impossible to define the storm area or tract. Even the simple and direct statement of *No storm to-day* is important, as, for example, on July 3, when many small storms developed in eastern Massachusetts and moved out to sea. By consulting the map for that day, it will be perceived how important the report of "Distant thunder, but no rain," may become, when combined with observations at other stations. It is therefore especially desirable that observers should in all cases *follow instructions* as closely as possible, *whether their record seems important or not.* The importance of an observation appears when it is brought together with all the other records of the same day. It is probably for similar reasons that many persons failed to see the necessity of timing their observations accurately; a record that gives time only in round numbers, such as 3.50, 4.10, 4.30, is at once open to suspicion; while one in which uneven times occur with natural frequency, such as wind-squall 16.37, rain 16.39, heaviest rain 16.45 to 16.58 (this being an actual record from one of our best observers), bears strong internal testimony to its accuracy. In many storms, an inaccuracy of seven minutes in timing the beginning of rain would cause an error of almost six miles in charting the rain-front. An accurate timepiece, carefully recorded, is therefore essential to the best success.

Reduction of Observations. — On receiving records from our observers, the forms were classified, first by dates, next by storms under the same date if possible, and last by States. Next, the time of rain beginning was charted, on a large map (six miles to the inch) if the records are numerous; on an intermediate scale (seventeen miles to an inch) for many dates; on a small map (thirty-five miles to an inch) for days when the records were scattering. The greatest part of this work has been done by Mr. Oswell. When reduced to this form, the rain times are examined to discover evidence of the progression of the rain area across the country, and, if this appear clearly enough, lines indicating the probable position of the rain-front are drawn for the even hours,* or for smaller intervals, and from these the direction and velocity of the storm's advance are measured. Only a small portion of the work thus performed can be presented in this report. Having obtained a general idea of the storm, the records are examined again in order of rain times, and the questions of wind directions, cloud motions, and temperature changes are considered.

Our insufficient number of stations has been a continual regret during this work; the storms have in several cases seemed to choose districts freest from observers, so that in one sense the labor of this first season's investigation must be regarded as having its best result in exciting more general interest and better work another year. The storms of New England are also generally so moderate that the detection of their circulation will be probably more difficult than if these studies were carried on in the Western States. Nevertheless, it is believed that the collection of facts here briefly summarized will prove of value in the study of local storms in this country, and that it will serve well as the basis for more extended study in New England during the present year.

Daily Maximum Temperatures. — The occurrence of thunder-storms is in many cases so closely connected with the change from high to low

* Throughout this report, the hours are counted from midnight to midnight, so that afternoon and evening hours fall between 12 and 24.

temperature that it has been thought advisable to present here a table, compiled from the records furnished for the Monthly Bulletin of the New England Meteorological Society, giving the mean of the daily maximum temperature for several stations through the summer. The stations chosen were all at some distance from the sea-coast, so as to be beyond the reach of the diurnal sea-breeze; they were Brattleborough, Vt.; Concord, N. H.; Amherst, Princeton, Lowell, and Taunton, Mass.; and Collinsville, Conn.; all the records being from self-registering thermometers.

TABLE I.

Date.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
June	73	75	71	70	62	71	73	80	63	74	76	79	79	84	78	88
July	64	74	75	80	82	82	80	87	91	82	78	80	78	69	80	83
Aug.	85	75	72	84	83	74	74	79	77	78	84	86	85	85	73	75

Date.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
June	75	78	82	85	79	77	69	77	84	83	82	81	80	68	—
July	92	86	82	87	90	86	84	82	88	87	83	84	82	75	85
Aug.	78	82	81	72	74	83	76	82	67	63	64	69	70	63	76

It is to the figures of this table that reference is made in the following general account of our thunder-storms, under the abbreviation "mean max."

General Account of Thunder-storms in the Summer Months.

June 1. Several thunder-storms appeared on this, the first day of systematic observations by our volunteers, and a brief account of them was issued in Bulletin No. 7 of the N. E. Meteorological Society; they were close to the south of a centre of low pressure that crossed from Lake Champlain to the Gulf of Maine during that day, and the best defined storm moved eastward across southern New Hampshire at a rate of 31 miles an hour.

June 2, 3. During the approach and passage of an area of high pressure on these days, there were a few reports of light thunder-showers, of thunder heard, or of lightning seen; but no general storm occurred.

June 4, 5. In the evening of the 4th, and during the 5th, observations increased in number; at this time, an area of low pressure was, according to the June Weather Review, advancing from southern Michigan to the New Jersey coast. On the 4th, a roughly defined storm of moderate strength, with rather heavy rain, advanced from southwestern Connecticut towards central Rhode Island, from $20\frac{1}{2}^h$ to 23^h, at about 40 miles an hour. It was the first of the season for this district. On the 5th, there was a general rain over New England, with low temperature and northeasterly winds during the morning, while the centre of low pressure moved from eastern New York southeastward over Long Island, or perhaps a little farther south. The rain seems to have begun, or at least to have distinctly increased, about the time that several peals of thunder were heard, their place of occurrence advancing southeastward with much regularity from southern Vermont at $5\frac{1}{2}^h$ to southeastern Massachusetts at 10^h, with a velocity of 28 miles an hour. Several careful observers in Connecticut and Rhode Island report that the low scud clouds moved with the surface wind from the northeast, while higher clouds could be sometimes seen above, moving from the northwest or west, in accordance with the advance of the storm; this was especially visible during a break in the clouds reported from several stations, at $8^h.45$ in central Connecticut, at $9^h.35$ in the eastern part of the State, and about 10^h in Rhode Island; but this cannot be considered as the "eye" of the passing cyclonic storm, as the barometer continued to fall for several hours afterwards, and the wind did not veer to north or northwest till noon or later, the temperature being from 60° to 70° during the morning. The time of passage of the lowest atmospheric pressure was a little after noon in eastern Connecticut and Rhode Island; it was accompanied by brisk northeast to north winds, thunder with an increase of rain, and a marked fall of temperature to below 50° in the later afternoon and evening, as the cloud cleared away with north or northwest winds. The afternoon thunder-storm moved eastward 20 or more miles an hour: it was not felt north of Rhode Island.

June 6, 7. On June 6, there were no reports of thunder, (if we except an isolated report, probably misdated for June 5,) the signal service weather maps showing that New England was on this day traversed by an area of high pressure, moving southeasterly. On June 7, there was rising temperature with southerly winds, flowing in obedience to the call of a low pressure centre north of the lower Lakes; the day was fair, and no storms were reported till evening, when three observers, far apart in western, central, and eastern Massachusetts, report local or distant thunder-showers: at this time the centre of low pressure was nearing Montreal, on its way down the St. Lawrence.

June 8. This was a day of greater warmth (mean maximum, 80°, Table I.) and numerous reports, while the centre of low pressure traversed the Gulf of St. Lawrence. Thunder was heard and rain came in showers with moderate or light southwest winds, sometimes veering to northwest shortly after midnight and during the early morning at many points; a tolerably well-marked progression is found from central Vermont at 2^h, central New Hampshire at 3^h to 4^h, southeastern New Hampshire and eastern Massachusetts from 4^h to 6^h; but as additional showers are confused with the main one, and as the time of occurrence was unfavorable to reporting, little can be said of the storm. It is noteworthy, however, that a good number of observers made detailed records even at three and four o'clock in the morning. The rain was hardly felt south of Worcester and Boston, although thunder was heard some distance farther south.

The temperature during the early storm was between 60° and 70°. The morning was fair, with southwesterly winds, and the warmth increased to 80° or 85° at noon. Clouds then began to gather, and between 13^h and 14^h developed into a long, narrow thunder-storm, stretching over one hundred and fifty miles, from northwestern Connecticut to Cape Ann in northeastern Massachusetts. The intensity of the storm varied along this line, as seems to be generally the case, but was nowhere very severe; at some stations, all the elements of the storm were moderate; at others, the rain, beginning gently, became heavy for a short time, and the heavy shower was preceded by a short-lived high wind from the northwest, and accompanied by a rapid fall of ten or fifteen degrees in the temperature. The electric action was inconsiderable at all stations. Northern Massachusetts and the States beyond had practically no thunder-storms in the afternoon. Starting from the beginning here defined, this storm extended southeastward, and reached eastern Connecticut, Rhode Island, and southeastern Massachusetts about 16^h, but was nowhere reported on the southern coast. The parallel lines representing its rain-front at 14^h, 15^h, and 16^h are distant only about 20 miles, if measured N. N. W. to S. S. E. at right angles to their length; but as nearly all observers agree in giving the storm a decided easterly motion, it would seem that the velocity should be measured very obliquely to the rain-front, in which case it may have been as much as 40 or more miles an hour. Although presenting the well-marked linear extension characteristic of thunder-squalls, the clouds of this storm cannot be well classified from the records that we have other than as heavy rain clouds. The several types described under the storm of July 9 do not appear here. The observer at Provincetown, Mass., reports high *stratus* clouds moving from the west-southwest before the lower *cumulo-stratus* clouds came with the storm from the northwest.

June 9–15. During the first three days of this period, the morning weather maps show that an area of high pressure came from the northwest, and crossed New England; as its centre lay off our coast, an area of low pressure stood in Colorado. From the 11th to the 15th, this low pressure centre moved along the usual east-northeast path, and ran down the northern slope of the St. Lawrence valley; during the latter part of its passage, there were three scattered reports of distant lightning in the evening of the 14th after a warm day (mean max. 84°). On the 15th, the day opened with low pressure centres in Newfoundland and Lake Superior, and high pressure off the Carolinas; it was probably within the circuit of the Western area of low pressure that two local storms occurred, one in Maine in the afternoon, the other in Connecticut in the evening of this day. They brought us only three reports, in spite of the rather high temperature, and the not great distance of the low pressure area.

June 16. Several small showers occurred in southern New England while the second of the above-mentioned low pressure areas hesitated in the Gulf of St. Lawrence on the hot afternoon and evening of the 16th (mean max. 88°). The most interesting of these was a well-developed storm of small size that was felt a little after 14^h over the northern part of Rhode Island, and moved eastward to Cape Cod Bay. It was unfortunate in selecting a district poorly represented by our volunteers, and thus lost the opportunity of being carefully portrayed. It arose in northeastern Connecticut, and moved eastward across northern Rhode Island and southeastern Massachusetts at a rate of about 35 miles an hour. The clouds were heavy, but the rain-fall was generally moderate; the temperature fell from 90° or 95°, as it had been shortly after noon, to 80° or 75°, and rose again a little after the storm moved past; the wind showed a distinct control by the storm, as a brief gust of moderate strength was felt at most of the stations just before or during the rain, the direction of its blowing being in all cases away from the centre of the rain area. On reaching Taunton, the rain had become very light; and no report of the storm came from Plymouth or Provincetown. Jewett City, Conn., Crompton, R. I., Fall River and East Freetown, Mass., saw the storm passing to the north; and Medfield and Pembroke, Mass., reported it to the south, about the time another storm was passing to the north. This second storm formed not far north of the first one, at a little later hour, and passed over Blue Hill on its way to the south shore of the Bay. The rain was reported heavy only on Blue Hill, where the wind was strong for a time during the shower.

This storm was visible from Cambridge as a great mass of boiling *cumulus* clouds overlain with flat, outspreading *cirrus;* their angular altitude was estimated at 30°, giving a height of five or six miles. A third storm, or group of showers, less defined than the others, appeared first on the Connecticut River in Massachusetts about 15^h to 16^h, and gave moderate showers to various stations on its way to the coast, at and north of Boston, where it arrived at 21^h or later. The first two storms here described were much like, but smaller than the noon thunder-squall of July 21, that is described in detail farther on. Very numerous and careful observations are needed for the full definition of such storms.

June 17–21. Another period without thunder-storms now appears. On the morning of the 17th, a large area of high pressure appeared over the Mississippi valley; on the 18th, it was on the Ohio valley; on the 19th and 20th, on the Middle Atlantic coast. On the 21st, an ill-defined area of low pressure was central on Lake Michigan. All these days were fair and warm in New England, and on the 20th the mean maximum temperature was 85°.

June 22. The low pressure area was central north of Montreal in the morning, with barometer down to 29.40; the isobars were strongly V-shaped, with the axis extending down the Hudson valley; but in spite of this apparently favorable condition for the collision of warm southwest and cool northwest winds, New England had only light showers, and among these there were several without thunder. No well-developed thunder-storm appeared. The temperature was moderate (mean max. 77°).

June 23–25. This period is a repetition of that from June 17 to 21; an anticyclonic area moving from the Mississippi valley to the sea-coast, with fair weather in New England; the mean maximum temperature was only 69° on the 23d, but rose to 84° on the 25th.

June 26. A number of stations in southern New Hampshire, and a few in southwestern Maine, report moderate thunder-storms on this date at noon, in the afternoon, and at night. Stations were wanting farther north, so it cannot be said how far the storms extended in that direction; but they were definitely absent in the south, in spite of continued warm weather (mean max. 83°). These storms are less distinctly dependent on cyclonic conditions than any of their predecessors, as there was no well-defined low pressure centre within the limits of the weather map at the time; a high pressure area was moving eastward from the Middle Atlantic States.

June 27. An area of slightly diminished pressure appeared on this morning north of Lake Superior, and moved to western Canada in the course of the next twenty-four hours. During the afternoon of this hot day (mean max. 82°), several rather strong storms occurred in northeastern Massachusetts, and scattered reports came from farther north and west. Showers without thunder are also reported. The two storms that can be partly defined began in northeastern Massachusetts; the first about noon, the second a little farther west than the first, at 13^h to 14^h. Both moved east-northeast at about 20 miles an hour, and passed out to sea over Cape Ann and farther north. On account of their coming so close together, it is difficult to distinguish them in some of the reports, but they showed the usual control over the winds and temperature at a number of stations. At a moderate distance away, the wind blew with moderate or light velocity towards the storm; nearer the rain area, and especially at times of heavy rain, the wind blew away from it, and for a time with increased strength. North of Salem, where the rain was especially heavy, the wind blew outward even at the *back* of the storm; this seldom appears, and in this case seems to be connected with the low velocity of the storm, and with its lateral or backward growth to the westward, even while moving east. The storms as a whole were seen from Cohasset, south of the Bay, moving slowly in an easterly direction; their angular altitude was estimated to be 20°; their distance must have been at least 20 miles, and was more likely 22 miles. This would make their height six or more miles.

An appreciative record from Southampton, Mass., on this date, describes in detail the extension of the rain area in a local thunder-shower in a direction contrary to the movement of the clouds, as above suggested. Cumulus clouds of ordinary type had been seen growing to larger and larger size from $10^h.30$, and moving from the southwest while the surface breeze blew towards them from the southeast. About noon, rain was seen falling from the clouds, and thunder was heard a little later. Then additional cumuli, coming from the southwest, developed very rapidly as they approached the shower, building the thunder-cloud southward. "The shower as a whole had a movement to the northeast, but the development of the cloud area in the manner noticed exceeded the velocity of the shower movement." Other observers describe this shower as moving slowly; it would be an excellent one for study had our stations been more numerous in this district. Its motion and that of several neighboring showers was from west to east, or a little to north of east, and the velocity seems to have been moderate, although this is poorly defined by our records.

June 28. The low pressure area of the preceding day moved eastward with warm weather, and while central over Lake Ontario, on the afternoon of the 28th, a moderate number of showers were reported in New England, generally light and in most cases moving from the west or southwest. Towards night, the thunder died away, but the rain increased.

June 29. (Storm charted by Mr. H. H. Clayton. See Fig. 1.) No better example than the storm of June 29th can be taken to show the need of some better classification of storms than that based simply on the fact of thunder being heard. The storm of this date was one of a series of rain showers that accompanied the approach and passage of the area of low pressure already mentioned. The night before (June 28), when the centre of low pressure was in northern New York, there was a general rain at many stations, but only a few reports mentioned thunder; the morning of the 29th was cloudy, and the air rather close and oppressive, although the thermometer did not often rise over 85° to 90° (mean max. 80°). The centre of low pressure, according to the Monthly Weather Review, moved southeastward during the day, from northern Vermont to Massachusetts Bay, and the next morning (June 30) lay in the Gulf of Maine. The afternoon thunder-storm began in or a little west of the Connecticut valley, just before noon, and moved about east or east-southeast, eighteen to twenty-five miles an hour, fading away as it approached the eastern and southern coast, before sunset. Its front was not well marked; the rain began gently, and there was seldom any clearly marked previous change in the wind's direction or strength, though, at some stations where the rain became heavy, the wind then shifted for a time to northwest and became "brisk"; nor was the rain-front continuous, as central Massachusetts had no rain, while Connecticut, eastern Massachusetts (about the Newtons), and southern New Hampshire had heavy rain. In Connecticut, the wind before the rain was light, from south or southwest, with moderately high temperatures (80°–85°); it shifted during the shower to west or northwest, and the temperature fell fifteen or more degrees (68° to 70°). At Hartford, Middletown, and Colchester, the rain was heavy, and hail as large as robin's eggs fell for a few minutes at the latter station.

The New Hampshire portion of the storm that came at the same time as that in Connecticut had less defined characteristics; the rain began very irregularly, and the changes of the wind seem to be without system, some stations reporting a change from southeast to northwest, others almost the reverse, and still others had a variable succession of light breezes. Nearly all stations agree in giving the storm an advance from some westerly point, and, according to the times of rain beginning, its progress was at about the same rate as in Connecticut, in spite of its standing to the north of the neighboring centre of low pressure.* About Concord, the rain was very heavy.

The northern and southern ends of the storm seem to have faded away while the central part increased in strength as it approached the eastern coast. There was heavy rain and some hail near Haverhill, Mass., and all the many Newton stations, along with Boston and those near by, give heavy rain; but the most marked feature of the storm

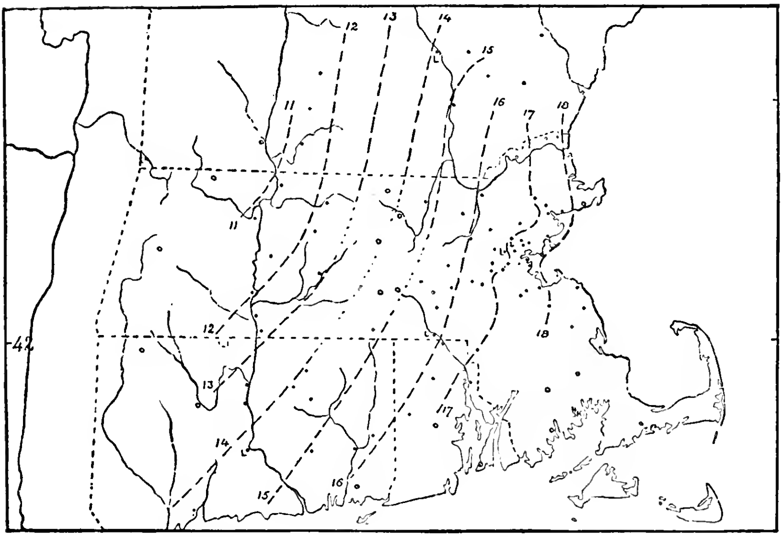

Fig. 1.

was the prevalence of easterly winds charged with low, foggy clouds, just before and during most of the rain; this was sometimes interrupted by a "moderate" or "brisk" northwesterly breeze about the time of the heaviest rain, but the east wind generally returned as the rain decreased. The indraft towards the storm in front of the rain, and the temporary control of the wind's direction by heavy showers, here find good illustration. Lightning strokes seem to follow the

* In Bavaria and Austria, it has been found that thunder-storms in this position very commonly move to the west.

heavy rain; four are reported about Waltham and Newtonville, others in Concord, N. H., Millville, Mass., with hail, and Middletown, Conn.

A composite portrait (see special description of squall of July 21) of this storm (June 29), prepared by Mr. Clayton, brings out with much distinctness its difference from the thunder-squalls of July 9th and 21st, in the absence of strong out-blowing winds in front of the rain, and in the presence of a district indraft of easterly winds in front of the middle and northern half of the storm. During the rain, no safe generalization can be made concerning the wind directions; it should not be inferred from this that there is no definiteness in the circulation of the wind at that time, but rather that this method fails to discover it. With more numerous stations, and more regular observations, there is good probability of discovering system where only disorder now appears.

June 30 and July 1. The centre of low pressure above described lay over the Gulf of Maine on June 30, giving us cool weather, and only three records of thunder were received for this day. On the 1st of July, the centre moved northward across western Maine, with still cooler weather (mean max. 64°), and no reports of local storms were made; they may have occurred in eastern Maine, where we had no observers. The abrupt change in the character of our weather on the two sides of a centre of low pressure is thus finely illustrated.

July 2. During the morning hours the centre of low pressure retrograded into western Canada, giving us warmer weather again; in the afternoon and night it returned across northern Vermont, and while there a moderate storm arose, about 17^h to 19^h, in central Massachusetts, and moved east-northeast, becoming rather strong at Lancaster and Sterling at 21^h, when the rain was heavy, and two buildings were struck by lightning. The rain extended little farther. The lightning from this storm was visible from a number of stations on the northeastern coast at the above-named hour. There were a few other isolated showers in the evening.

July 3. The same centre of low pressure still controlled our weather, moving on this date from Mt. Washington north to the St. Lawrence valley; and a number of separate storms appeared in the afternoon in central and southern New Hampshire and central and eastern Massachusetts. These local storms followed one another in such close succession in eastern Massachusetts that it has been impossible to trace them all. Ten of the more distinct ones are represented in Figure 2, moving southeast or east-southeast, at different hours, their velocity averaging sixteen miles an hour. In several of the storms the clouds seem to have been simply overgrown *cumuli;* in others the ordinary high-level *cirrus* overflow is mentioned. An

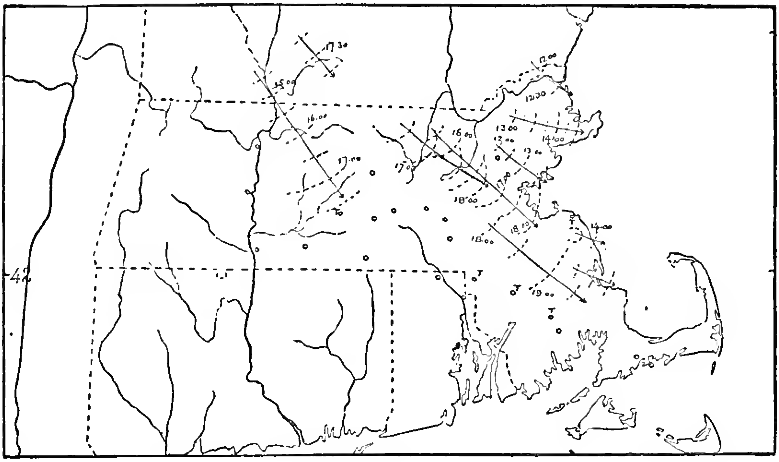

Fig. 2.

inflow of winds before or alongside of the storms is seen in several cases, followed by a reversal or deflection of the wind as the area of heavy rain approaches.

July 4. The distribution of atmospheric pressure east of the Mississippi was rather uniform on this day, with gentle northward gradients and rising temperature. A few light local storms appeared in central New England in the late afternoon and evening.

July 5. The barometric gradients were on this day directed westward, from a high pressure area off the coast to a low pressure centre in Minnesota. The temperatures were high, but not excessive (mean max. 82°), and the day passed with trifling showers; but in the evening, from 18^h to 22^h, a very severe storm, with heavy rain and hail and incessant lightning, striking in many places, passed eastward across central and northern New Hampshire. Our observers there were too few to define it. Lightning from this storm was very noticeable south of Boston, over one hundred miles distant. In eastern New York a destructive hail-storm occurred near Chatham-Four-Corners at about 18^h; its path was five miles long and one wide. No reports of it were received from western Massachusetts.

These two are the first strong storms of the summer that occurred without close connection with a centre of low pressure.

July 6. The western centre of low pressure on this day followed a curious retrograde course from Lake Superior towards Lake Winnipeg. Under its influence, New England had warm southerly winds, turning to southeast or east along the eastern coast, and southwest inland. Several local showers of no great intensity arose in Vermont, New Hampshire, and Eastern Massachusetts in the afternoon and evening, moving east-northeast at a moderate rate; they appeared to be developed from ordinary *cumulus* clouds, whose motion was persistent from the southwest or south, little affected by the inflection of the surface winds along the coast. As an example, a shower that passed over the south shore of Boston Bay may be mentioned. The morning sky had been nearly covered with light *cirro-cumuli*, beneath which large *cumuli* formed rapidly about noon, and united into a long *nimbus* stretching about north and south, and moving to the northeast: the light surface winds at one station were east before the rain, calm during the light shower, west for a short time after the shower, and then east again through a fair afternoon. Other stations report a continued east or southeast wind during and after the passage of the shower. The showers in New Hampshire were heavier: in the eastern part of the State they also presented the peculiarity of advancing from the southwest over an easterly wind.

July 7. A few local showers, with moderate electric action. The winds were still warm southerly, under the influence of high pressure off the coast and the low pressure centre that hesitated over Lake Winnipeg.

July 8. A new centre of low pressure appears on the morning weather map for this date in Dakota. Violent thunder-storms appeared south of the Great Lakes, but none formed in New England, although the temperature rose rapidly (mean max. of 7th, 80°; of 8th, 87°).

July 9. The newly formed area of low pressure moved eastward, north of the lower lakes, and on the afternoon of this day stood near Quebec. Under its influence the mean maximum temperature rose to 91°, and the largest storm of the summer was developed, extending with almost continuous front from southwestern to northeastern New England, and accompanied by all the characteristics of a full-grown storm. It forms the subject of a special description on p. 38.

July 10. The low pressure centre of the previous day turned southward from the St. Lawrence valley, and this morning stood in western Maine. Had this attitude been preserved through the hotter hours of the day, we should doubtless have had more than scattered reports of light thunder-showers and heat-lightning; but it moved away eastward, leaving an area of cool fine weather behind it.

July 11 to 20. This peculiar period of ten days almost free from storms is one of the most marked features of the summer. There were no reports on the 11th, 12th, or 13th, during the passage of an area of high pressure, and the approach of two low pressure centres which passed north and south of New England on the 14th. The northern of these cyclonic centres ran down the St. Lawrence valley, on a path seemingly well adapted to giving us local storms; but the other one moved northeastward from New Jersey, probably along the southern coast of New England, and controlled our weather, giving us a light general rain, with easterly or southeasterly winds and a low temperature (mean max. 69°). A few reports of moderate thunder came from Rhode Island in the evening. On the 15th, the temperature rose, but there were no reports. The 16th brought an area of high pressure along the Atlantic coast, with still rising temperature (mean max. 83°); a few sharp local storms were here developed, the most severe being in central New Hampshire at 15^h, where the lightning struck in several places; but reports were received from only five observers. The absence of storms on the 17th is remarkable. A low pressure centre had come from the West to Lake Huron, and thence over Canada north of the St. Lawrence. It produced the hottest mean maximum temperature of the summer (92°), with the characteristic circulation of winds that in other cases developed violent storms; and yet on this day there were only three reports, all of heat-lightning in the evening. We are led to suppose that the position of the low pressure centre and the arrangement of winds proper to give storms in New England was not reached until night, when the absence of sunshine prevented their development. Still, it is surprising that none came to us that had formed farther west in the daytime.

The 18th, 19th, and 20th furnished no reports; they were characterized by the passage of an area of high pressure, with fair, warm weather.

July 21. After this long period of inaction in New England, there came a low pressure centre that had been loitering in Dakota on the 18th and 19th, and that moved rapidly eastward on the 20th. The morning of the 21st found it north of Lake Huron, and at 15^h it was in southwestern Maine: its progressive velocity was therefore about 60 miles an hour during this interval. Several storms accompanied this low pressure area. Two of them are among the most interesting of the summer, both being notable for their high velocity of 48 and 43 miles an hour, and their violent wind squall. They are described in some detail on p. 45. The mean maximum temperature for the day was 90°.

July 22, 23, 24. These days were occupied with the passage of an area of high pressure, with fair, warm weather, and had only three, three, and seven reports respectively: the most severe of the last day was in central New Hampshire, where our lack of observers prevented its receiving more notice.

July 25. An area of low pressure moved from Lake Michigan on the 24th north of the St. Lawrence, and was north of the Gulf on the afternoon of the 25th, when several storms occurred in southern New England, after an oppressively hot day. The complication of successive storms at a number of stations makes it difficult to determine their advance. The most distinct one moved from the Connecticut valley, at 14^h, east-northeast across Massachusetts, reaching the sea about 16^h, and having a velocity of about 35 miles an hour: its rain-front stood northwest and southeast, a somewhat unusual attitude. Heavy storm-clouds were developed over southern central Connecticut about 15^h to 16^h, but they gave only moderate rain. Few reports make mention of violent winds, although the rain-fall was not infrequently heavy. These storms did not mark any distinct change of weather, as the mean maximum temperatures for the 25th and 26th were 88° and 87°.

July 26. On this date there was still low pressure over the Gulf of St. Lawrence, and high pressure north of the Lakes. The day became oppressively hot, but only two thunder-storms of any defined form can be recognized. One crossed the Connecticut valley near Amherst, Mass., about noon, moving from northwest to southeast, with heavy rain preceded by high northwest wind, and cooling the air from 90° down to 80°; it seems to have been short-lived, as stations farther east did not report it. The other and larger one began south of Framingham and Natick and north of Medfield and Norwood, about $12^h.45$, and moved southeast, crossing Martha's Vineyard at $15^h.10$ to $15^h.40$; its velocity therefore averaged about 23 miles an hour, but the time of the storm's arrival at intermediate stations implies a gain in velocity in the latter part of its course. The wind of the day was generally northwest; it was not seriously affected by this storm till the cloud had passed Taunton ($13^h.50$) and reached East Freetown ($14^h.14$); here and beyond, the wind before the storm was light southerly, with temperature 92° inland, and 85° to 80° on the coast; then, with the beginning of the rain, the wind-squall came high from the northwest, and the temperature fell ten or fifteen degrees in half an hour or less. The rain became very heavy, and numerous lightning strokes are reported near New Bedford and on

Martha's Vineyard. On Vineyard Sound and on the island the storm was severe. At Cottage City, on the island, the storm-clouds were seen in the distant north at $12^h.30$, when the storm was forming, seventy or eighty miles away.

July 27, 28. The passage of another area of high pressure again brought fair weather, with only two reports of thunder on the latter date.

July 29. (Fig. 3.) During the previous day the baric gradients were very gentle, and our temperatures were high (mean max. 84°). On this morning a slight baric depression lay north of Quebec, and still maintained warm weather under its southwesterly winds (mean max. 82°). Five separate storms have been traced for this day, the charting being done by Mr. Clayton.

a. The first one came early in the morning, being reported in northern Vermont at 2 A. M., and reaching eastern New Hampshire about eight o'clock, having travelled over a narrow path to the east-southeast at a rate of perhaps eighteen miles an hour: it does not seem to have reached the sea-coast.

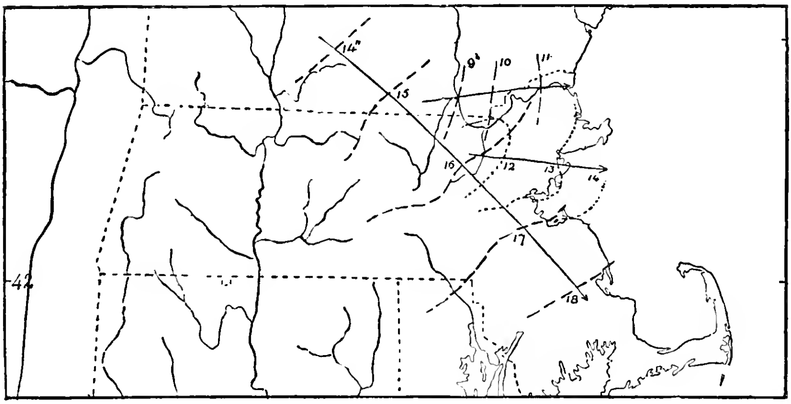

Fig. 3.

b. The second storm advanced eastward along the boundary of New Hampshire and Massachusetts, at a rate that may be estimated at twenty miles an hour, and passed out to sea at noon.

c. The third storm developed in northeastern Massachusetts about noon, and moved eastward at the same leisurely rate as its predecessors. Its rain-fall is recorded as over half an inch at several stations; its clouds were dark and heavy, and several lightning strokes are reported; but there was no squall connected with the storm, the wind remaining fresh southerly or southwesterly during the rain, except at Haverhill and Newburyport, on the northern side of the storm, where it was reversed to northeasterly.

d. The fourth storm probably consisted of several parts: it extended over central Connecticut in the middle afternoon, but its motion cannot be well determined for lack of observations. Fine festoon clouds were seen on the after side of its *cirro-stratus* cover in the southern part of the State.

e. The last and most extensive storm of the day began in southern New Hampshire about 14^h, and moved to the southeast about twenty-five miles an hour. It does not seem to have been a well united storm, but consisted of numerous loosely connected parts, from which showers of varying strength fell. At Lowell storms *c* and *e* together yielded about four inches of rain, one gauge reporting 3.93 and another 4.20 inches; and of this the greater part fell from $15^h.15$ to $16^h.15$, without much wind, although the clouds were much agitated as the storm approached. Violent winds appeared only in a limited district north of Worcester, about Holden and Princeton, and hail fell a little farther north, at Westminster.

Mr. Clayton has constructed several synoptic charts for storms *c* and *e*, as far as the observations would allow, showing the extent of the rain area and the direction of the wind at certain even hours. Owing to the failure of many observers to carry out their instructions literally, it was found impossible to make these charts very complete; but the later ones show a tolerably distinct cyclonic motion of the winds within and around the oval rain area, implying that the thunder-storm area possessed a gentle spiral rotary circulation on a small scale, as has been determined for storms of this kind in Europe. On this date the very moderate gradients gave good opportunity for the formation of such "secondary depressions." Especial effort will be made to accumulate data for such synoptic charts during the coming summer, as they promise to be of particular interest in connection with the smaller local storms.

July 30 possessed no well-defined centres of high or low pressure; its temperature was lowered (mean max. 75°) by the passage eastward of the area of low pressure that controlled the weather of the preceding day. A few scattered reports were received, the only storm of any severity being in central New Hampshire about 8^h.

July 31. This was a day of generally equable distribution of pressure, of rather high temperature, and with winds of indeterminate circulation. Through the afternoon, showers of local formation began at a number of places over New England, and moved about without coalescing into any general storm. Their distribution seems to have been more detailed than that of our observers, so that it is quite impossible to follow their tracks. The rain was seldom heavy, but when so, there seems to have been a wind of more or less strength caused by it, blowing away from the storm; in such cases, the breeze was often felt at points beyond the area of the heavy rain. No definite statement can be made as to the direction or rate of the storms' motion, but a number of observers speak of the cloud velocity as slow, and record the direction as W. to E., or N.W. to S. E. A marked peculiarity of the day was the severity of the lightning and thunder with but moderate rain-fall, and the extension of the area where thunder was heard twenty or thirty miles southeast of the margin of the rain area.

Aug. 1 had an even more equable distribution of pressure than the previous day, and its maximum temperatures averaged again 85°. Thunder-storms developed about noon, and from 16^h to 18^h a large storm of much severity was felt in central and eastern Massachusetts. The wind of the storm was generally light, but in central Massachusetts showed the outblowing squall. A newspaper report mentions destructive wind (tornado?) at Bernardston, Mass. The rain was very heavy at many stations, hail fell at a few places, and twenty-five strokes of lightning were reported, although attention was not given especially to this question. The early motion of the storm cannot be satisfactorily determined; much time has been spent in attempting to analyze the many records gathered, but without good success, on account of the irregularity in the line of rain-front and the complicated succession of showers. After raining heavily between Worcester and Boston, the storm moved southeast, with a velocity of twenty or thirty miles an hour, decreasing in intensity as it approached the coast after sunset.

Aug. 2. A low pressure centre now appears in Illinois, moving northeastward. Under the influence of its easterly winds, the temperature fell ten degrees below that of the day before, and rain was recorded at a number of points. Few thunder-storm reports were received; several from southern Rhode Island imply a small storm of some severity, with heavy rain, moving eastward about noon.

Aug. 3. The low pressure centre, still moving slowly to the northeast, occupied this day in passing between Lakes Huron and Erie; in New England, the temperature was moderate (72°), with easterly winds and rain; very few stations reported any thunder. On the afternoon of this day, several tornadoes occurred in eastern Pennsylvania.

Aug. 4. The low pressure centre passed slowly along north of the St. Lawrence, and gave rain that began gently on the afternoon of the 3d, and continued through the night, becoming very heavy, with strong south or southeast wind, just before clearing in the morning, and this latter part of the rain was accompanied with violent thunder and lightning, striking in several places. Many observers speak of this storm as a peculiar one, describing it as an ordinary southeast storm during the night, but culminating in a violent thunder-storm with torrents of rain as it was about to break away. The time of rain beginning cannot be used in this case as a guide to the progress of the storm; but the hour of loudest thunder and heaviest rain serves well instead. This shows the storm to have passed over western Connecticut and Massachusetts and southern Vermont shortly after midnight, reaching the Connecticut valley at 2^h, Rhode Island to the upper Merrimack valley between 8^h and 9^h, Boston about $9^h.30$, Salem and Newburyport at 10^h, Cape Ann at $10^h.30$, Provincetown at 11^h, and appearing later on the Maine coast. This gives an east-northeast progression of ten or twelve miles an hour. The storm may have increased in intensity from central Massachusetts, where several good observers made no report, to the eastern part of the State, where reports are numerous, and where many stations measured two or three inches of rain. The wind was not noticeably affected by the rain; it was strong southeast, with heavier gusts during the storm, and soon fell off to gentle southwest as the sky cleared. The temperature was rising in eastern Massachusetts before the heavy rain, and fell five or ten degrees during its continuance. As the storm passed away, the temperature rose rapidly, and the mean maximum of the day was 84°. This storm was therefore quite unusual in separating a period of cooler from a period of warmer weather.

A second storm was felt in Vermont in the late afternoon and evening, possibly derived from an afternoon storm in New York State; its lightning was seen in eastern Massachusetts. Many observers also report heat-lightning in the southeast at 20^h to 22^h, but we have no direct record of the storm from which it came except that the observer at Provincetown saw a bank of low clouds out over the ocean at these hours, with frequent and brilliant flashes of lightning.

Aug. 5. A warm day, with southwest winds drawn towards the low pressure centre, now north of the Gulf of St. Lawrence. A thunder-storm came down the Mohawk valley shortly after noon, crossed the Hudson at Albany at $14^h.25$, traversed northern Massachusetts and southern Vermont and New Hampshire during the afternoon, moving eastward at about 27 miles an hour, and reaching the sea-coast about $19^h.40$, at the mouth of the Merrimack; its rain-fall was not heavy, although the lightning was active and the out-blowing wind was tolerably well marked in advance of the storm. A similar storm traversed southern Massachusetts, Connecticut, and Rhode Island at the same rate about an hour behind the first one; its clouds were heavy, the lightning was brilliant and struck in several places, and the change from warm southwest to cool, brisk northwest winds was generally distinct. The rain was heavy, but brief, until it decreased and nearly disappeared on reaching Massachusetts Bay, about $20^h.30$.

Aug. 6–11. This period was relatively cool and free from thunderstorms, with the exception of a light shower on the 11th, corresponding to a distinct rise in temperature on that date. The time was chiefly occupied with the passage of high pressures with low gradients, except on the 10th, when a vague depression, with very faint gradients on its western side, passed over Canada. The shower of the 11th seems to be connected with the warm southerly winds on the northwestern side of a high pressure area.

Aug. 12–14. Following the high pressure above named, there came a low pressure centre over Lake Superior on the 12th, that moved eastward and became better developed on the 13th. From the 6th to the 10th, the temperature was moderate (mean max. 74–79°); from the 11th to the 14th, it became distinctly warmer (mean max. 84–86°). On the 12th, there were ten reports that seem to belong to a sharp local storm moving from southwest to northeast across southern New Hampshire from 15^h to 17^h or 18^h, with moderate rain and west or southwest squall. The morning of the 13th was generally cloudy, close and oppressive, — "dog-day weather." About noon, several local showers with southerly winds were reported in southern New England, but, as a rule, not near the coast; in central New Hampshire near the mountains the rain was heavier. Later in the day, a shower or series of showers stretched from southwest to northeast over Connecticut and central Massachusetts, and moved obliquely to the east-northeast; at this time the lower clouds came from the south, and the upper from the west. Rain was recorded at several stations without thunder, and seemed generally without the characteristics of a thunder-storm; the day would have been called showery rather than stormy. On the morning of the 14th, the low pressure centre stood over the lower St.

Lawrence, and it was not till after a high temperature had been reached with southerly winds (mean max. 86°) that the cooler northwesterly winds appeared. It is rather curious to note that this change was not accompanied by distinct storms, for only six reports came in for this day, and of these only one (from Mayfield, Me.) describes a storm of any violence.

Aug. 15–17. There were no reports received for this cool period of high pressures and fine weather.

Aug. 18. During the approach of the succeeding area of low pressure and consequent rise of temperature under southwesterly winds, there came another period of storms. Several showers were felt on the 18th. A small one occurred in southern Rhode Island and Massachusetts about sunrise. A much larger one arrived in northwestern Massachusetts about 16^h, and moved southeastward, at a rate of 20 to 30 miles an hour, into Rhode Island at 20^h; its rain was rather heavy, and the lightning severe at several places, and there was generally a change from moderate southerly to gusty westerly winds as the storm approached. A third and less defined storm passed over nearly the same district in the evening. At this time, the low pressure area was central in Canada north of Montreal.

Aug. 19. Under the influence of the same low pressure area, which moved slowly northeastward, a high temperature was maintained into the 19th, and the day began with a storm that came from New York a little after midnight. It was felt as a heavy rain at Albany about one A. M.; a few reports at early morning hours in Massachusetts and Connecticut probably refer to the same storm, and at $5–6^h$ it passed over Rhode Island. This would make its velocity and direction about the same as those of the storm the afternoon before, but this conclusion is not very securely based. In the afternoon, several showers occurred in Vermont, New Hampshire, and Maine, but they cannot be safely traced, owing to the want of sufficient observers. At about the same time, a storm of some strength passed over Connecticut and Rhode Island, moving east-southeast about 30 miles an hour. It entered northwestern Connecticut about $15^h.30$, with dark clouds, a brisk to high squall from the northwest, followed by heavy rain and some hail. At Norfolk, the temperature fell from 75° to 57° in an hour, and 0.87 of an inch of rain was collected in eighty minutes. But this degree of strength was not long continued, and in Rhode Island the storm faded away between 18^h and 19^h.

Aug. 20, 21. During the passage of an area of high pressure, the maximum temperature fell ten degrees below that of the preceding period, and no storms * are recorded till late in the evening of the 21st.

Aug. 22. A low pressure area moved eastward north of Lake Huron on the afternoon of the 21st, and crossed over Canada in the night, its centre passing well to the north of the St. Lawrence. Several interesting storms occurred in connection with it. The first was the outgrowth of showers that began in the evening of the 21st, with southerly winds. At a number of stations, the rain began some time before thunder was heard, but increased greatly in amount when the thunder-storm was passing. Our first records are at 22^h on the evening of the 21st, from Burlington, Vt.; then come a number of midnight or early morning records from southern Vermont, New Hampshire, and western Maine; at 3^h to 4^h, the storm had reached central Massachusetts and southeastern New Hampshire; about 5^h, it extended along the coast from Boston towards Cape Ann, and lightning was reported in the north from Provincetown at 6^h. Southern New England did not feel this storm. It may therefore be concluded that its motion was easterly, and at a rate of about 35 miles an hour, while its front stretched obliquely from southwest to northeast. Although occurring at hours inconvenient for observation, it attracted much attention from the loud and frequent peals of thunder accompanying its vivid lightning flashes, from its heavy rain, and in several places from the violent wind-squall from the northwest that accompanied it. A remarkable number of destructive lightning strokes appear on the records, and hail was reported from Lowell and Magnolia, Mass. The observer at Longmeadow, Mass., reported "low clouds flying up from the south" just before the rain began, while the body of the storm passed eastward to the north of him.

The rest of the 22d was showery and sultry; several showers passed without thunder, but there were three distinct small thunder-storms among them. The first began somewhere east of the Connecticut River, and moved eastward along the northern boundary of Massachusetts over Newburyport between 7^h and 10^h, with a velocity roughly estimated at 30 miles an hour. It was of short duration and covered a narrow path, but the times of rain beginning imply an oblique attitude of the rain-front, like that of the previous larger storm. Its rain was heavy, though brief, and its lightning struck in several places;

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* Two reports for the 20th are almost certainly misdated for the 19th, with whose storms they agree very well; and one report, dated 1 A. M. Aug. 21, pretty surely belongs twenty-four hours later.

notably at Wenham, Mass., five miles or more south of the rain area indicated by the records. The second storm began in central Massachusetts a little before noon, moved 30 to 35 miles an hour a little south of east, passing Boston at $12^h.30$, Plymouth at $13^h.40$, and Provincetown at $14^h.10$; like the preceding storm, its rain was brief and heavy, with a well-marked northwest or west squall, and at Plymouth there was some hail at $13^h.45$. The oblique position of the storm-axis with respect to its motion, as indicated by the times of rain beginning, is in this case directly confirmed by the record from Provincetown, where the storm-cloud was described as about three times as long as it was wide, with its longer axis standing west to east, while it moved to the southeast "with a sidewise drifting motion." The third shower was a very mild one, beginning a little west of northern Rhode Island about $13^h.30$, and crossing southeastern Massachusetts between 15^h and 16^h.

August 23. No reports were received for this day; the distribution of pressure gave gentle northward gradients, without any centre of low pressure being visible.

August 24. On this day the gradients to the northeast were better defined, between an area of high pressure on the Southern States and a centre of low pressure that moved across the northern part of the Gulf of St. Lawrence. A rather remarkable series of storms occurred in the afternoon, as these conditions gave way before the approach of a tropical cyclone, whose centre lay off the coast of Georgia on the morning of the 25th. The morning was fair; soon after noon showers entered western Connecticut and Massachusetts, of moderate intensity at first, but gathering strength notably in two cases as they advanced eastward. In Connecticut, the separate showers were so numerous that they cannot be very satisfactorily traced. The first one traversed the State from northwest to southeast corner, at a rate of twenty miles or more an hour; it had heavy rain, some hail, and a strong northwest squall at Norwich and on the border of Rhode Island. In this and some of the later showers there were many lightning strokes. In northern Massachusetts, a storm gathered east of the Connecticut Valley about 14^h and became very violent on the shore between Boston and Cape Ann about $16^h.30$; the rain, wind-squall, and lightning were all exceedingly strong as this storm ran off the coast to the east-southeast. Again, a storm that was described only as a shower in central Rhode Island about 16^h, became very energetic about New Bedford at 18^h. In the evening, the winds that had been southwesterly, bringing high temperatures (mean max. 82°), changed to northeasterly, and later at night rain began, continuing into the next day (August 25); this was evidently the approaching rain area of the cyclone on the southern coast.

August 25–30. The 25th was a cool day of northeast rain without thunder, the centre of low pressure being on the southern coast; and with the coming of this cool general storm the more continuous hot weather of summer was ended (mean max. from Aug. 25 to 30 not over 70°), and thunder-storms were practically over for the season. No thunder was reported during this period.

August 31. Eight scattering reports on this day, when a faint barometric depression with weak gradients stood in the north, close the records of the three summer months.

From the large mass of material collected, the records for July 9th and July 21st have been chosen for fuller discussion.

Storm of July 9th. — The large number of reports received for this date, and the violence of the storm described in many of them, justify its special description. Its rain was generally heavy, though not great in amount, on account of its rather short duration; its winds were often destructive, and at two places, Kent's Hill, Me., and West Brookfield, Mass., they developed into distinct tornadoes, with the funnel cloud and its dangerous accompaniments. We have here, as on all other dates, greatly to regret the absence of reports from northern New England; they are so few that it is impossible to trace the storm across northern Vermont and New Hampshire with much confidence; but farther south its attitude is defined with considerable accuracy, as shown in Figure 4. Our earliest records come from Burlington and Charlotte, Vt., on the eastern shore of Lake Champlain, where the storm was felt about 13^h. At 15^h it stretched northeastward from southern Vermont to the angle of the Androscoggin River in Maine, and at this hour there appeared to be a division of the storm by an east and west line a little north of Concord, N. H.; the northern portion being somewhat in advance of the southern. The S. W. to N. E. attitude of the front was maintained with tolerable regularity, but the rate of advance seems to diminish as the storm faded away after sunset on nearing the southeastern coast; on the coast itself several stations report "no rain."

Although the front of the storm extended from southwest to northeast, there is good reason for not giving it a direction of advance at right angles to this line; many observers described its motion as from west to east; and the crowding of the lines representing the successive attitudes of the rain-front where they trend east-northeast, as in

Connecticut and Rhode Island, compared with the greater distance between them where they turn more to the north, suggests an advance oblique with the front of the storm. Taking east by south as its direction of motion, we find an average velocity from southern Vermont to Cape Cod of about thirty-seven miles an hour; but if the quarter-hour front-lines are to be trusted, this rate varied from over fifty in southern New Hampshire down to about twenty on Cape Ann, Mass.

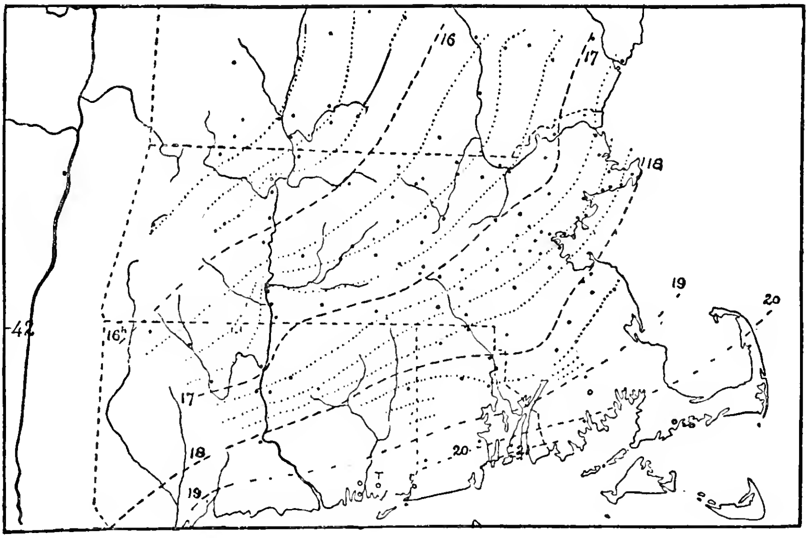

Fig. 4.

The frequent mention of the storm's dividing as it approached an observer is not fully explained by the observations thus far gathered. It probably means that the intensity of the storm varied along the front line, and varied again as the storm advanced; future observations must decide this. The individuality of the storm was, on the whole, well preserved: certain features were observed with considerable uniformity at a good number of widely separated stations, and if the observers had all been equally watchful, the record of this uniformity would doubtless have been much increased. To illustrate this statement, the following extracts are made from the records, as far as possible in the observer's words.

Clouds before the Rain. — The high, forerunning *cirro-stratus* overflow was observed well at several stations; it is of especial interest in connection with the theory of storms, and its first appearance on hot summer days, its gradual extension, and the motion of its filaments as compared with that of lower clouds, deserve careful watching. The rise of the *cumuli*, or "thunder-head" clouds, should be noted also, and their angular attitude and apparent direction of motion recorded several times.

Northfield, Mass.: Thinnest high clouds had passed zenith before 14.08; black bank of *cumuli* in N. W. at 14.50; rain about 15.40. Greenfield, Mass.: Clouds gathering rapidly at 14.00; rain at 15.50. Athol, Mass.: Clouds rising in N. and N. W. at 13.00; rain at 16.01. Deerfield Centre, N. H.: A little cloud in W. at 14.00; large black cloud in W. at 14.30; "clouds overhead," 14.55; rain at 16.20. Manchester, N. H.: Clouding up for three hours before rain began at 16.22. Tyngsborough, Mass.: Thin *cirrus* clouds rising in S. W. and N. W. at 15.00; *cumulo-stratus* low in west at 15.50; the *cirrus* covers eight-tenths of sky at 16.10, and top of *cumulo-stratus* estimated 20° above horizon; at 16.30, 60° over horizon; at 16.37, edge overhead; at 16·39 rain began.* Hartford, Ct.: Western sky hazy at 14.00, temperature 93°+, with brisk southerly wind; a few light *cumuli* floated rapidly from S. W. to N. E., and a bank of *cirro-stratus* was seen low in the N. W.; at 15.15 the bank had risen somewhat, and *cumuli* were seen beneath it; at 16.30 *cumuli* could be seen rising from the *cirrus;* thunder was then heard and the sun was soon obscured. Clouds were rising in the west, but the storm seemed to be passing from S. W. to N. E. At 17.00 the storm seemed to approach the city, and at 17.23 the rain began and the wind veered from S. W. to N., blowing brisk; later, the wind turned to E.; plentiful large hail-stones and destructive wind were reported a few miles east. Coventry, Ct.: Heavy clouds in N. W. at 15.30; rain at 17.30. Lynn, Mass.: "Edge of storm overhead" at 16.00; rain at 17.30. Chelsea, Mass.: Hazy clouds in W. at 12.30; heavy clouds in W. at 16.30; sky half covered at 17.10; rain at 17.32. Swampscott, Mass.: Heavy clouds rising in W. at 15.30; heavy shower in W. at 16.00; destructive N. W. squall at 17.25; rain

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* By means of these observations of altitude, it is possible to determine the height of the clouds, when the velocity of the storm's progress is known. In this case, the velocity was about forty-eight miles an hour for this part of the storm; and a simple construction then gives the heights as about eight and nine miles, at the times of the two observations. These, however, are not, even in spite of their good agreement, sufficiently accurate or certain to base much argument upon; but they serve well to show how easily observations may be made that will lead to most interesting results.

at 17.35, in torrents at 17.40. Beverly Farms, Mass.: S. W. breeze and small black cloud in W. at 15.00; cloud grew till it extended along W. and N. horizon; at 17.00 thunder-clouds moved rapidly towards S. E.; at 17.10, edge of cloud in zenith, wind suddenly lulled, but a furious W. squall came up at 17.15; rain began at 17.35, and from 17.45 to 18.00 the rain poured in torrents. Quincy, Mass.: Clouds first seen in N. W. at 15.35; high N. W. wind at 17.32; rain at 17.49. Bar Harbor, Me.: Dark cloud in N. W. at 15.30; clouds darker and a heavy squall at 16.00; heaviest wind at 17.30; rain began 17.50. N. Attleborough, Mass.: Thunder-caps just visible over N. W. horizon at 14.30; "edge of cloud overhead" at 16.55; rain began at 17.55. Taunton, Mass.: A stratum of hazy clouds in N. W. at 13.00; rising higher at 14.00; a lower stratum appears at 15.00; rain at 18.05. S. Weymouth, Mass.: Clouds rising in N. W. and thunder heard from them at 16.15; rain at 18.15. N. Marshfield, Mass.: Heavy clouds in N. W. at 16.45; rain at 18.15.

It appears from this summary that the *cirrus* overflow was often seen two or three hours before the rain began; its edge passed the observer's zenith from an hour to an hour and a half ahead of the rain, and therefore probably extended thirty to fifty miles in advance of the main mass of the storm *cumulus*. The thunder-clouds themselves were often visible an hour or more before the rain fell. The edge of the heavy cloud generally passed the observer's zenith three to twelve minutes before, that is, two to six miles ahead of, the rain-front; at several southeastern stations, where the storm's intensity (and velocity?) had decreased, this interval was over half an hour. At one station (Gilmanton, N. H.) the rain began fifteen minutes before the edge of the cloud passed overhead; and this was, as the observer well remarks, the more surprising, as no high wind occurred with the storm there.

The occurrence of "pocky" or "festoon" clouds (smooth masses hanging from the under surface of broad *cirro-stratus*, convex downwards, like inverted *cumulus* clouds) is indicated by the following: "Rockland, Mass.: The setting sun was shining upon the under retreating edge of the storm-cloud and showing all the irregularities of its usually smooth under surface, — a very pleasing sight." These clouds are of relatively rare occurrence; they seem to be formed most commonly in connection with thunder-storms, and they should be carefully noted. The squall cloud is described in the account of the wind.

TABLE II.

Relation of Wind and Rain: Storm of July 9, 1885.

Station.	Wind. 0 — 5.	Time.	Duration.	Rain. Inches.	Time.	Amt per hour.	Remarks.
Burlington, Vt.	S. 4	13.00	—	0.46	12.45-13.30	0.61	Much damage.
Bridgton, Me.	— 4	—	—	0.37	15.00-17.00	0.18	" "
Chesterfield, N. H.	N.W. 4	15.20	20	$\frac{5}{8}$	15.18-15.55	1+	" "
Brattleboro', Vt.	N.W. 3	15.12	20	0.45	15.21-15.55	0.77	
Acworth, N. H.	N.W. 4	15.00	45?	Light.	15.30-16.20	—	Much damage.
Northfield, Ms.	N.W. 4+	15.35	10?	0.80	15.35?-16.16	1.18	Destructive.
Kent's Hill, Me.	W. 4	16 15	10?	$\frac{1}{8}$	15.40-16.25	$\frac{1}{6}$	Tornado near by.
Ashburnham, Ms.	N.W. 4	16.10	10	Mod.	16 13-17.05	—	Trees broken.
Allentown, N H.	W. 4	16.39	8	$\frac{1}{2}$	16.43-17.20	$\frac{2}{3}$	
Tyngsborough, Ms.	W.N.W. 4	16.37	6	Heavy.	16.43- —	—	
Lowell, Ms.	N.N.W. 3	16.45	15?	—	16.49-18 00	—	
Westford, Ms.	W.N.W. 4	16.43	15?	$\frac{3}{4}$	16.43 18.15	$\frac{1}{2}$	
Millville, Ms.	N.W. 4+	17.20	20?	$\frac{9}{16}$	17.35-18.15	$\frac{13}{16}$	Almost a tornado.
Beverly Farms, Ms.	W. 4+	17.15	30?	$\frac{2}{5}$	17.35-18.00	$\frac{3}{5}$	Furious squall.
Bar Harbor, Me.	N.W. 4	17.30	—	Light.	17.50-18 20	—	Very heavy squalls.
Providence, R. I.	N.W. 4	17.55	13	0.57	18.08-19.10	0.55	Almost a hurricane.
Rockland, Ms.	N.W. 4	17.43	15	Light.	18.00-18 05 18.21-19.05		

The most obvious relation of wind and rain is, that a brief heavy squall shortly precedes a heavy rain-fall; and this is so commonly stated to be the case that one is tempted to regard the first as the effect of the second. But the relation has two exceptions: first, as in the above table, where heavy winds occur with light rain, although in those cases heavy rain may have occurred near by; second, in other storms there is often heavy rain and no severe wind. More data are needed before attempting further generalization.

It has been stated that a ragged fringe of cloud always advances in the front of a storm that is accompanied by a squall.* The observations made at a number of stations seem to confirm this opinion. The following may be quoted: Northfield, Mass.: A bank of inky clouds rose from the N. W. bordered by a line of fog; a violent gale sprang up suddenly; soon after this, the line of fog passed the zenith, and the air was suddenly darkened. Amherst, Mass.: A scud of low black clouds was blown rapidly from N.W. at about the time of high N.W. wind; heavy rain soon after. Allenstown, N. H.: An arch of boiling scud before the heavy storm-clouds, followed shortly by violent W. wind, with rain whirling in sheets. Tyngsborough, Mass.: Air calm; high *cumuli*, "preceded by a ragged and turbulent gray squall-cloud"; seven minutes later, a heavy squall, air filled with dust, and "white caps"

* Hann, Beitrag zur Morphologie der Gewitterwolken. Zeitschrift für Meteorologie, 1880, xv. 434.

on Merrimack River. Ward Hill, Mass.: Black clouds rising, "with a swirling mass of light, smoky clouds along the whole length of the upper edge; at 16.45, the bank was overhead, stretching from N. E. to S.W., and rushing on with great speed"; about 17.00, a high S.W. wind. Lowell, Mass.: Dark clouds rising in N.W.; at 16.44, "a white, foamy, frothy cloud, considerably disturbed, seemed to be pushed or rolled rapidly along ahead of the black clouds, and came towards us fast from the N.W. and N."; as it passed overhead, the wind changed from S. to N. with sudden gusts at 16.45, and heavy rain at 16.49; a relatively clear space was noticed between the squall-cloud and the heavy black clouds that followed rapidly behind and above it. This observer describes the squall-cloud as rolling along, the upper part seeming to pass forward over the lower. Special attention is desired on this point. Haverhill, Mass.: at 16.50, an immense windrow of white clouds, extending from the W. to the N. horizon, came literally rolling along toward our city; behind it, a great area of black clouds with continuous lightning; very high, sudden wind, with moderate rain, at 17.00.

TABLE III.

CHANGE OF TEMPERATURE IN THE STORM OF JULY 9, 1885.

Station.	Before Rain.	Rain.	After Rain.	Change.
	° h.	h.	° h.	° m.
Pittsfield, Mass.	91 at 15.00	15.10	70 at 15.45	21 in 45
Athol, "	82 " 16.01	16.01	67 " 16.20	15 " 19
Belchertown, "	90 " 16.00	16.15	72 " 16.30	18 " 30
" "	95 " 15.00	16.15	70 " 17.00	25 " 120
Fitchburg, "	92 " 16.08	16.16	74 " 16.22	18 " 14
Gilbertville, "	90 " 16.00	16.28	68 " 16.50	22 " 50
" "	85 " 16.24	16.28	68 " 16.50	17 " 26
Monson, "	88 " 16.45	16.50	72 " 17.05	16 " 20
Worcester, "	88 " 16.49	16.51	73 " 17.02	15 " 13
" "	94 " 16.30	16.53	71 " 17.15	23 " 45
N. Grafton, "	88 " 16.53	16.58	74 " 17.06	14 " 13
Southbridge, "	85 " 17.00	17.05	68 " 17.15	17 " 15
Newton, "	81 " 17.18	17.18	72 " 17.30	9 " 12
Watertown, "	90 " 16 45	17.20	72 " 17.30	18 " 45

A rapid fall of temperature is thus shown to accompany the storm-front; its average rate is probably a degree in one to three minutes, but the most rapid change is much faster; the total value of the change ranges from ten to twenty or more degrees. The cause of the change is to be found in part in the protection from hot sunshine by the storm-clouds, but it is probably much more dependent on the low temperature of the cold rain and hail that have been condensed high up in the clouds and chill the air as they fall through it. The relation of amount and rate of rain-fall, temperature of rain (or hail), and change of air temperature, form an interesting subject for study.

We have two valuable automatic traces of the temperature curve in this storm from the Boston Water Works at Chestnut Hill, Mass., and the City Engineer's office at Providence, R. I. The first curve shows a rapid fall from 86° at 17.30 to 69° at 18.00, followed by a temperature at midnight a little warmer than that of the early evening. The second gives a fall from 86° to 74° during a few minutes before and after 18.00.

Barometric Changes in Storm of July 9. — The self-recording barometers (Draper's pattern) at Providence (City Engineer's office) and at the Blue Hill Meteorological Observatory were both affected by this storm in a similar way. The hundredths of an inch over twenty-nine inches are given in the following table for fifteen-minute intervals before and after the rain began.

TABLE IV.

Time.	Blue Hill.	Providence.
m.	in.	in.
120 before rain.	.085	.715
105 " "	.085	.715
90 " "	.090	.710
75 " "	.085	.700
60 " "	.080	.710
45 " "	.065	.715
30 " "	.080	.720
15 " "	.100	.785
Rain began.	.115	.800
15 after rain.	.130	.800
30 " "	.170	.825
45 " "	.155	.775
60 " "	.140	.745

From this it may be said that there was a slight fall of the barometer before the storm, followed by a rapid rise as the storm came on, and succeeded by a fall again as it passed away.

A composite portrait of this storm has been prepared similar to the one here figured in illustration of the squall of July 21 (Fig. 6); its size is too large to admit of reproduction. By means of a simple process of construction, all the observations of wind, temperature, rain, thunder, etc., are thrown in their proper relative positions with respect to the storm-front, so that a graphic average is obtained of the distribution of these elements in the whole storm. An hour and a half or an hour before the storm, clouds are seen rising on the western horizon, while the winds are light southerly, and the temperatures high (85–95°). Nearer the storm-front, the clouds are seen to rise higher, and the temperature falls slightly, but the wind does not change significantly. The first thunder is heard from thirty to sixty minutes, and the clouds are recorded as reaching the zenith or passing overhead from ten to thirty minutes, before the rain. The sudden change from gentle southerly wind to the northwest squall seldom comes more than fifteen minutes before the rain, and is generally only five to seven minutes before it; with this change the temperature falls rapidly. The squall seldom continues after the rain begins. The heaviest rain is marked close to the rain beginning in many cases; in others, it falls from seven to twenty-five minutes later. The loudest thunder runs from ten to thirty-five minutes after the rain-front, and the lightning strokes, as far as reported, fall with one exception between thirteen and twenty-seven minutes after the rain-front. Already at twenty to twenty-five minutes after the rain had begun, the western horizon is seen lighting up, and soon the clouds begin breaking away; their rear edge is overhead in an hour to an hour and a half, while the rain had ceased fifteen minutes sooner on the average, its shortest duration being thirty, and longest ninety minutes. During the rain, the temperature stood fifteen to twenty-five degrees lower than before the storm, and the winds were light and variable; as the storm passed over in the afternoon, an absolute rise of temperature after its passage is seldom seen, and then is faint; but a relative rise is clearly found in the maintenance of an almost uniform temperature past those hours when it ordinarily decreases most rapidly. Rainbows make their appearance between an hour and an hour and a half after the rain beginning, and the last thunder is heard from one to two hours after the storm began. We gain easily, from such a portrait as this, a general view of the storm that can be acquired only with much labor in other ways. As to the accuracy of the view, that can be greatly increased as our observers come to use more uniform methods in making their records.

Storms of July 21. — The thunder-squall that traversed southern New England on the morning of July 21 was in some respects the most interesting storm of the summer. The persistent maintenance of its several features throughout its whole path is especially instructive. It closely resembles squalls that have been described in Iowa by Hinrichs.

The squall entered New England at the western end of the Massachusetts-Connecticut boundary about 10.10 A.M. (See Fig. 5.) Before this it had been noted at Hensonville, Greene Co., N. Y., where the rain began at 9.22, with a strong N.W. gust of wind, in which the temperature fell ten degrees (81° to 71°) in two minutes; the storm seemed to pass centrally over the station, and its clouds were very black and angry. Still earlier observations were made in New York, as follows: Peterborough, Madison Co., loudest thunder at 7.22 in the south, with light rain at 7.45; Palermo, Oswego Co., storm to south with loudest thunder at 6.20; Constantia, Oswego Co., thunder first heard at 6.45, continuing for two hours. The last two reports

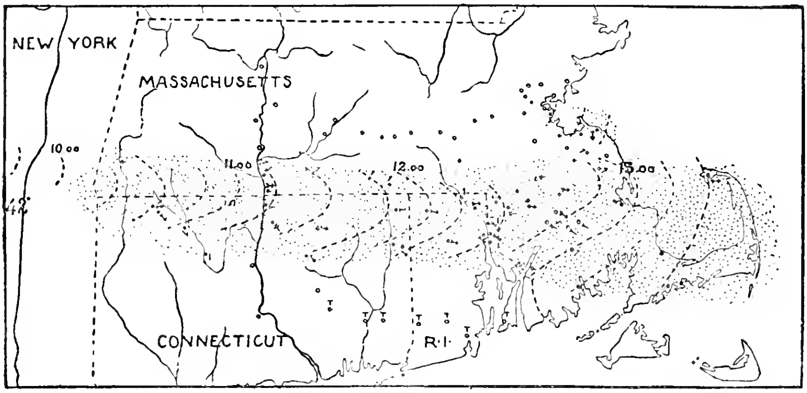

FIG. 5.

are furnished by Prof. H. A. Hazen, U. S. Signal Service, and are here mentioned with the rest to point out the probability that this storm either began at a very unusual morning hour, or else was a survival from some storm of the previous afternoon. That they refer to the squall here described admits of no question, as they correspond closely to the position that it would have at their several times, as deduced by backward projection from the New England observations. Returning now to our own records, we have Great Barrington, Mass., rain at 10.40 with heavy clouds and continuous thunder. West Norfolk, Ct., lt. rain 10.30. Norfolk, Ct., rain by three observers 10.35, 10.40, 10.40, heavier to N. with high N.W. wind at 10.40. Winsted, Ct., 10.33, clouds rising in N.; lt. rain at 11.08, with moderate N.W. wind; shower nearly out of sight at 11.35. Collinsville, Ct., black thunder-cloud to N. at 11.00, wind moderate S.W. shifting to brisk N. at 11.15, lt. rain at 11.25. Longmeadow, Mass., dark clouds rising in W. at

10.43, soon rising very fast, bringing a strong W.N.W. gust with clouds of dust and leaves at 11.10; considerable damage to hay, grain, and trees was done by this wind; rain began at 11.12, and about ¼ inch fell in 18 minutes; the storm was nearly out of sight in the E. at 12.00. Springfield, Mass., a heavy wind (no direction given) from 11.20 to 11.35 with a few drops of rain. Chicopee, Mass., lt. rain with W. wind about 11.10. Broad Brook, Ct., violent wind and dust storm just before noon. Monson, Mass., lt. rain at 11.30, with brisk S.W. wind at 11.35. Tolland, Ct., black clouds came up very fast, lt. rain and brisk W. wind at 11.35, more rain to N. Quarryville, Ct., rain at 11.45 with strong N.W. gust about noon. Southbridge, Mass., lt. rain at 11.45 with fitful gusts from S.W. Dudley, Mass., lt. rain at 11.55 with S.W. wind. Thompson, Ct., a shower came up very quickly from a little N. of W. about 11.45, violent but short-lived; rain-fall moderate; lightning struck a church spire. Danielsonville, Ct., lt. rain (no time given), but heavier to N., with thunder from 11.30 to 13.00. S. Killingly, Ct., rain with sudden heavy gust at 12.10.

The storm now enters Rhode Island. Pascoag, rain at 11.55, and high wind from W.N.W.; at 12.40, thunder-clouds receding in the east. N. Scituate, clouds passed the zenith at 12.15, lt. W. wind; sudden rain, heavy thunder and high W. wind at 12.19; rain over at 12.45. Woonsocket, rain and brisk S. wind at 12.20; rain in torrents at 12.22. Ashton, clouds rising rapidly in W., temp. 96°; rain at 12.25, and brisk W. wind at 12.30. Pawtucket, very violent N.W. squall and heavy rain at 12.27, temp. 94°; at 12.45, temp. 77°; at 12.58, rain over; lt. W. wind, temp. 84°, and dark clouds in E. and S.E.: second observer; very dark wild-looking clouds, moving rapidly from W. to E., rain in torrents with very high W. wind at 12.29½; at 13.00, sun shining hot. Providence, five observers: 1st, heavy wind-clouds in N. W. at 12.19; clouds passed zenith and moderate rain began with high N.W. wind at 12.27; clouds disappeared by 13.15: 2d, heavy clouds in W. and N.W. at 12.08; clouds at zenith at 12.13; high west wind at 12.26, rain at 12.28: 3d, temp. 93°, with moderate S.W. wind at 12.15, lt. rain at 12.28, high W.N.W. wind at 12.30, temp. 88°; at 12.45 temp. 77°: 4th, at 12.20 heavy gusty wind; brisk rain at 12.30: 5th, cumulo-stratus cloud rapidly forming in W. at 11.00; fresh W. S.W. wind, temp. 90° at 12.00; very strong dust squall at 12.27, and heavy rain at 12.30 with edge of storm overhead; temp. 74½° at 12.37. Silver Spring, edge of cloud overhead, with high W. wind at 12.30; very heavy W. N.W. squall at 12.34; moderate rain at 12.35; blue sky in W. at 12.49; rain ended, dark clouds in S. E. at 12.58.

The storm next enters southeastern Massachusetts, and at the same time extends northeastward suddenly. N. Attleboro', shower came up very quickly; at 12.00, temp. 98°; edge of cloud overhead at 12.20; lt. rain and very high W. gusts at 12.30; temp. 84°, 12.45. Attleboro', storm at its height with W. wind about 12.25. Norton, temp. before the storm 94°, the hottest of the season; about 11.00 clouds arose, wind S.; about 12.00 a dense black "fog" rose in the west; rain at 12.15; wind increased, with terrific lightning and thunder; at 12.20 the "gale" struck in full force, lasting 5 to 8 minutes, breaking down and uprooting trees; the track of the gale was about $\frac{3}{4}$ mile wide, extending from W.N.W. to E.S.E. Mansfield, smart shower about noon, house struck by lightning. Bridgewater, black clouds seen about 12.00; hurricane of dust and pouring rain about 12.45. N. Easton, heavy shower and destructive gale about noon. Raynham, rain at 12.15; high wind and hard rain at 12.30. Taunton, 1st, clouds rising in W. 12.20; moderate rain and high W. wind, 12.40; light in west, 12.50: 2d, storm came up quickly from N.W.; heavy rain and destructive S.W. wind, 12.50: 3d, lt. rain with very high W. wind at 12.55. Middleborough, damage by wind and lightning. Lakeville, brief destructive storm. Fall River, heavy rain in W. at 12.35, temp. 87°; high S.W. wind with a rush "like a squall contained in a large black cloud" at 12.55; lt. rain began at 12.57; blue sky in W., temp. 77°, at 13.15. Pembroke, rain and brisk S.W. wind at 12.42, temp. 92°; hard rain, 12.52; rain ceased, temp. 81°, 13.00; heavy black clouds in the S. Plymouth, high S.W. wind at 12.45; hard rain at 12.50; violent S.W. squall at 13.00; damage by wind and lightning. E. Freetown, a brief shower with light rain beginning at 13.04, came up very quickly. Long Plain, tree struck by lightning. New Bedford, shower heavier to N.; lt. rain at 13.15. Cotuit, brief shower at about 13.30. Osterville, heavy clouds in N. at 13.00; lt. rain with no wind at 13.50; clear in W. at 14.00. Provincetown, lt. rain at 13.31; high W.S.W. wind at 13.37; clouds moved from W.N.W.; clearing at 14.00. Adjacent stations reporting "no rain" or "distant thunder" are shown in Figure 5.

These extracts are given as nearly as possible in the words of the observers; they embody but a small part of the observations recorded, but represent all the stations from which definite statements have been received. They are given here, not only to illustrate the character of the reports that have been made, but also to show in detail, for one storm at least, the facts on which the generalizations as to form, path, and velocity are based. The importance of accurate time records is especially evident in a fast moving storm like this one, where the velocity was almost a mile in a minute: an inaccuracy of ten, or even of five minutes, would cause a considerable error in drawing the storm-front curve. The incompleteness of records is especially to be regretted; for example, at Springfield two observers failed to make any report, and the brief statement for that station is taken from the regular record of the observer of rain-fall, who reports for our monthly Bulletin. Hartford makes no mention of the storm, although it must have passed within sight, if not within ear-shot. A number of stations in central Rhode Island were also silent. Besides this, the occurrence of considerable stretches of country from which we have no records is especially unfortunate. Although the number of reports is considerable, there are certain districts where they are lamentably insufficient, and, in constructing the maps to illustrate this storm, one has continually to regret the lack of observers in numerous good-sized towns situated directly in the path of the squall.

Figure 5 represents the path and progress of this storm, as determined by charting all the observations collected. Stations where rain was noted are marked by a black dot. The curved dotted lines show the supposed attitude of the rain-front for every quarter-hour. Arrows indicate the velocity and direction of wind accompanying the rain. A number of valuable negative records, such as "no rain" or "distant thunder" while the storm was passing, are represented by small circles, with T on the side from which thunder was heard. As thus determined, the average velocity of the storm's progress is forty-eight miles an hour; its path lay a little south of east; it seems to have run faster in eastern Connecticut, and on entering southeastern Massachusetts it suddenly extended to the northeast. Besides the larger storm of the afternoon, three others were observed on the morning of this day; one in southeastern New Hampshire and northeastern Massachusetts; another to the southeast of Boston, which may have united with the principal squall out at sea; but while on land they were distinct, as is proved by the three "no rain" stations between them; the third was a small storm in southern Rhode Island, about 13.00 to 14.00 hours. Returning again to the chief storm of the morning, we find that in southeastern Massachusetts the scanty time records do not suffice to define the storm-front, which there seems to become irregular; but elsewhere the storm was strongly convex to the east, with its most violent action in rain, wind, and lightning at the apex of the curve. All observers agree that the storm came and passed away quickly; the rain-fall seldom measured over a quarter of an inch, but the fall was often heavy in its brief duration. The radially outblowing wind, of destructive strength, at and a little south of the apex of the storm-curve, was an invariable accompaniment of the storm for at least two hundred miles along its path. It was doubtless felt before the storm reached Hensonville, and after it crossed Massachusetts Bay and ran out to sea beyond Cape Cod; it would be interesting to obtain a record of it in these at present unknown parts of its path, to see how nearly they would fall in with the observations here charted. A rapid fall of temperature accompanied the fall of the rain, as will be further shown below. The Catskill Mountains, over 2,500 feet high, the Hudson valley, the mountains of western Connecticut and Massachusetts, with summits up to 2,500 feet, and the Connecticut valley, were all traversed by the storm, without exerting any definite effect on its course or velocity. Whatever the mechanism of the storm may be, it is evident that it is at work chiefly at a considerable altitude, and that it is borne along by the general winds in which it is engendered, while only its more remote effects reach the ground.

A "composite portrait" of the surface effects of this storm is presented in Figure 6. It is constructed by throwing all the observations (except certain ones in S. E. Mass.) into their proper place with respect to the rain-front and middle-path.* The spaces between the curved lines represent intervals of fifteen minutes before or after the time of rain-beginning, and hence correspond to a distance of about twelve miles, as the velocity of the storm was forty-eight miles an hour. All observations of a single station fall on a line to one side of and parallel to the middle-path, and at their appropriate interval before or after the rain-front. The temperatures are given by numbers, showing degrees Fahrenheit. The winds are marked by arrows whose feathers increase with their velocity; arrows without barbs represent winds when force but not direction was given. The first, loudest, and last thunder are indicated by T_1, **T**, and T_0. A few lightning strokes are marked by L. The condition of the sky is roughly shown by black or white crescents, which mean clouds or clear sky in the direction of their convex curve. The duration of the rain is marked by black lines. The portrait as thus constructed therefore gives a graphic generalization of the average relations among all these features of the storm.† In this case the material is insufficient for a wholly satisfactory diagram; but a good purpose is served in

* See Proceedings of the American Academy, 1885–86, xxi. 346.

† Figures 5 and 6 are reprints from *Science*, May 14, 1886.

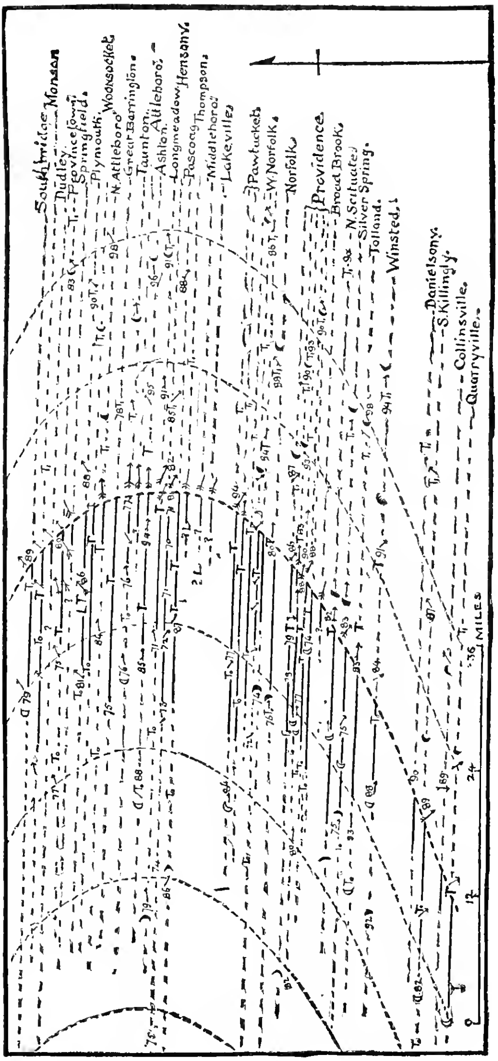
Southbridge
Monson
Dudley
Provincetown
Springfield
Plymouth
Woonsocket
N. Attleboro
Great Barrington
Taunton
Attleboro
Ashton
Longmeadow
Henson
Pascoag
Thompson
Middleboro
Lakeville
Pawtucket
W. Norfolk
Norfolk
Providence
Broad Brook
N. Scituate
Silver Spring
Tolland
Winsted
Danielson
S. Killingly
Collinsville
Quarryville
MILES

FIG. 6.

bringing all the data together in a convenient shape for further examination. The errors of the method consist in the assumption of uniform shape of the storm-front, and a uniform velocity of progression; but I do not think they are serious in this case. The convexity of the storm-front is perhaps too great, but that it was really well bowed forward is shown by the late arrival of the rain at the lateral, as compared with the central stations. The concavity of the rear of the rain area is not so well established, but it seems to have approached a parallelism to the front.

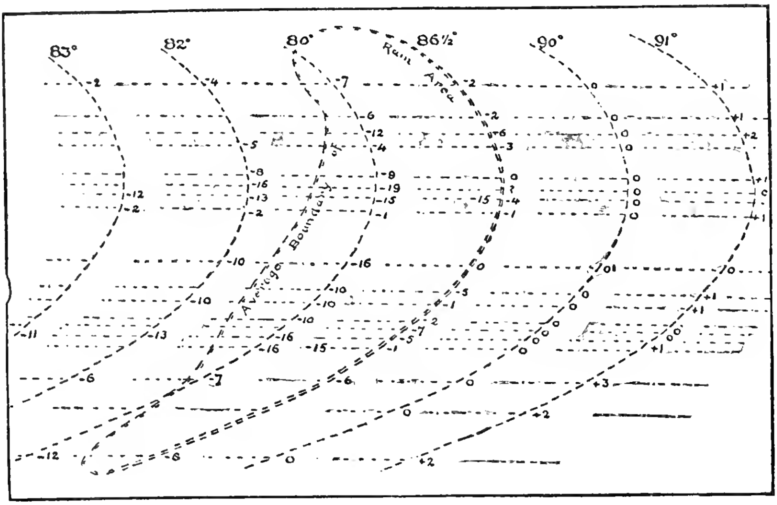

Fig. 7.

The changes of temperature with the passage of the storm are well determined. For their better illustration I have prepared Fig. 7, as follows: by interpolation, an approximate temperature was determined for a number of stations at the several fifteen-minute lines of Fig. 6; then, taking the temperatures at fifteen minutes before the rain as standards, the departure from them was determined for the other times, and these plus and minus numbers are exhibited in Fig. 7. Averaging the departures and the observed temperatures on every time line gives the following results: —

Interval.	Departures.	Mean Temperatures
30 min. before rain.	+ 1°	91°
15 " " "	0	90
Rain begins.	— 3½	86½
15 min. after rain.	—10	80
30 " " "	— 8	82
45 " " "	— 7	83

There is some indication that the greater changes of temperature are near the apex of the curve, as would be expected. We are fortunate in having two records close to the apex that show the greater part of the temperature fall to have been very sudden; one is at Hensonville, N. Y., as follows: —

Time	9.13	9.20	9.25	9.27	9.30	9.35	9.40	9.50	10.8	13.30
Temperature	85°	82°	81°	71°	70°	71°	72°	73°	74°	92°
Wind	—	—	Strong.	—	—	—	Light.	V. light.	—	—

The second is from the City Engineer's office, Providence, R. I., where a self-recording thermometer (pattern of Richard Frères) gives a curve showing a fall of 13° in thirty minutes, the greater part of the change being accomplished in a small fraction of this time. A second fall at 16.35 was caused by the large afternoon storm of this date. From the same source we have the automatic record of a Draper's mercurial barometer, showing the abrupt increase of pressure characteristic of thunder-storms, from 12.33 to 12.40 the pressure rising from 29.695 to 29.730; and also an automatic wind record, showing the sudden wind-squall at Hope Reservoir, Providence, blowing at a rate of three miles in the five minutes from 12.33 to 12.38; before and after the squall, the velocity was ten to twelve miles an hour. Another barometric record, from a Richard Frères aneroid, was obtained from Plymouth, exhibiting an abrupt rise of one millimeter = 0.04 inch at a few minutes after 13.00. It is greatly to be hoped that self-registering instruments — especially barometers — may be more generally kept at our stations: considering the great value of their records, their cost is not relatively high. Detailed observations of the clouds of this storm were so few that no generalizations can be made from them.

The afternoon storm of July 21 (Fig. 8) came from New York, crossing the Hudson mostly below Albany. The temperature in New England had risen over 90°, with southwesterly winds, in many places after the passage of the noon squall; the heat became very oppressive before the larger storm arrived. The thin front of the high cirro-stratus was visible in the northwest at least three hours before the rain began, and as it obscured the sun the temperature fell slowly. The front edge of the lower clouds stretched S.W. to N.E. in Connecticut, where the short-lived squall-wind attained a destructive strength, and was accompanied with hail at a number of points; but, unfortunately, our observers there were few, and many records had to be gathered simply from the current reports of the newspapers.

New Britain, Willimantic, and New London all had a violent storm, and a belt of destructive hail fell between Middletown and Colchester. In Massachusetts the storm was brief, but rather violent around Worcester, where numerous lightning strokes were reported; but the distribution of these strokes, as well as of the hail, is not based on sufficiently uniform reports to serve as the ground of any general statements. On Blue Hill the wind was very violent for a short time, but elsewhere in eastern Massachusetts it was generally of moderate severity. The backward turn of the rain-front in Massachusetts began too far inland to be attributed to the effect of the ocean; it is rather to be regarded as the ordinary lagging behind of the side of

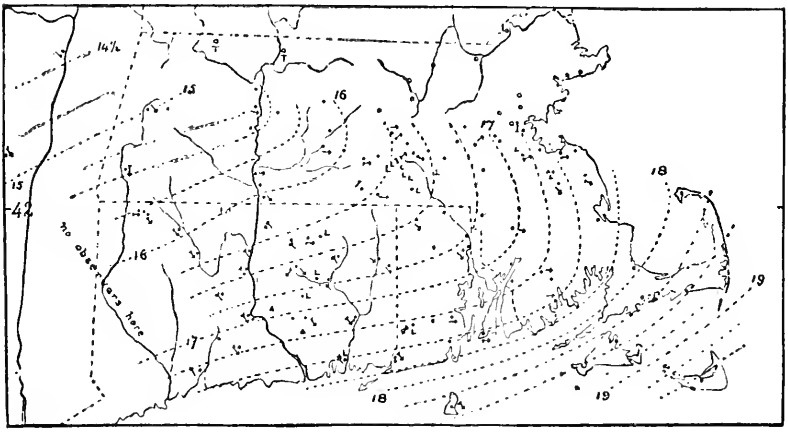

Fig. 8.

the storm. The wind-squall at a number of the marginal stations turned from its general northwest direction, and blew out from the side of the storm to the northeast or north. The observations off shore, on Block Island, Martha's Vineyard, and Nantucket, and at Provincetown, accord tolerably well with the advance of the storm as determined on land; and Provincetown reported seeing lightning in the east till late in the evening.

The storm seems to have advanced to the east-southeast at an average rate of forty-three miles an hour. Like the storm of the morning it is peculiar in approaching the sea-coast with hardly diminished severity.

Review.—In view of the many questions that still remain unsettled, it does not seem safe to enter yet very far on the interesting task of generalizing the results obtained; but a brief statement may be allowed in review of the foregoing pages.

Table V. gives the hours of "loudest thunder" for June, July, and August, 1885, and their percentages; also the totals for the three months. Owing to the growth in the number of observers through June, and the omission of a number of reports not adapted to being counted here, the table cannot be taken as giving a precise view of the relative frequency of storms in the three summer months; and, again, on account of the smaller number of observers who record the storms that occur at inconvenient hours, the percentages of night observations are probably below their true figures. Nevertheless, the general distribution of storm occurrence is clearly made out.

TABLE V. — HOURS OF "LOUDEST THUNDER."

Hours.	June.		July.		August.		Total.	
	Obs.	%	Obs.	%	Obs.	%	Obs.	%
A. M. 0–1	1	0.18	3	0.35	3	0.51	7	0.35
1–2	0	0.00	3	0.35	10	1.70	13	0.65
2–3	5	0.91	3	0.35	8	1.36	16	0.80
3–4	11	2.00	5	0.58	9	1.50	25	1.25
4–5	27	4.90	5	0.58	10	1.70	42	2.10
5–6	47	8.64	3	0.35	16	2.72	66	3.30
6–7	1	0.18	4	0.47	5	0.85	10	0.50
7–8	4	0.73	5	0.58	12	2.04	21	1.05
8–9	8	1.45	12	1.39	27	4.50	47	2.34
9–10	18	3.27	5	0.58	18	3.00	41	2.05
10–11	7	1.27	11	1.28	13	2.21	31	1.55
11–12	8	1.45	26	3.02	3	0.51	37	1.85
P.M. 12–13	16	2.90	69	8.12	16	2.72	101	5.04
13–14	49	8.88	57	6.61	22	3.74	128	6.39
14–15	129	23.41	68	7.89	24	4.08	221	11.04
15–16	106	19.06	130	15.08	38	6.46	274	13.69
16–17	38	6.90	164	19.02	79	13.43	281	14.04
17–18	56	10.34	153	17.75	101	17.17	310	15.48
18–19	8	1.45	78	9.05	79	13.43	165	8.24
19–20	2	0.36	37	4.29	47	7.92	86	4.30
20–21	3	0.54	14	1.62	33	5.61	50	2.50
21–22	1	0.18	6	0.70	12	2.04	19	0.95
22–23	5	0.91	0	0.00	3	0.51	8	0.40
23–24	1	0.18	1	0.12	1	0.17	3	0.15
	551	100.10	862	100.13	589	99.88	2,002	100.01

The excess in the later afternoon hours appears distinctly enough. But the time of greatest frequency does not depend simply on the hour of the day. If we take, on the one hand, southern Vermont, southwestern New Hampshire, western Massachusetts, and western Connecticut as a western group of areas, and, on the other hand, eastern and south-eastern Massachusetts and Rhode Island,* as an eastern group, the hours of maximum percentages come out as follows: —

Area.	June	July.	August.	Mean.
Western,	13–15	15–16	16–17	15–16
Eastern,	14–16	18–19	18–20	18–19

This clearly implies that distance from some at present unknown starting-point exerts a decided influence on the hour of maximum storm frequency; or, in other words, that most of our New England storms come to us ready made from a source where they begin at a rather uniform hour of the day. Another season's work may perhaps determine where our storms begin. The importance of this question in the attempt to predict thunder-storms is evident. In Bavaria, Von Bezold finds a second faint maximum in the early morning hours, and attributes it to the arrival of storms from a source more distant than that which furnishes the more numerous ones of the afternoon. Our faint secondary maximum, at five to six o'clock in the morning, may have a similar meaning; but the question cannot be decided from the observations of a single season, when one or two storms would exert a strong effect on the total percentage.

A brief examination of the "general account" suffices to show that, while the summer storms there recorded are much more frequent than they are in the winter months, still they are not at all uniformly distributed through the summer season: they appear in greater number and size for a few days, and then are almost or quite absent for a time. The cause of this seems to be found in their dependence on the larger disturbances in the atmospheric circulation, for which I should wish to use the name of "cyclonic storms" (following Piddington, Redfield, Ferrel, and many European writers), but which are perhaps more generally known by the phrase "areas of low pressure," as used in the Signal Service publications, or as "barometric minima" in Germany. It is as a rule only when we stand in a certain attitude with respect to the centre of these low pressure areas that large and well-developed thunder-storms appear. It may therefore be concluded that the development of such storms depends, not only on the heat of the summer afternoons, but also on the equilibrium of the atmosphere as determined by the

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* Fourteen reports of the squall of July 21, falling between 12^h and 13^h, are omitted in this count.

circulation of cyclonic winds.* The greatest number of our summer thunder-storms occur when a centre of low pressure lies to the north or northeast of us. But there are also examples of storms occurring in areas of high or equable pressure, as on August 1st; these would seem to correspond to the *Wärme-Gewitter* of Mohn, and to depend on a local warming of the lower air sufficient to bring about the unstable equilibrium that in the other cases (*Wirbel-Gewitter*) depends on the arrangement of upper and lower currents in the cyclonic circulation. A more peculiar exception to the general rule of occurrence is found on certain dates when a well-developed low pressure centre passed north of New England, without bringing any local storms to us. The most pronounced example of this condition was on July 17th, in the middle of a long period remarkably free from storms; it was one of the hottest days of the summer, and yet passed without reports worth mentioning. Other exceptions have a more visible explanation: on June 15th, low pressure centres stood both northeast and northwest of us, and no storms occurred; on July 10th, low pressure centres were north and south of us, and we had only light rains; the occurrence of two neighboring low pressure areas may in these cases have interfered with the arrangement of upper winds needed for the development of the heavy clouds of thunder-storms.

The direction of motion of thunder-storms seems to be about at right angles to the radius joining them with the low pressure centre; that is, about parallel with the higher winds in which they are borne. This is clearly shown in the following table, embracing thirty-five storms whose course was sufficiently well determined to be used in evidence.

TABLE VI.

Motion of Thunder-storms.	Direction to Low Pressure Centre.			
	West of North.	North	N. N. E	N E.
North of East . .	7	1	1	0
East	1	4	2	4
South of East . .	0	2	7	6

* The first definite announcement of the fact that thunder-storms have a definite position in areas of low pressure was made by Marié-Davy, of the French meteorological service, in 1864: "The appearance of storms always coincides with the presence of rotary winds known under the name of 'bour-

The relation of the velocity of local storms to the gradients and the velocity of the cyclonic areas in which they occur, needs still further investigation. The same may be said of the conditions that determine the arrival of some storms early in the day, and of other storms late; the passage of some storms with apparently undiminished strength off the sea-coast and their endurance into the evening, while others act in the opposite way; and the maintenance of high temperatures after some storms (morning squall of July 21, and morning storm of August 4), while most are followed by decidedly cooler weather.

The surface winds flowing towards the storm at a little distance from it, and the squall commonly met blowing outwards in front of the rain area, are well defined on many occasions. The relation of the rain to the out-blowing squall is variable; in many cases, the former seems to be the effect of the latter; but in others we have heavy rain and no squall; sometimes the squall is felt at only a few stations, while the heavy rain is general. Many observers speak of a connection between lightning flashes and an increase in the rain-fall immediately following; it is quite possible that this relation exists, but the evidence usually quoted to prove it does not seem conclusive.

The more general distribution of storms in the areas of low pressure, their total duration, and the possibility of their surviving the cooler hours of night, are problems that can be better determined by the work of the Signal Service in reviewing the more detailed studies of local services. It is hoped that many of these problems may find their solution in that larger fund of material towards which this report is offered as a contribution.

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rasques.'" This conclusion has been confirmed by other European services, and by Prof. H. A. Hazen in this country. Lieut. Finley has shown that it obtains also for our tornadoes.

CAMBRIDGE, MASS., June, 1886.

III.

CONTRIBUTION FROM THE HERBARIUM OF HARVARD UNIVERSITY.

A PRELIMINARY SYNOPSIS OF NORTH AMERICAN CARICES,

INCLUDING THOSE OF MEXICO, CENTRAL AMERICA, AND GREENLAND, WITH THE AMERICAN BIBLIOGRAPHY OF THE GENUS.

By L. H. Bailey, Jr.

Presented April 14, 1886.

In the following Synopsis I have divided the genus, or rather its American representatives, into two sub-genera and fourteen sections. The primary divisions of the sections, designated by capitals, may be called groups. The names of the groups are the plurals of specific names. Sectional names of various ranks are now so numerous, that I have made the endeavor to choose in accordance with recognized rules of priority. If I have seen and examined critical or historic specimens, the collector's name has been printed in Italics. In no case have I admitted uncertain authorities for geographical distributions. *Herb.* is an abbreviation for Herbarium. Distinguishing characters have been given for those species which are not described in Gray's Manual, Chapman's Flora, or Coulter's Manual of Rocky Mountain Botany.

A genus so vast as Carex must always suffer divisions which are founded upon appearances rather than characters. The most remarkable of such disruptions with which I am acquainted is that proposed by Rafinesque, in 1840, in "The Good Book and Amenities of Nature." With a religious dread of large genera, this author divided Carex into eighteen genera, and raised them, together with four genera made from Uncinia, into ordinal rank under the name Carexides. Long before this time he had divided the genus into four genera: Carex, Scuria, Triplma, and Triodus. In 1844, J. Heuffel, in Flora, adopted nine genera, of which eight were erected upon those species, comparatively few in number, which lie without the division commonly recognized as Carex proper. The genus Carex as received by Linnæus included Uncinia, which was separated by Persoon in 1807. In 1819, Beauvois, in Lestiboudois's "Essai sur la Famille de Cypéracées," proposed the genus Vignea, to include most of the distigmatous homostachyous species, choosing the name in honor of Prof. G. F. de la Vigne, translator of Schkuhr's "Riedgräser" into French.

The sectional divisions of the genus have been built heretofore largely upon artificial groups. So far as I know, the monostachyous species have always been thrown together, until an attempt was made to distribute them in natural groups in Coulter's Manual of Rocky Mountain Botany. I have neglected such names as Unispicatæ, Monostachyæ, Homostachyæ, and Heterostachyæ, as unsuitable for the designation of natural sections, however valuable they may be for artificial keys. For the same reason, I have not made use of the Dontostomæ and Cyrtostomæ of Fries, nor the Chlorostachyæ and Melanostachyæ of Tuckerman. In 1835 Elias Fries made a number of names, mostly plurals of the names of well-known and representative species, to designate some of the lesser groups of the genus. These were published in "Corpus Florarum Provincialium Sueciæ." This idea was followed to a small extent by Kunth, in 1837, in the second volume of "Enumeratio Plantarum." In 1843, Prof. Edward Tuckerman published his curious and critical "Enumeratio Methodica Caricum quarundam," a pamphlet of twenty-one pages, which was the first professed attempt to make a natural arrangement of Carices with named divisions. A year later Drejer's excellent "Symbolæ Caricologicæ" appeared, in which the general affinities of many species were discussed at length, and eleven sections proposed for the true Carices. The next important additions to the names of minor groups were made by John Carey, in the first edition of Gray's Manual, 1848.

SUBGENUS I. EUCAREX, Cosson, Fl. Paris, 744. Staminate flowers forming one or more terminal linear or club-shaped spikes (which, however, are often pistillate at base or apex). Pistillate flowers usually in distinct and simple mostly peduncled spikes. Cross-section of the perigynium circular, obtusely angled, or prominently trigonous in outline. Style mostly 3-parted and the achenium trigonous or triquetrous.

Section I. PHYSOCARPÆ, Drejer, Symb. Car. 10 (*Deflexocarpæ*, Bailey, Coulter Man. 373, in part). Perigynium mostly straw-colored at maturity, papery in texture, more or less inflated, smooth, nerved, tapering into a beak as long or longer than the body: spikes few to many, distinct, compactly flowered: stigmas mostly three. — The representative species of the section are the larger members of the Vesicariæ and Lupulinæ. The extreme is represented on the one hand by the monostachyous *C. microglochin* and *C. pauciflora*, and on the other by the comose and green-spiked *C. Pseudo-Cyperus*. But even with these widely dissimilar extremes the section is a natural one. There are complete and almost insensible gradations from the one limit to the other. Most of the Lupulinæ and the extreme species of the Pseudo-Cyperæ do not have straw-colored perigynia until full or over maturity, while the perigynia of the Paucifloræ and Pseudo-Cyperæ are scarcely inflated or papery in texture. Occasionally the nerves are indistinct, rarely wanting. *C. Grayii* alone has hispid perigynia, and that rarely. The species of this section, almost entirely North American and European, are mostly large and stout, and probably to be regarded as the most developed of the genus.

A. *Paucifloræ*, Tuckerman, Enum. Meth. 7. (*Leucoglochin*, Fries, Summa, 73. *Orthocerates*, Koch, Fl. Germ. 748, is a sectional name made for *C. microglochin.*) Perigynium greenish, linear-lanceolate or almost needle-shaped, not inflated, strongly deflexed at maturity, several times longer than the inconspicuous scale: spike androgynous, the pistillate flowers at the base, few. — Small species, rare or local.

1. Carex microglochin, Wahl. Köngl. Acad. Handl. xxiv. 140.
   Uncinia microglochin, Spreng. Syst. Veg. iii. 830; C. B. Clarke, Journ. Linn. Soc. xx. 401.
   Uncinia Europæa, J. Gay, Flora, 1827, 28.

Remarkable for the elongated rhacheola which projects from the perigynium, completely filling the orifice. This plant stands midway between Carex and the singular genus Uncinia. — Colorado, *Hall & Harbour* 607; Greenland, *Andersson*. N. Europe, Alps, Himalayas.

2. Carex pauciflora, Lightfoot, Fl. Scot. 543, t. 6.

Cold swamps: Vermont, Central and Western New York and Central Michigan, northward and northwestward to N. Minnesota, *Sandberg*, Rocky Mts. of British America, *Drummond*, and Sitka, *Bongard*, *Mertens*.

B. *Lupulinæ*, Tuckerman, Enum. Meth. 13. Perigynium green or greenish-tawny or sometimes yellow, more or less inflated (except in *C. subulata*), long, usually very turgid at the base, mostly erect or nearly so, very gradually lengthened into a long slenderly toothed beak, exceeding the scale:

spikes three or more, the staminate mostly one and commonly stalked, the pistillate often sessile, usually short and thick, often becoming dark colored in drying. — Mostly large and coarse species in meadows and bogs.

* *Plant green, in appearance much like those of the last group, very slender; perigynium needle-shaped with reflexed teeth, not inflated.*

3. Carex subulata, Michx. Fl. Bor.-Am. ii. 173.
C. Collinsii, Nutt. Gen. N. Am. Pl. ii. 205.
C. Michauxii, Dewey, Sill. Journ. x. 273.

Deep cedar swamps in sphagnum: Canada, Michaux; Rhode Island, Olney, to New Jersey, *Dewey*, *Nuttall*, *Carey*, *Parker;* Schuylkill Co., Penn., *Porter;* Fayetteville, N. Carolina, Curtis; Aiken, S. Carolina, *Canby*, and Georgia, *Neisler*. Rare.

* * *Whole plant yellowish; staminate spike sessile or nearly so; pistillate spikes loosely few-flowered; perigynium long-lanceolate, more or less spreading at maturity, somewhat turgid.*

4. Carex Michauxiana, Boeckeler, Linnæa, xli. 336.
C. rostrata, Michx. Fl. Bor.-Am. ii. 173, not With.
C. xanthophysa, vars. *nana* and *minor*, Dewey, Sill. Journ. xiv. 353, ff. 57, 58.

In cold bogs: Newfoundland, *La Pylaie*, to mountains of New England and Eastern New York; Northern Michigan, *Porter*. Local.

5. Carex folliculata, Linn., Sp. Plant. 978.
C. xanthophysa, Wahl. Köngl. Acad. Handl. xxiv. 152.

Scales, at least the lower ones, rough-awned and nearly as long as the perigynium. Leaves broad and flat. — Cold swamps: Newfoundland, *La Pylaie*, to New England, New York, Pennsylvania, New Jersey, *Parker*, and Michigan, Wheeler and Smith's Cat.

Var. australis.
C. folliculata, Ell. Sk. Bot. ii. 545? Chapm. Fl. 544.
C. folliculata, β, Boott, Ill. 91.

Plant much smaller and more slender, with narrower bracts and leaves; pistillate spikes longer and looser; perigynium much more slender, scarcely inflated, more spreading; scales, at least all above the lowest, much shorter than the perigynium, muticous or slightly awned. — Florida and northward, Chapman; New Orleans, *Herb.;* St. Augustine, Florida, *Canby;* "damp pine land," Santee Canal, South Carolina, *Ravenel*.

* * * *Plant green; staminate spike commonly stalked; pistillate spikes thick and compactly flowered; perigynium very turgid at base.*

6. Carex intumescens, Rudge, Linn. Trans. vii. 97, f. 3.
C. folliculata, Wahl. Köngl. Acad. Handl. xxiv. 152, fide Boott.

Varies considerably in the size of the spikes. — Common in moist, shady pastures and in swamps: Norway House, S. W. of Hudson's Bay, about lat. 54°, *Herb.;* Newfoundland, *La Pylaie;* throughout the States east of the Mississippi. Evidently more common northward.

7. CAREX GRAYII, Carey, Sill. Journ. iv. 22.

C. intumescens, var. *globularis*, Gray, Ann. N. Y. Lyc. iii. 236.

Perigynia sometimes hispid (see Coult. Bot. Gaz. x. 295). — Central New York to Central Michigan (common) and Illinois; New Jersey, *Brinton*, Closter, Austin; Rome, Georgia, *Chapman*. Rare eastward.

8. CAREX LURIDA, Wahl. Köngl. Acad. Handl. xxiv. 153; Fl. Lapp. 250.

C. lupulina, Muhl.; Willd. Sp. Pl. iv. 266.

C. Canadensis, Dewey, Sill. Journ. 2d ser. xli. 229.

Very variable in the shape and size of the spikes. — Hudson's Bay, Boott; common in wet places in the Northern States east of the Mississippi, rarer southward; "deep river swamps, Florida and northward," Chapman; Santee Canal, South Carolina, *Ravenel;* Apalachicola, Florida, *Chapman;* Decatur, Alabama, *J. D. Smith;* Limestone Gap, Indian Terr., *Butler;* Houston, Texas, *Lindheimer*.

Var. DIVERGENS.

C. Bella-villa, Dewey, Sill. Journ. 2d ser. xli. 229.

Plant more slender; spikes scattered or remote, oblong or cylindrical, much more loosely flowered, more or less staminate at the apex; perigynium more straw-colored, less turgid, slenderly beaked, diverging at right angles; scales longer, conspicuously awned. Much like *C. folliculata*, from which it may be distinguished by habit, narrow leaves, longer (1 inch or more) spikes, the upper of which are sessile. Possibly a hybrid with *C. folliculata*. — Belleville, Canada West, *Macoun*.

Var. POLYSTACHYA.

C. lupulina, var. *polystachya*, Schwein. & Torr. Monogr. 337.

C. gigantea, Kunth, Enum. Pl. ii. 503.

C. lupuliformis, Sartwell, Exsicc. 147.

C. Beyrichiana, Boeckeler, Linnæa, xli. 239.

Penn Yan and Jefferson Co., New York, *Sartwell*, *Crawe*, to Connecticut, *Wright*, and New Jersey, *Carey*, *etc.*, and Delaware, *Canby;* Georgia, according to Boeckeler, l. c.; Red River, Louisiana, *Hale;* "Fort Smith to Rio Grande," *Bigelow*. Runs into the species in Michigan and other central States.

9. Carex gigantea, Rudge, Linn. Trans. vii. 99, f. 2.

Distinguished from *C. lurida*, var. *polystachya*, which it closely resembles, by its more slender and spreading pistillate spikes, its less turgid, more abruptly beaked and spreading perigynia, and shorter and smooth scales. Staminate spikes one to five. — Swamps: Kentucky, *Short;* Delaware, *Canby*, *Commons*, to Florida, *Chapman*, and Texas, *Hall*, 758. "Pine barren ponds, Florida to South Carolina and westward," Chapman. Evidently local.

10. Carex Halei, Carey, Chapm. Fl. 543.

C. turgescens, Dewey, Sill. Journ. 2d ser. iii. 356.

C. Halei, var. *minor*, Boott, Ill. 94.

Banks of the Apalachicola River, Florida, *Chapman*, to Louisiana, *Hale*, *Joor;* Arkansas, Carey, according to Boott, and E. Texas, *Wright*.

11. Carex Elliottii, Schwein. & Torrey, Monogr. 357.

C. castanea, Ell. Sk. Bot. ii. 546.

C. Baldwinia, Dewey, Sill. Journ. xxvi. 107.

"Boggy margins of pine-barren streams, Florida to North Carolina," Chapman. I have seen specimens from Florida collected by *Chapman*, and from North Carolina collected by *M. A. Curtis*. A rare and pretty species.

C. *Vesicariæ*, Tuckerman, Enum. Meth. 13. (*Tentaculatæ*, Tuckerman, l. c.) Perigynium smooth and shiny, much inflated, at maturity straw-colored or occasionally purple, beaked and conspicuously short-toothed, usually prominently few-nerved, much shorter than in the Lupulinæ: staminate spikes commonly two or more: pistillate spikes as a rule long and densely cylindrical. — The types of the group are *C. vesicaria*, *C. monile*, and *C. Tuckermani*.

* *Plants tall but slender; spikes few-flowered, globular or short-oblong, few, scattered or remote, straw-colored; leaves long and narrow.*

12. Carex turgescens, Torrey, Monogr. 419.

"Pine-barren swamps, Florida to North Carolina," Chapman. I have examined specimens from Florida collected by *Chapman*, from Society Hill, South Carolina, collected by *M. A. Curtis*, and from New Orleans in Herb. Torrey. Rare.

13. Carex oligosperma, Michx. Fl. Bor.-Am. ii. 174.

C. Oakesiana, Dewey, Sill. Journ. xiv. 351.

Borders of swamps and lakes: Bear Lake, Arctic America, English River, and Norway House (lat. about 54°), *Richardson*, southward to N. Minnesota, Central Lower Michigan, Central New York, and Pennsylvania; Labrador, *Allen*.

14. Carex Raeana, Boott, Rich. Arc. Exped. ii. 344.

Differs from *C. oligosperma* chiefly as follows: Pistillate spikes cylindrical, long (½ in. to 1½ in.), the lower loosely flowered at the base and peduncled; perigynium long-beaked, conspicuously toothed, the teeth scabrous; pistillate scales narrow and acuminate. — Methye Portage, British America, long. about 110°, lat. about 57°, *Richardson.* Some of the perplexing and immature specimens from N. Maine, collected by *C. E. Smith* (Gray, Manual, 602), and from New Brunswick, collected by *J. Fowler*, are evidently to be referred here. The specimens vary in the shape of the orifice of the perigynium. Abundant and mature specimens from these regions are needed for the full determination of this species, and likewise of *C. rotundata* and *C. saxatilis*, var. *miliaris.* *C. Raeana* evidently occurs in Montana also. The species was named for Capt. John Rae, of Richardson's Arctic expedition.

15. Carex physocarpa, Presl, Reliq. Hænk. i. 205.

The only typical specimens which exist in this country, so far as I know, I have from Professor Macoun. The species is allied to *C. monile* on one side and *C. saxatilis* on the other. Its distinguishing marks are the long peduncles (1 to 4 in.) of the oblong spikes, the two or more elevated staminate spikes, and a very slightly toothed or obliquely cut nearly nerveless perigynium, which is about equalled by the somewhat obtuse scale. *C. saxatilis*, var. *Grahami*, is apparently its nearest ally, but that variety has shorter and thicker pistillate spikes which are short-peduncled, one or two short-stalked staminate spikes and a sharply cut, strongly nerved perigynium which is twice longer than the scale. The merits of *C. physocarpa* and *C. saxatilis*, var. *Grahami*, cannot be determined until more material accumulates. My present impression is that expressed by Dr. Boott (Linn. Trans. xix. 220), that the plants of our Rocky Mountains, which have been referred to the var. *Grahami*, belong rather to *C. physocarpa.* The plants vary widely from the type of *C. physocarpa*, but fully as widely from var. *Grahami.* It may be that the two species are not distinct. Var. *Grahami* is founded upon a plant of Scotland. — Nootka Sound, Vancouver's I., Haenke; Rocky Mountains of British America, *Drummond*, named by Dr. Boott; Bow River at Morley, Rocky Mountains of British America, *Macoun.*

* * *Plants mostly low, with short and more or less purple spikes. Perigynia erect or ascending.*

16. Carex saxatilis, Linn. Fl. Lapp. 259.

C. pulla, Gooden. Linn. Trans. iii. 78.

C. vesicaria, var. *alpigena*, Fries, Mant. ii. 142.

Greenland, *Vahl*, *Warming* & *Holm*, *Fries*. Kamtschatka, *Wright*. N. Europe.

Var. (?) GRAHAMI, Hooker & Arnott, Brit. Fl. 8th ed. 510.

C. Grahami, Boott, Linn. Trans. xix. 215.

C. vesicaria, var. *dichroa*, Anderss. Cyp. Scand. 18.

C. saxatilis, var. *major*, Olney, Bot. King's Rep. 370.

See *C. physocarpa*. — High mountains from Colorado and Utah northward.

Var. (?) MILIARIS, Bailey, Coult. Bot. Gaz. ix. 120.

C. miliaris, Michx. Fl. Bor.-Am. ii. 174.

C. pulla, var. (?) *miliaris*, Gray, Manual, 5th ed. 602.

Very slender, 6 to 16 inches high; leaves and bracts very narrow, almost filiform: spikes 1–3, small (two lines to six lines long, two lines to three lines broad), sessile or the lowest very short-stalked, brown-and-green, the upper usually ovoid or globular, and sometimes very much reduced in size: perigynium ovoid, small, nerveless or nearly so, little inflated, the beak minutely toothed, about the length of and broader than the acute purple-margined scale. — Moosehead Lake, Maine, *Smith*, and northward to Lower Canada and New Brunswick, *Fowler*. More material is needed. Singular specimens from Ungava Bay, N. Labrador, coll. by *Turner*, 1884, appear to belong here. This plant is said by Olney to occur in N. Minnesota.

+ + *Perigynia squarrose.*

17. CAREX COMPACTA, R. Brown, Ross's Voy. Appx. cxliii.

C. membranacea, Hook. App. Parry's 2d Voy. 406.

C. hymenocarpa, Drejer, Revis. Crit. Car. 58.

C. ampullacea, var. *borealis*, Lange, Rink's Groenl. ii. 118.

Six to sixteen inches high, stout: culm smooth or very nearly so, longer than the flat leaves: lowest spike subtended by an abruptly spreading leafy bract: pistillate spikes usually two, mostly closely sessile (the lowest sometimes very short-stalked), densely and evenly cylindrical, in typical specimens about an inch long, often shorter: staminate spikes one or two, short and obtuse or nearly so: perigynium broadly ovate, very short-beaked, the orifice nearly entire, a little longer than the white-pointed scale, bladder-like and shining, very fragile. Evidently too near the next. — Arctic America: "Cumberland House [about lat. 54° and southwest of Hudson's Bay] to Arctic coast," Boott; Baffin's Bay, R. Brown; Southampton I., Capt. Parry; North Somerset, Duckett Cove, Ross; Kotzebue's Sound, Arnott;

Greenland, Vahl, fide Drejer; Nottingham I., Hudson's Straits, *Macoun;* Bear Lake, *Drummond;* Kamtschatka, *Wright.* Figured in Bot. Gaz. for August, 1885.

18. Carex rotundata, Wahl. Fl. Lapp. 235.

Distinguished from the last by its firmer perigynium and involute-filiform leaves. Andersson regards it as an extreme form of *C. rostrata*, With. (*C. ampullacea,* Gooden.). — Arctic America: Slave Lake and Fort Enterprise, Boott; Greenland, Vahl, *Warming* & *Holm.* Specimens from Ungava Bay, N. Labrador, *Turner,* 1884, are evidently this species. One of *C. E. Smith's* specimens from Moosehead Lake, Maine, may belong here also. N. Europe.

* * * *Plants mostly large and stout.*

+ *Perigynium not conspicuously turgid, squarrose at maturity and the spikes comose in appearance.*

19. Carex rostrata, Withering, Arrang. Brit. Pl. ed. ii. (1790).
C. obtusangula, Ehrh. Calam. Exs. no. 50 (1791).
C. ampullacea, Gooden. Linn. Trans. ii. 207 (1792).

Mackenzie's River, *Herb.;* Saskatchewan, *Bourgeau, Macoun;* Oregon, *Lyall,* and others; Colorado, *Canby, Hall* & *Harbour* 615, and others; N. Michigan, *Porter.* Probably generally distributed throughout British America, the Rocky Mountain region, and westward. Europe.

Var. utriculata.
C. utriculata, Boott, Hook. Fl. Bor.-Am. ii. 221.
C. utriculata, var. *minor,* Boott, l. c.; Sartwell, Exsic. no. 153.
C. ampullacea, var. *utriculata,* Carey, Gray's Man. 1848, 566.
C. utriculata, var. *globosa,* Olney, Bot. King's Rep. 374.
In bogs entirely across the continent north of Ohio.

C. Bongardiana, C. A. Meyer, ex Trautv. & Meyer, Fl. Ochot. 101 (*C. vesicaria,* Prescott in Bongard's Obs. Sitcha, 169), is evidently an attenuated and long-beaked form of *C. ampullacea.* Dr. Boott, however, regarded it as a form of *C. vesicaria.* — Sitka, *Mertens;* Oregon, *Hall.*

+ + *Perigynia conspicuously turgid, ascending at maturity.*

20. Carex monile, Tuckerman, Enum. Meth. 20.
C. Vaseyi, Dewey, Sill. Journ. xxix. 347.

Common in wet places in all the Northern States east of Nebraska; Colorado, *Vasey;* Ostrander's Meadow, California, *Bolander* 6211; "Cumberland House to Bear Lake," Boott.

Var. OBTUSISQUAMIS.

C. vesicaria, γ, W. Boott, Bot. Calif. ii. 252.

C. vesicaria, var. (?) *obtusisquamis*, Bailey, Carex Cat., and Bot. Gaz. ix. 121.

Spikes short (an inch long or less), sessile, purple; perigynium abruptly contracted into a short nearly entire beak, longer than the broad purple and white-margined very obtuse scale. — Soda Springs, head of Tuolumne River, California, *Brewer*, 1781.

21. CAREX VESICARIA, Linn. Sp. Pl. 979.

Huntington Valley, Nevada, *Watson* 1270, a young specimen; California, Summit Camp, *Dr. Kellogg*, Yosemite Valley, *Brewer* 1654, Tomales Bay, *Bolander* 2303, Sprague River, east of Klamath Valley, *Hildebrand;* Northern British Columbia, *Rothrock*. Evidently rare. Europe.

Var. MAJOR, Boott, Hook. Fl. Bor.-Am. ii. 221.

Vars. *lanceolata* and *globosa*, Olney, Proc. Am. Acad. viii. 407, 408.

Mostly larger: perigynium long-lanceolate, greenish or rusty, little inflated, thick in texture, many-nerved, much longer than the small scale. — Oregon, *Hall* 608, 609, *Henderson*, Multnomah Co., *Howell;* Columbia River, Douglas, Scouler.

22. CAREX TUCKERMANI, Boott, Hook. Journ. Bot. v. 73.

C. bullata, Dewey, Sill. Journ. ix. 71.

C. Tuckermani, var. *cylindrica*, Dewey, Sill. Journ. xlix. 48.

C. cylindrica, Carey, Gray's Man. 1848, 566.

Perigynia more inflated than in any other American species. — W. New England and N. Vermont to Ohio, Illinois, and Wisconsin; N. Jersey, Britton Cat.

23. CAREX BULLATA, Schkuhr, Riedgr. Nachtr. 85, f. 166.

C. cylindrica, Schw. An. Tab.

C. Greenii, Boeckeler, Flora, 1858, 649.

Culm very sharply angled, at least above, and slender. The perigynia have a peculiar greenish-brown appearance. The roughness of the beaks is not always apparent. — Wet places, Mass. to N. Jersey and Pennsylvania, *Porter;* Society Hill, S. Carolina, *Curtiss*.

C. BULLATA × UTRICULATA (*C. Olneyi*, Boott, Ill. 15, t. 42). — Providence, R. Island, *Olney*. Sterile or nearly so.

24. CAREX RETRORSA, Schweinitz, An. Tab.

C. reversa, Sprengel, Syst. Veg. iii. 827.

Marshy places: River du Loup, Quebec, *Pickering;* New England to Pennsylvania, Michigan, and Wisconsin; Sault St. Marie, N. Michigan, *Porter;* Saskatchewan, *Bourgeau;* Northwest Coast, *Douglas;* Oregon, *Hall.*

Var. HARTII, Gray, Man. 5th ed. 600.

C. Hartii, and var. *Bradleyi*, Dewey, Sill. Journ. 2d ser. xli. 226.

C. Macouni, Dewey, Sill. Journ. 2d ser. xli. 228.

Pistillate spikes loosely flowered, long, all scattered or remote, the lower ones on very long peduncles: perigynium spreading or somewhat reflexed. — Pompet, Vermont, *Morgan;* New York, Dundee, Yates Co., *Samuel Hart Wright*, Ludlowville, Tompkins Co., *Lord*, Greece, near Rochester, *Bradley;* Flint, Michigan, *D. Clarke;* Hastings Rood and Belleville, Canada West, Macoun.

25. CAREX TENTACULATA, Muhl.; Willd. Sp. Pl. iv. 266.

C. rostrata, Willd. Sp. Pl. iv. 282.

C. tentaculata, var. *rostrata*, Pursh, Fl. 14.

C. Purshii, Olney, Exsicc. fasc. i. no. 30.

Variable. — Common in wet grounds throughout the States east of the Mississippi; Texas, *Wright.* South America.

Var. GRACILIS, Boott, Ill. 94.

Smaller and slender, with about two small erect pistillate spikes which are densely cylindrical (an inch to an inch and a half long), the size of a slender lead pencil. — Mountains of Vermont and New Hampshire; Tennessee, Lesquereux. One of the handsomest of our Carices.

C. TENTACULATA × LURIDA (var.? *altior* of *C. tentaculata*, Boott, l. c.). — Penn Yan, N. York, Sartwell; Amherst, Mass., *Tuckerman;* North Hero, Vermont, *Morong.*

D. *Pseudocyperæ*, Tuckerman, Enum. Meth. 13. Perigynium less inflated, more conspicuously nerved or even costate, provided with more or less setaceous or aristate teeth; scale usually aristate; spikes mostly nodding, comose in appearance, in color greenish, greenish-yellow, or whitish-yellow.

26. CAREX SCHWEINITZII, Dewey, Sill. Journ. ix. 68.

A fine local species. — "Canada to New Jersey," Boott; "New England, New Jersey, W. New York, and northward," Gray's Manual; Pittsfield, Mass., and Pownal, Vermont, Dewey; New York, *Cowles*, Fairfield, *Gray.*

27. CAREX HYSTRICINA, Muhl.; Willd. Sp. Pl. iv. 282.

C. Cooleyi, Dewey, Sill. Journ. xlviii. 144.

C. Georgiana, Dewey, Sill. Journ. 2d ser. vi. 245.

C. Thurberi, Dewey, Bot. Mex. Bound. 232.

Wet meadows and marshes throughout the States east of the Mississippi from Canada to Georgia, but evidently inclining to be local; New Mexico, *Wright;* Santa Rita Mts., Arizona, *Pringle.* — The name was originally written *hystericina*, a name of no application. That the author meant to refer to the comose or hystricinous character of the spikes is evident from Willdenow's German name of the plant, no doubt suggested by Muhlenberg, "Stachelschweinartige Segge," porcupine-like sedge.

28. Carex acutata, Boott, Linn. Trans. xx. 124.

C. feminea, Steud. Cyper. Pl. 203.

Much like the last, from which it differs in its greater size (two to four feet high): pistillate spikes long and thick (one and a half to three inches long), erect, the lowest one or two short-stalked: perigynium elliptic-ovate, thick in texture, dull, very prominently many-ribbed, abruptly contracted into a rather short, white nerveless beak, longer than the rough and aristate scale. — S. Arizona, near Fort Huachuca, *Lemmon* 2903 (1882). Founded upon South American specimens.

29. Carex Pseudo-Cyperus, Linn. Sp. Pl. 978.

Swamps and lakes: New England to Pennsylvania and Michigan; Portage de Ratz at Fort de la Rivière, Winnipeg, *Bourgeau.* Evidently not common. Europe, Asia, Africa, South America.

Var. comosa, W. Boott, Bot. Calif. ii. 252.

C. furcata, Ell. Sk. Bot. ii. 552.

C. Pseudo-Cyperus, Schw. & Torr. Monogr. 355.

C. comosa, Boott, Linn. Trans. xx. 117.

Common east of the Mississippi, in low grounds, from Canada to Georgia; Multnomah Co., Oregon, *Howell;* near San Francisco, Cal., *Bolander* 2301.

E. *Squarrosæ,* Carey, Gray's Man. 1848, 564. Perigynium obconic or obovoid, squarrose in exceedingly dense spikes.

* *Spikes mostly three to six inches long.*

30. Carex spissa.

Culm four to six feet high, very stout, from a woody root, smooth or nearly so: leaves very numerous, a half-inch wide, stiff, glaucous, conspicuously serrate on the margins, about as long as the culm: lower bract very long and leafy, the uppermost short or nearly obsolete: spikes 6–12 or more, the lowest four to six inches long and long-peduncled (peduncle one to fifteen inches long), the upper becoming sessile, often two or three from an axil, the intermediate ones often staminate at the top, the pistillate portions densely and evenly cylindrical, all erect, the staminate four to six or more in number and one to four inches long; perigynium small (a line and a half long), yellowish green, elliptic or obovate, firm in texture, few-nerved, often slightly compressed, squarrose, about the length of or shorter than the stout and toothed awn of the scale: stigmas three. — California, San Diego Co., *Pringle*, San Juan Capistrano, *J. C. Nevin;* Arizona, *Pringle;* Lower California, Guadeloupe Cañon, *Orcutt.* The stoutest Carex I know.

* * *Spikes not exceeding an inch and a half in length.*

31. CAREX STENOLEPIS, Torrey, Monogr. 420.
 C. Frankii, Kunth, Enum. Pl. ii. 498.
 C. Shortii, Steud. Nomen. Bot. 296.

Swamps and meadows; Central Pennsylvania, *Porter*, to the upper districts of Georgia, westward to Kentucky, *Short*, and southwestward to Louisiana and Texas, *Wright*, *Reverchon.*

32. CAREX SQUARROSA, Linn. Sp. Pl. 973.
 C. typhina, Michx. Fl. Bor.-Am. ii. 169.
 C. typhinoides, Schwein. An. Tab.

Bogs, New England to Georgia, and west to Michigan and Illinois; N. W. Arkansas, *Harvey;* Red River, Louisiana, *Hale.*

Section II. TRACHYCHLÆNÆ, Drejer, Symb. Car. 9. Perigynium mostly thick and hard in texture, commonly scabrous or hirsute, straight-beaked; pistillate spikes compactly flowered, mostly large, erect or nearly so; staminate spikes one or more; stigmas three. — Large and coarse species, mostly paludose. A heterogeneous section, originating in the Anomalæ with very short and entire beaks and terminating in the much-developed beaks of the Paludosæ. The Anomalæ connect the section with the Granulares. *C. vestita*, *C. Oregonensis*, and *C. Houghtonii* are not paludose, and perhaps others of the section are not. *C. filiformis* and *C. acutiformis* may be said to represent the section.

A. *Shortianæ.* Terminal spike androgynous, staminate below; perigynium small and smooth, nearly beakless, entire. — Including one anomalous species, which Dr. Boott prefers to associate with *C. verrucosa*, Ell.

33. CAREX SHORTIANA, Dewey, Sill. Journ. xxx. 60.
 C. Shortii, Torr. Monogr. 407.
 C. formosa, Kunth, Enum. Pl. ii. 431.

S. Pennsylvania to Virginia and westward to Ohio, S. Illinois, Nebraska according to Dewey, and Limestone Gap, Indian Territory, *Butler*.

B. *Anomalæ*, Carey, Gray's Man. 1848, 557. Terminal spike all staminate; pistillate spikes long and cylindrical, mostly densely flowered; perigynium broad and short, short-beaked, the orifice very slightly notched or entire, mostly granulate. — Tall species with rough leaves.

34. Carex Joori.

Culm two feet high, very sharply angled, rough: leaves narrow, slightly carinate, rough on the margins, much surpassing the culm: bracts sheathless, setaceous, very rough on the margins, the lower one or two surpassing their spikes, the others much shorter: spikes about six, cylindrical, densely flowered, one or two inches long, erect or slightly spreading, all on slender rough peduncles an inch or two long, the terminal distant and staminate: perigynium short-obovate, nearly circular in cross-section, abruptly contracted into a short entire and sharp beak half as long as the body, strongly many-nerved, granulate, somewhat inflated, dark-colored, squarrose, about as long as the serrate awn of the hyaline scale: achenium triquetrous, broadly obovate or oval; stigmas three. — Comite Swamp, near Baton Rouge, La., *J. F. Joor*, Aug. 5, 1885.

35. Carex scabrata, Schweinitz, An. Tab.

Transition to the Granulares. — New England to South Carolina, *J. D. Smith*, and Tennessee, *Curtiss*, and westward to Michigan.

36. Carex amplifolia, Boott, Hook. Fl. Bor.-Am. ii. 228, t. 226.

Culm stout (two to three and a half feet high), very sharply angled, rough above: leaves many, very broad (5–8 lines), rough on the margins, usually exceeding the culm: bracts leaf-like, sheathless: pistillate spikes four to six, erect, the upper ones sessile, the lower very short-stalked, all erect, one to four inches long, slenderly cylindrical: perigynium elliptic, conspicuously few-nerved, abruptly narrowed into a whitish beak, spreading, about as long as the awn-pointed whitish narrowly purple-margined scale. — California, Plumas Co., *Mrs. Bidwell*, Mariposa Grove, *Bolander* 5011; Oregon, *Hall*, *Howell*, etc.; N. Idaho, fide Boott.

C. *Hirtæ*, Tuckerman, Enum. Meth. 14. (*Lasiocarpæ*, Fries, Summa, 70. *Lanuginosæ* and *Scariosæ*, Carey, Gray's Man. 1848, 560.) A heterogeneous group distinguished from the last by the longer and more deeply cut beak and by the hairy perigynium. — The perigynium of *C. striata* is often smooth. *C. filiformis* and *C. Houghtonii* may be taken as types of the group.

* *Beak entire or nearly so.*

37. Carex Sartwelliana, Olney, Proc. Amer. Acad. vii. 396.

Whole plant softly pubescent: culm two to three feet high, rigid: leaves about two lines broad, about the length of the culm: bracts leafy, sheathless: staminate spike one, sometimes bearing a few pistillate flowers: pistillate spikes four or five, sessile, an inch or two long, densely flowered, ferrugineous: perigynium trigonous-obovoid, minutely beaked, the orifice entire, densely tomentose, a little longer than the mucronate purple-margined and ciliate scale. — Named in memory of Dr. Henry P. Sartwell of Penn Yan, New York, an ardent botanist, an early student of this genus, and author of an Exsiccatæ. — Yosemite Valley, California, *Brewer* 1636, Bolander 6221.

38. Carex vestita, Willd. Sp. Pl. iv. 263.

In sandy soils, New England and New York to Pennsylvania, *Porter*, and Georgia. "Sandy swamps in the upper districts," Chapman.

39. Carex hirtissima, W. Boott, Bot. Calif. ii. 247.

Culm rather slender but strict, a foot and a half high, smooth: leaves shorter than the culm, pubescent, those on the culm producing conspicuous pubescent sheaths: spikes three or four, the upper short-stalked, erect, about an inch long, scattered rather loosely flowered, usually exceeded by the leafy bracts: perigynium triangular-elliptic, contracted at both ends, nerveless or nearly so, hirsute, ribbed on the angles, produced abruptly into a slender beak, about the length of the white and very abruptly aristate scale. The beak becomes more or less bifid by splitting at full or over maturity. — Summit Camp, Sierra Nevada, California, *Dr. Kellogg*.

* * *Beak distinctly bifid.*

40. Carex Oregonensis, Olney, Proc. Amer. Acad. 1872, 407.
C. Halliana, Bailey, Bot. Gaz. ix. 117.

Culm a foot high, smooth or nearly so, very leafy: bracts leaf-like, with thin white auricles, the lower exceeding the culm: pistillate spikes about three, an inch long, often staminate at the top, erect, approximate, shortly peduncled: perigynium ovate, tapering at both ends, prominently many-nerved, thickly covered with short stiff hairs, gradually produced into a white and smooth toothed beak, longer than the ovate, acute, membranaceous, and often dull-margined scale: achenium large, triangular-obovoid or rarely lenticular-obovoid. — Name given by Mr. Olney in the list of Hall's Oregon plants without description, and the numbers of the collection became mixed. In the Olney herbarium at Providence I found the plant with Mr. Olney's name attached. — Oregon, *Hall* 605, Howell, sandy hillsides on subalpine slopes of Mt. Hood, *L. F. Henderson*, 1884; Washington Terr., *Suksdorf.*

41. Carex striata, Michx. Fl. Bor.-Am. ii. 174.

C. polymorpha, Torr. Monogr. 413.

New Jersey to Florida in pine-barren swamps. "Quite common in pine-barren regions, and mostly confined to the yellow drift," Britton's N. Jersey Catalogue. The Southern specimens have more hairy and more tapering perigynia than the New Jersey form.

42. Carex Houghtonii, Torrey, Monogr. 413.

Dr. Douglas Houghton, a brilliant naturalist, first State Geologist of Michigan. — New Brunswick, *Fowler;* Maine, at Orono, Scribner, Milford, and Cumberland, *Blake;* Gilmanton, N. H., Blake; New York, near Lake Placid, Essex Co., *Peck;* shore of Lake Ontario (in New York?), *Whitney*, 1849; Michigan, Clare Co., central part of lower peninsula, Wheeler, Keweenaw, *Robbins*, and Isle Royal, *Porter;* sixty miles north of Belleville, Ontario, Macoun: Minnesota, Lake Itasca, Houghton (the original station), Blue Earth Co., Leiberg; Council Bluffs, Geyer; British America on Athabasca Plains, *Macoun*, Saskatchewan, *Herb.*, Methye Portage, long. about 110°, lat. about 57°, Richardson. Rare.

43. Carex filiformis, Linn. Sp. Pl. 976.

In bogs from New England to Pennsylvania and Michigan, and northwestward to the Saskatchewan and northward. Europe.

Var. latifolia, Boeckeler, Linnæa, xli. 309.

C. lanuginosa, Michx. Fl. Bor.-Am. ii. 175.

C. pellita, Muhl.; Willd. Sp. Pl. iv. 302.

C. æmathorhyncha, Olney, Bot. King's Rep. 373.

C. filiformis, var. *æmatorhyncha*, W. Boott, Bot. Calif. ii. 250.

In bogs across the continent from Ohio and Kentucky northward; also in New Mexico, *Wright.*

44. *Carex hirta*, Linn. Sp. Pl. 975.

Resembles *C. Houghtonii* and *C. trichocarpa*, but differs in its very remote and smaller pistillate spikes and its loosely hairy perigynium, sheaths, and leaves. — Introduced at Ashland, Mass., *Morong*, where it is thoroughly established, about Boston, W. Boott, in ballast at Philadelphia, *Scribner*, and at Ithaca, N. York, Dudley.

D. *Paludosæ*, Fries, Corp. 190. (*Lacustres* and *Aristatæ*, Carey, Gray's Man. 1848, 561.) Staminate spikes two or more, long-stalked: pistillate spikes two to several, usually all peduncled, long and heavy, loosely flowered, erect or nodding: perigynium large, thick in texture, strongly nerved, mostly smooth, usually produced into a long beak which terminates in conspicuous awl-like erect or spreading teeth. — Coarse species.

45. CAREX TRICHOCARPA, Muhl.; Willd. Sp. Pl. iv. 302.

C. striata, Carey, Gray's Man. 1848, 561.

C. trichocarpa, var. *turbinata*, Dewey, Sill. Journ. xi. 159.

Marshes throughout the States east of the Mississippi, south to Georgia.

Var. IMBERBIS, Gray, Man. 5th ed. 597.

Perigynium smooth, teeth usually shorter, pistillate scales longer and sheaths scabrous. — New York, *Sartwell*, to Illinois. Bolander's no. 4689, referred here in Bot. Calif. ii. 251, is probably not this plant.

Var. DEWEYI, Bailey, Bot. Gaz. x. 293.

C. læviconica, Dewey, Sill. Journ. xxiv. 47.

Big Sioux and Yellowstone Rivers, *Hayden*, Bismarck, Dakota, *Seymour*, and northward.

Var. ARISTATA, Bailey, Bot. Gaz. x. 294.

C. aristata, R. Br. Narr. Frankl. Exp. App. 764.

C. atherodes, Sprengel, Syst. Veg. iii. 828.

C. orthostachys, C. A. Meyer, Fl. Alt. iv. 231.

C. mirata, Dewey, Wood's Bot. 1848, 593.

C. aristata, var. *longo-lanceata*, Dewey, Sill. Journ. xviii. 102.

Generally distributed from New England to Oregon, and far northward.

46. CAREX WATSONI, Olney, Bot. King's Rep. 370.

Culm erect, a foot and a half high: spikes about seven, deep red-brown, the four uppermost staminate, the topmost much the longest: scales of the staminate spikes lanceolate and acute or aristate, hispid, red-brown on the margins, three-nerved and pale in the centre: pistillate scales lanceolate and abruptly aristate, ciliate at the apex: perigynium deeply cleft, the teeth spreading and clothed with a few lax hairs. — Founded upon very young and unsatisfactory specimens. I imagine that it is *C. riparia*. — Washoe Mountains, on a creek bank at the mouth of King's Cañon near Carson City, Nevada, alt. 4,500 ft., *Watson* 1246.

47. CAREX SERRATODENS, W. Boott, Bot. Calif. ii. 245.

Culm one to two feet high, smooth, leaves a line or two broad, mostly shorter than the stem: bracts leafy, the lowest exceeding the culm, sheathless or nearly so, with purple auricles at the base: spikes

3 or 4, the terminal club-shaped and staminate, an inch or so long, the others pistillate, an inch or less long, sessile: perigynium lance-ovate, rather obscurely nerved, smooth, the spreading teeth conspicuously hispid, mostly longer than the ovate and awned brown scale. — Found by Wm. Boott in Herb. Olney, without date, collector, or locality, but ticketed "California."

48. CAREX RIPARIA, W. Curtis, Fl. Lond. iv. t. 60.

C. lacustris, Willd. Sp. Pl. iv. 306.

Throughout the States east of the Mississippi and in Louisiana; Pend d'Oreille River, N. Idaho, *Lyall;* Arctic America, *Herb.* Europe.

49. *Carex acutiformis*, Ehrhart, Calam. Exs. no. 30.

C. paludosa, Gooden. Linn. Trans. ii. 202.

Thoroughly established at Dorchester, Mass.; boggy meadow, New Bedford, Mass., *Willey*.

Section III. MICRORHYNCHÆ, Drejer, Symb. Car. 9. (Including *Ærostachyæ* and *Melananthæ*, Drejer, l. c.) Parallel with the last section: distinguished in general by the much smaller and nearly or entirely beakless and mostly entire-mouthed perigynium which is much thinner in texture: stigmas two or three. — Paludose and alpine species of various habit, mostly possessing colored spikes, often growing in dense tufts or tussocks. This is the most critical section of the genus. It is largely represented in Europe and North America.

A. *Atratæ*, Kunth, Enum. Pl ii. 431. Terminal spike club-shaped and androgynous with the staminate flowers below; pistillate spikes mostly short and dark-colored, either erect or drooping; plants mostly alpine or boreal. — The members differ widely in habit, the spikes of *C. Mertensii* and *C. atrata*, var. *ovata*, being mostly light-colored or parti-colored and drooping, while those of the others are black or nearly so, and more or less erect, although some black-spiked forms of *C. atrata* have drooping spikes.

50. CAREX ALPINA, Swartz, Lilj. Svensk. Fl. ed. ii. 26.

C. Vahlii, Schkuhr, Riedgr. 87.

C. media, R. Br. App. Frankl. Narr. 763.

C. alpina, var. *nigrescens*, Olney, Prelim. Cat. Wheeler's Pl. 53.

From Isle Royale, Lake Superior, and the mountains of Colorado and Oregon, to Arctic America. Europe. Asia.

Var. HOLOSTOMA.

C. holostoma, Drej. Revis. Crit. Car. 29.

Differs from *C. alpina* chiefly in its beakless perigynium. — Greenland, *Fries*, *Warming* & *Holm*, etc.

51. Carex Mertensii, Prescott, Bong. Veg. Sitcha in Mem. Acad. St. Petersb. vi. ser. ii. 168.

Culm two feet high, rough on the very sharp angles, very leafy: leaves short, broad, and flat, loosely and conspicuously sheathing, rough: bracts leaf-like, sheathless or nearly so, the lower exceeding the culm: spikes five to eight, an inch or two long, very densely flowered, all more or less staminate at the base, the upper one conspicuously so, all drooping on filiform scabrous peduncles: perigynium very flat and very broadly ovate, winged, very thin in texture, green or whitish, few-nerved, appressed, much longer and broader than the purple white-ribbed scale: stigmas mostly 3. — Named for Karl Heinrich Mertens, 1796–1830, of St. Petersburg, who made a botanical voyage around the world. — Marais Pass, Montana, *Canby;* Oregon, *Cusick*, *Hall* 599, *Henderson;* Washington Terr., *Lyall*, and northward to Sitka, *Mertens*.

52. Carex atrata, Linn. Sp. Pl. 976.

White Mts., N. H., and high mountains of Wyoming, Colorado, Utah, Arizona, and California, and northward. Europe. Asia.

Var. nigra, Boott, Ill. 114.

C. nigra, All. Fl. Ped. ii. 267.

Westward with the last. Europe.

Var. ovata, Boott, Ill. 114.

C. ovata, Rudge, Linn. Trans. vii. 96, t. 9.

Mountains of Colorado and Utah southward; Newfoundland, Rudge, the original locality, but not since found there, so far as I know.

Var. erecta, W. Boott, Bot. Calif. ii. 239.

High mountains of Nevada and California.

53. Carex Gmelini, Hooker, Bot. Beechey's Voy. 118, t. 27.

Differs from *C. Buxbaumii*, to which it is very closely related, by its shorter and thicker spikes, which are peduncled and darker colored, the ferrugineous and smooth (not granulated) perigynium and the hispid awn of the scale. — Named for Johann Georg Gmelin, of St. Petersburg, 1719–55, author of *Flora Sibirica.* — Oregon, according to Boott, to Alaska, *Herb.* Siberia.

54. Carex Buxbaumii, Wahl. Köngl. Acad. Handl. xxiv. 163.

Bears the name of Johann Christian Buxbaum, an early European botanist, 1693–1730. — Bogs throughout, from Georgia northward and across the continent. Europe.

B. *Rigidæ*, Fries, Summa, 72. (*Cæspitosæ*, Fries, l. c. *Stylosæ*, Bailey, Coulter's Man. 387.) Mostly stiff and rigid species, largely alpine or boreal, with short and erect very closely flowered spikes, an entirely staminate terminal spike, and bracts possessing purple or black auricles at their base. — Species ranging from six to eighteen inches high, rarely higher. The typical form of *C. vulgaris* may be taken as the type of the group.

* *Stigmas three*, or in *C. heteroneura* perhaps often two.

55. CAREX BIFIDA, Boott; Olney in Proc. Am. Acad. vii. 394.

Much like *C. Buxbaumii.* Culm two or three feet high, sharply angled, smooth or nearly so: leaves two lines broad, pale, mostly shorter than the culm: bracts narrow, sheathless, the lowest leaf-like and exceeding the culm: pistillate spikes two to five, very short and thick (usually about a half-inch long), sessile and contiguous, somewhat glaucous: perigynium triangular-ovate, pale green, punctate, conspicuously nerved, the orifice cleft and the teeth ciliate, longer and broader than the purple white-ribbed, obtuse or muticous scale. Terminal spike rarely bearing a few pistillate flowers above. — California: Salinas Valley, in rather dry soil, *Brewer* 574; Pacheco Pass, Santa Clara Co., *Bolander* 4837; Red Mountains, Humboldt Co., *Bolander* 6476; Yreka Co., *E. L. Greene.*

56. CAREX HETERONEURA, W. Boott, Bot. Calif. ii. 239.

Culm slender but erect, nearly two feet high, sharply angled, scabrous or smooth: leaves narrow (two lines or less broad), flat, shorter than the stem: lower bract leaf-like, nearly as long as the culm, sheathless: pistillate spikes small (about a half-inch long and three lines or less broad), sessile or the lower ones on very short peduncles, more or less contiguous, whitish or yellowish: perigynium oval, smooth, straw-colored, few-nerved or nerveless, thin in texture, produced abruptly into a very short beak which is slightly emarginate, longer and broader than the obtuse or muticous purple white-ribbed scale. If the terminal spike were androgynous the species would strongly resemble *C. atrata*, var. *erecta*, although the perigynia are narrower and not so flat as in that variety. Variable in the nerving of the perigynia. — California, in the Sierras, *Bolander;* from Lake Tahoe to Bear River, *Kellogg;* Cœur d'Alene Lake, N. Idaho, *Watson* 437.

57. CAREX RAYNOLDSII, Dewey, Sill. Journ. xxxii. 39.

C. Lyallii, Boott, Ill. 150, t. 483.

Named for Capt. W. F. Raynolds, of an early government exploring expedition. — Mountains from Wyoming and Montana to California and Washington Territory.

58. CAREX PARRYANA, Dewey, Sill. Journ. xxviii. 239.

C. arctica, Dewey, l. c.

C. Hallii, Olney, Hayden's Rep. 1871, 496.

Bears the name of Capt. Parry, the Arctic explorer. — South Park, Colorado, *Wolf*, *Hall & Harbour* 617, and northward to Hudson's Bay. Rare.

59. CAREX STYLOSA, C. A. Meyer, Act. Acad. St. Petersb. i. 222, t. 12.

C. nigritella, Drejer, Revis. Crit. Car. 32.

Culm slender but erect, a foot or a foot and a half high, scabrous: leaves narrow (scarcely exceeding a line or a line and a half), mostly shorter than the culm: staminate spike one, an inch or less long, slender, very short-stalked: pistillate spikes two or three, a half-inch or less long, the lowest on a slender peduncle an inch or less in length, the others sessile or nearly so: lowest bract nearly or quite equalling the culm: perigynium turgid-ovate, fuscous, minutely punctate, nerveless, the entire orifice closed with the stiff and persistent style from which the stigmas are caducous, longer than the very obtuse black white-ribbed scale. A pretty species. — Fox Harbor, Labrador, *Allen;* Greenland, *Vahl;* Sitka, *Bongard*, *Mertens*.

Var. VIRENS.

Stouter: leaves broader: spikes all closely sessile and much thicker: perigynium green, much broader than in the species and the scales much narrower. Perhaps a good species. — Sauvie's Island, Oregon, and Mt. Adams, Washington Territory, at 5,000 feet, *Howell*.

60. CAREX TOLMIEI, Boott, Hook. Fl. Bor.-Am. ii. 224.

C. vulgaris, Olney, Proc. Am. Acad. 1872, 407.

Culm rigid, a foot to foot and a half high, triquetrous, smooth or nearly so: leaves ordinary, rough on the margins, mostly shorter than the culm: lower one or two bracts leafy and about equalling the culm, sheathless: spikes four to six or seven, the uppermost an inch or less long, staminate and mostly short-peduncled, the others mostly contiguous, oval or oblong (three fourths inch or less long), dark-colored, often staminate at the apex, the two or three lowest on slender peduncles an inch or two long, the others sessile: perigynium compressed-trigonous, oval or oval-oblong, pale and more or less discolored with purple dots, lightly nerved, produced into a very short and entire cylindrical beak, either longer or shorter than the obtuse or muticous purple white-ribbed scale. — Tolmie was an Indian trader and early botanical collector. — Columbia River, *Tolmie;* Oregon, *Hall* 597; Northwest Coast, according to Boott; Behring Straits, Langsdorff. Kamtschatka, Wright.

61. CAREX NIGELLA, Boott, Hook. Fl. Bor.-Am. ii. 225.

Smaller than the last: staminate spikes usually more than one: perigynium elliptical, the orifice bidentate: scales lanceolate and mucronate. — Columbia River, Tolmie.

* * *Stigmas two,* or very rarely a specimen may bear a few flowers with three stigmas.

62. CAREX CÆSPITOSA, Linn. Fl. Suec. ed. ii. 333.

C. Pacifica, Drejer, Fl. Ex. Hafn. 292.

C. Drejeri, Lang, Fl. Ratisb. 548.

Differs from *C. vulgaris* in its always single staminate spike, its short pistillate spikes (three fourths inch or less long), which are closely sessile and contiguous, and its round or ovate, gibbous, entirely nerveless, somewhat squarrose, pale perigynium. — Said by Boeckeler to occur in British America, and by Drejer to occur in Greenland. Specimens collected by Dr. Gairdner in Oregon and by Dr. Richardson on the arctic coast were referred here by Dr. Boott, but the specimens are too young for satisfactory identification. No. 593 of Hall's Oregon collection, distributed as *C. cæspitosa*, is *C. acuta*, var. *pallida*. Europe.

Var. FILIFOLIA, Boott, Ill. 182.

C. aperta, var. *angustifolia*, Boott, Hook. Fl. Bor.-Am. ii. 218.

Culms weak, often with basal sheaths somewhat reticulated: leaves weak and slender, more or less involute, about as long as the culm: spikes dark-colored, slender: perigynium more or less ovate, obscurely nerved, deciduous. — Fort Good Hope, Mackenzie's River, lat. 67°, *Dr. Richardson;* Cascade Mts., lat. about 49°, *Dr. Lyall*, a stouter form. The materials are far too scanty to allow of a satisfactory estimate of any of the American representatives of this species.

63. CAREX VULGARIS, Fries, Mant. iii. 155.

C. cæspitosa, Gooden. Linn. Trans. ii. 195, t. 21.

C. Goodenovii, Gay, Ann. Sci. Nat. 2d ser. xi. 191.

C. antucensis, Kunze, Suppl. Riedgr. 50, t. 13.

C. turfosa, Fries, Summa, 228.

C. limula? Gray, Man. 5th ed. 582.

Newfoundland, *Thaxter*, to New England and Wisconsin; Twin Lakes, Colorado, *Wolf;* Alaska, *Herb.*

Var. JUNCELLA, Fries, Summa, 230.

C. Kelloggii, W. Boott, Bot. Calif. ii. 240.

Wahsatch Mts., Utah, *Watson, Jones;* Union Co., Oregon, *Cusick*, and in British America, *Macoun.*

Var. HYPERBOREA, Boott, Ill. 167.

C. Bigelovii, Torr.; Schwein. An. Tab.

C. Washingtoniana, Dewey, Sill. Journ. x. 272.

C. saxatilis, Dewey, Wood's Bot. ed. i. 581.

C. saxatilis, var. *Bigelovii*, Torr. Monogr. 397.

C. hyperborea, Drej. Revis. Crit. Car. 41.

C. rigida, var. *Bigelovii*, Tuckerman, Enum. Meth. 19.

C. limula, Fries, Summa, 229.

C. dubitata, Dewey, Wood's Bot. 1861, 755.

White Mountains to Greenland; Mountains of Colorado and N. California to Alaska.

Var. ALPINA, Boott, Ill. 167.

C. rigida, Gooden. Linn. Trans. ii. 193, t. 22.

C. saxatilis of Scand. authors, not Linn.

Westward with the last.

Var. BRACTEOSA.

Culm slender, a foot or more high, rough, erect, bearing a long and leafy auricled bract about equalled by the flat pale leaves: pistillate spikes two or three, small and globular, black or nearly so, sessile, the one or two upper ones adjoining the small staminate spike (which is a half-inch or less long), the lowest one sometimes remote and borne in the axil of the long bract: perigynium much as in var. *alpina*, but smaller. — Ebbett's Pass, California, alt. 8,000 feet, *Brewer* 2015.

64. CAREX DECIDUA, Boott, Linn. Trans. xx. 119.

C. Andersoni, Boott, Hook. Fl. Antarct. ii. 364.

See Bot. Gaz. x. 204 (plate). — Differs from *C. vulgaris* as follows: spikes heavier: scales and perigynia deciduous: perigynium conspicuously stipitate and strongly nerved. — California, Thurber, according to Boott; Oregon, *Herb.* Founded upon specimens from Terra del Fuego and the Falkland Islands.

65. CAREX NUDATA, W. Boott, Bot. Calif. ii. 241.

Distinguished from *C. vulgaris* by its fibrillose sheaths and deciduous perigynium, and from both that species and *C. decidua* by its long and thin finely punctate, lightly nerved perigynium, which is empty in the upper half. Not well defined. The perigynia are often straw-colored and somewhat inflated. The fibrillose sheaths are conspicuous, a character which is supposed never to occur in *C. vulgaris*. Northern Lower California, *Orcutt*, to Trask River, Oregon, *Henderson*.

C. *Acutæ*, Fries, Corp. 191. (*Prolixæ* and *Salinæ*, Fries, Summa, 71. *Aquatiles*, Fries, l. c. 72.) Species mostly larger than in the last group, mostly paludose, with green or light-colored large and long spikes; stigmas two. — Distinguished from the Rigidæ mostly by habit. One of the species, *C. subspathacea*, is small and boreal. *C. stricta* and *C. aquatilis* may be taken as types of the group. Some of the species bear more or less conspicuous auricles at the base of the bracts.

66. Carex Hallii.

C. elata and *C. decidua*, Olney, Proc. Am. Acad. 1872, 407.

Culm sharply angled and rough, strict (eighteen inches to two feet high), longer than the narrow rough-margined leaves, the base purple-sheathed and enclosed in reticulated fibres: bracts all serrate on the margins, sheathless, the lower more or less leafy and often prolonged as high as the culm, the upper setaceous: spikes sessile, about five, the terminal staminate and usually more or less stalked, the others closely sessile and short: scales of the staminate spike very broad and obtuse, often emarginate, purplish-black: perigynium flat, almost white, elliptic with contracted ends, prominently few-nerved, smooth, the beak very short and entire but conspicuous, either much exceeding or about the length of the very obtuse black scale. — Oregon, *Hall* 594 and 598. In the latter specimen the white perigynia are much longer than the hidden scales, and the scales are less obtuse than in no. 594, which I take as the type. Distinguished at once from *C. senta*, Boott, by the broad and obtuse scales and smooth perigynia.

67. Carex senta, Boott, Ill. 174.

Culm nearly two feet high, very rough on the sharp angles: leaves usually less than the culm, narrow, very rough on the margins: spikes about three, the terminal staminate and more or less stalked with long-linear and acute white-nerved scales, the others pistillate, sessile, an inch or so long, the lowest subtended by a short and very rough bract: perigynium flat, ovate, pointed, several-nerved, serrate on the margins above, the orifice entire, broader and longer than the narrow and acute or muticous scale. — California, Santa Inez Mts., 20 miles northeast of Santa Barbara, *Brewer* 350, and Santa Susanna Mts., *Brewer* 218. (The no. 218 was referred to *C. Jamesii* in Bot. Calif.)

68. Carex invisa.

C. podocarpa, W. Boott, Bot. Calif. ii. 245, excl. descr.

Culm fifteen inches to two feet high, sharply angled, erect, smooth: leaves nearly as long as the culm, two lines wide, roughish on the margins, short-pointed: spikes four or five, all sessile or the two lowest on short peduncles and erect, oblong and somewhat narrowed at base (an inch long) or short and nearly globular, the upper one or two staminate and short, the others all approximate or contiguous and pistillate: bracts short and sheathless: perigynium elliptic-ovate, prominently few-nerved, green and over-colored with black-purple blotches, flat, very short-pointed, the orifice entire or nearly so, broader and commonly a little longer than the black-purple and very conspicuously white-nerved apiculate scale. Varies somewhat, especially in the length of the spikes and the coloring of the scale. The aspect of the spikes is much like that of the spikes of *C. luzulæfolia* and *C. frigida*. The sheathless bracts at once distinguish it from those species. The spikes in some of the immature forms of *C. Mertensii* closely resemble those of *C. invisa*. — California: Summit Camp, *Kellogg*, the type growing "in exceedingly tough and matted clumps," Ebbett's Pass, *Brewer* 2084 and 2076, Big Trees, *Hillebrand*, Lassen's Peak above snow, *Brewer* 2186 (a globular-spiked form), Carson Pass, *Brewer* 2126; Selkirk Range, British Columbia, *Macoun*.

69. Carex laciniata, Boott, Ill. 175, t. 594.

C. Wilkesii, Torr. Bot. Wilkes Exped. 477, t. 17.

Culm stout and very sharply angled, rough, two feet to three and a half feet high: leaves stiff and carinate, pale, long: lower sheaths fibrillose: bracts sheathless, leaf-like, the lowest very long: spikes four to six, mostly long (two or three inches, rarely an inch), evenly cylindrical and densely flowered, commonly short-peduncled or the upper ones sessile, erect or somewhat cernuous (the lowest often long-peduncled), yellowish or fuscous: perigynium oval or ovate or nearly orbicular, more or less obscurely nerved, often minutely serrate on the margins above, spreading, abruptly contracted into a short entire or short-toothed beak, much broader and usually shorter than the purple broadly white-nerved and hispid aristate scale. — In the coast ranges and near the sea from Santa Barbara, California, to Rogue River at Grant's Pass, Oregon, *Howell*. Perhaps also in Provo Cañon, N. Utah, *Watson* 1245.

70. Carex ultra.

C. hispida, W. Boott, Bot. Gaz. ix. 89, in part.

Culm stout and rigid (two to three feet high), rather obtusely 3-angled, smooth: leaves a fourth inch or more wide, rigid, pale, as long as the culm or longer, carinate, the margins serrate: lower bract leafy, short-sheathed, the upper very abruptly pointed from a broad and clasping base and shorter than the spike: spikes six to eight, all long (two to six inches) and erect, the three or four upper ones staminate and either aggregated or scattered, the others pistillate, sessile, or the lower short-stalked: perigynium ovate or elliptic, flat, pale, usually sprinkled with ferruginous dots, nerveless or nearly so, smooth, ending abruptly in a short and straight entire beak, broader and either longer or shorter than the narrow white-ribbed acute scale. — A stouter plant than *C. laciniata*, with broader leaves which are very conspicuously serrate, shorter bracts which clasp the bases of the spikes, larger spikes, the staminate more numerous, the perigynia pale and the scales not aristate. — S. Arizona, *Lemmon* 2901, 2902, also coll. of 1880.

71. Carex Jamesii, Torrey, Monogr. 398.

Bears the name of Dr. E. James, botanist to Long's Exploring Expedition. — Colorado, Utah, Nebraska, and Oregon, and probably *Brewer* 1970 from Silver Valley, California.

Var. Nebraskensis, Bailey, Carex Cat. Suppl.

C. Nebraskensis, Dewey, Sill. Journ. xviii. 102.

Colorado and Utah and southward.

72. Carex aquatilis, Wahl. Köngl. Acad. Handl. xxiv. 165.

From New England across the continent and northward.

Var. epigeios, Læstadius, Vet. Ac. Handl. 1822, 339.

C. borealis, Lang, Syll. 398.

C. anguillata, Drej. Rev. Crit. Car. 36.

C. stans, Drej. l. c. 40.

C. aquatilis, var. *sphagnophila*, Anderss. Cyp. Scand. 46.

C. aquatilis, var. *minor*, Boott, Ill. 163.

From Colorado to the Arctic Coast and Greenland.

73. Carex stricta, Lamarck, Dict. de Bot. iii. 387.

C. acuta, Muhl. Descr. Gram. 263; Torr.

C. Virginiana, Smith, Rees' Cycl. vii. sp. 100.

C. stricta, Dewey, Sill. Journ. x. 269.

C. commutata, Gay, Ann. Sci. Nat. 2d ser. xi. 198.

C. angustata, Boott, Hook. Fl. Bor.-Am. ii. 218.

C. strictior, Dewey, Wood's Cl. Book, 755.

C. Watsoniana and *C. Kelvingtoniana*, Steudel, Cyper. Plant. 215.

C. xerocarpa, S. H. Wright, Sill. Journ. 2d ser. xlii. 334.

C. Virginiana, var. *elongata*, Boeckeler, Linnæa, xl. 432.

Immensely variable. — New England to Georgia and across the continent to California; Texas, *Wright*. Specimens from British Columbia, *Macoun*, are probably to be referred here.

Var. EMORYI.

C. Emoryi, Dewey, Bot. Mex. Bound. 230.

C. acuta, var., Reverchon's distr. Texan pl. 1407.

Spikes more numerous (six to eight), more densely flowered, mostly obtuse if not staminate at the apex, all or the lowest subtended by very long and leaf-like bracts. — Texas; margins of Blanco River, *Wright*, New Braunfels, *Lindheimer*, "along the streams, Cherokee Creek, Llano Co.," *Reverchon*. Wright's specimens, upon which Dewey founded the species, bear much longer and more leafy bracts than the other specimens which I have seen.

C. STRICTA + SALINA (*C. spiculosa?*, W. Boott, Bot. Gaz. ix. 88. "*Forma sterilis salinæ*," Christ, Cat. Car. Eur. 7). Brackish marshes near Boston, Mass., *W. Boott*, *Morong*.

74. CAREX APERTA, Boott, Hook. Fl. Bor.-Am. ii. 218, t. 219.

C. Haydenii, Dewey, Sill. Journ. xviii. 103.

C. aperta, var. *minor*, Olney, Exsicc. fasc. v. no. 15.

Apparently not common. A smaller plant than *C. stricta*, with shorter spikes and very conspicuous spreading scales. — Northeastern United States; also Oregon, Washington Terr., and Idaho, from several collectors. Founded upon specimens from the far Northwest. Perhaps the eastern United States plant is not *C. aperta*.

Specimens from Colorado from several collectors appear to combine characters of *C. aquatilis*, *C. stricta*, *C. aperta*, and *C. interrupta*. At different times I have referred these specimens to different species. Four different specimens collected last year by H. N. Patterson I named *C. aquatilis*. Specimens collected in 1872 by C. C. Parry evidently belong to the same species with Patterson's, and Olney says that *Hall & Harbour* 616 is the same as Parry's. No. 582 of Powell's Expl. Exped. is the same. I am now at a loss to make any satisfactory determination of any of these specimens.

75. CAREX INTERRUPTA, Boeckeler, Linnæa, xl. 432.

C. angustata, var. *verticillata*, Boott, Hook. Fl. Bor.-Am. ii. 218.

C. verticillata, Boott, Ill. 67, t. 183, f. 2, not Zoll. & Mor.

Differs from *C. aperta* and *C. stricta* in its stoloniferous habit, nearly smooth and shorter culm, its more approximated spikes which are usually much attenuated at the base, the appressed and obtuse or muticous scales, and especially in the small perigynium which is about three fourths of a line long and half a line wide. — Oregon, *Scouler*, *Howell*, *Henderson*, etc.

76. Carex lenticularis, Michx. Fl. Bor.-Am. ii. 172.

C. concolor, R. Br. Suppl. App. Parry's Voy. 218?

C. lenticularis, vars. *Albi-montana* and *Blakei*, Dewey, Wood's Bot. 1860, 755.

Labrador, lat. 51½°, *Allen*, *Storer;* N. Maine, *Blake*, *Smith;* White Mts., *Pringle*, etc.; Mt. Mansfield, Vt., *Pringle;* Northern New York to N. Michigan, *Loring*, and Isle Royale, *Porter;* Saskatchewan, *Bourgeau*, and northward to Bear Lake, *Richardson;* Washington Terr., *Lyall;* California in the Sierras, Yosemite, *Bolander*, Silver Lake, *Brewer*.

77. Carex acuta, Linn. Sp. Pl. 1388.

C. aperta, var. *divaricata*, Bailey, Bot. Gaz. ix. 119, in part.

Plant pale and mostly very smooth: culm erect, eighteen inches to two feet high, smooth or rough above: sheaths destitute of fibrillose reticulations: leaves flat and thin, about as long as the culm, mostly loose in aspect: the lower one or two bracts flat and leaf-like, about equalling the culm, the margins mostly serrate, often very conspicuously so: spikes four or five, the upper one or two staminate, all approximate and erect or very nearly so, all sessile or the lower short-peduncled (one to three inches long, one fourth inch thick): perigynium thin and soft and somewhat inflated, yellowish, granulated, nerved, the small beak entire, broader and either shorter or longer than the dark obtuse or muticous scale. — Oregon, Portland, *Kellogg & Harford* 1081, Deschutes River, *Howell* 935, base of Mt. Hood, *L. F. Henderson;* Sitka, Mertens, fide Boeckeler; Greenland, according to Drejer, probably in some of its boreal varieties if at all. Europe.

Var. prolixa, Hornem. Plantel. ed. iv.

C. prolixa, Fries, Mant. iii. 150.

Leaves narrower and shorter, not so flat, more rigid: spikes all peduncled or the upper one sessile, the lower more or less cernuous, an inch or inch and a half long and nearly one fourth inch thick when mature: scales very slender and produced into a point which surpasses the more or less ferruginous perigynium. — Oregon, Sauvie's Island, *Howell*, along the Willamette and Columbia Rivers, *Henderson;* bottom lands of Columbia River, Klikitat Co., Washington Terr., *Suksdorf*. — Although the plant does not agree in all characters with Scandinavian specimens, I refer it here pending the accumulation of more material. This is the "hay carex" of the Columbia. It forms whole meadows, and its second growth produces hundreds of tons of excellent hay. Probably the most valuable plant of the genus. Often mistaken for *C. cryptocarpa*, small forms of which it very closely resembles. It differs from that species in its shorter peduncles (the upper two or three not over a half-inch long) and its nearly erect upper spikes, its nerveless perigynium which is sprinkled with ferruginous dots, and the much shorter scales (seldom over half as long again as the perigynium).

Var. PALLIDA, Boott, Ill. 166.

C. cæspitosa, Olney, Proc. Am. Acad. 1872, 407.

Spikes shorter and narrower than in the species, often an inch or less long, "pale from the predominance of the perigynia over the squamæ": perigynium greenish, strongly nerved, resembling that of *C. lenticularis*. — Oregon, Lyall, *Hall* 593; Summit Camp, Calif., *Dr. Kellogg;* and probably also specimens distributed as *C. lenticularis* by Olney from Maine, coll. by *Blake* or *Porter*. Little known; probably to be associated with some other species.

78. *Carex glauca*, Scopoli, Fl. Germ. 455.

Glaucous: culm smooth, a foot or two high, erect: leaves mostly shorter than the culm, narrow, more or less rigid, carinate; lower bract leafy: spikes densely cylindrical, all peduncled, nodding: perigynium round-ovate, lightly nerved, clothed with short hairs or granulated, broader and either longer or shorter than the dark mostly obtuse scale. — Nova Scotia, *Macoun*, Windsor, 1868, *Fowler;* London, Ontario, Burgess. Introduced from Europe.

79. CAREX BARRATTII, Schweinitz & Torrey, Monogr. 361.

C. flacca, Carey, Gray's Man. 1848, 549; Chapm. Flora, 542.

"*C. littoralis*, Schw.," Olney, Exsicc. fasc. i. no. 17.

Named for Dr. Joseph Barratt, of Middletown, Conn., a critical student of the sedges and willows. — Marshes near the coast from New Jersey to North Carolina.

80. CAREX TORTA, Boott; Tuckerman, Enum. Meth. 11; Ill. 63, t. 169.

Var. *composita*, Porter; Olney, Exsicc. fasc. iii. no. 6.

Northern New England to North Carolina, in cold swamps and along the mountains. Local.

81. CAREX PRASINA, Wahl. Köngl. Acad. Handl. xxiv. 161; Fl. Lapp. 249.

C. miliacea, Muhl.; Willd. Sp. Pl. iv. 290.

Meadows and bogs, Vermont to Georgia.

82. CAREX SALINA, Wahl. Fl. Lapp. 246.

C. cuspidata, Wahl. Köngl. Acad. Handl. xxiv. 164.

C. stricta, Hook. & Arn. Bot. Beechey's Voy. 131.
C. recta, Boott, Hook. Fl. Bor.-Am. ii. 220, t. 222.
C. hæmatolepis, Drej. Rev. Crit. Car. 44.

Wahlenberg's original *C. salina* was reduced by himself to the var. *mutica*, and the more developed form elevated to be the type in Flora Lapponica. — In salt marshes near the coast, from Boston to Labrador; about Hudson's Bay according to Boott, Kotzebue's Sound, *Herb.* N. Europe.

Var. MUTICA, Wahl. Fl. Lapp. 246.
C. salina, Wahl. Köngl. Acad. Handl. xxiv. 165.
C. lanceata, Dewey, Sill. Journ. xxix. 249.
C. reducta, Drej. Rev. Crit. Car. 36.
C. salina, var. *minor*, Boott, in part, Ill. 160, t. 528.

Distinguished from the species by its smaller size (ranging in height from six to eighteen inches), narrow leaves, few spikes which are slender and often loosely flowered and usually sessile or nearly so, its narrow fewer-nerved elliptical or ovate-lanceolate perigynium, and the shorter muticous scale. — British America, Cumberland House and Hudson's Bay, *Drummond*, and probably no. 4702 *Bolander* from Mendocino City, Calif.; Greenland, Drejer. N. Europe.*

83. CAREX SUBSPATHACEA, Wormskjold, Fl. Dan. ix. 4, t. 1530 (1818).
C. Hoppneri, Boott, Hook. Fl. Bor.-Am. ii. 219, t. 220.

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* CAREX AMBUSTA, Boott, Ill. 64, t. 172 (*C. salina*, var. *ambusta*, Bailey, Carex Cat.). Dr. Boott proposed this species upon a plant from Herb. Prescott without a habitat, venturing the opinion that it came from Sitka or its neighborhood. Later on in his Illustrations he expressed the opinion that it is inseparable from *C. salina*, and I consequently made it a variety of that species in my preliminary catalogue. Last year I received, through Dr. Geo. Vasey, a peculiar Carex from Ungava Bay, N. Labrador, collected by L. M. Turner. It resembled *C. saxatilis* very closely in general habit, but differed widely in the character of its perigynia. A subsequent search through the Gray Herbarium discovered among the specimens of *C. saxatilis* other plants from near the Western coast to match the Labrador specimens. These plants are to be referred to *C. ambusta*, to be distinguished from *C. saxatilis*, which they imitate closely, by the nearly lanceolate, long-pointed and spreading perigynia, which possess none of that shining, papery, and inflated appearance so characteristic of that species, and by the long and often weak peduncles of the pistillate spikes. I see no reason for uniting this plant with *C. salina*. I had at first thought it to be a good species, but recent material leads me to think that it is a form of *C. physocarpa*. The specimens which I have referred here are from Sitka, *Dr. Mertens*; Unalaska, *Harrington;* Northern British Columbia, *Rothrock;* Ungava Bay, N. Labrador, *Turner*.

C. salina, var. *subspathacea*, Tuckerman, Enum. Meth. 12.

C. salina, var. *minor*, Boott, in part, Ill. t. 529 and 530.

The most reduced of the Acutæ. Culm one to six inches high, rigid, smooth, shorter than the very narrow stiff leaves: staminate spike one, usually more or less peduncled: pistillate spikes one to three, a half-inch long or less, sessile or very nearly so in the axils of sheathless bracts (rarely a short sheath in the lower bract of large specimens): perigynia ovate, more or less nerved, usually exceeding the obtuse or barely pointed scale. — Cumberland House and Hudson's Bay, *Herb.;* Greenland, Wormskjold, etc. Shores of the White Sea.

D. *Cryptocarpæ*, Tuckerman, Enum. Meth. 11. (*Spiculosæ*, Fries, Summa, 71. *Maritimæ*, Nyman, Consp. Fl. Eur. 776. *Incisæ*, Olney, Exsicc. fasc. iii.) Large species with cernuous or drooping large spikes which bear very long and conspicuous mostly dark scales; stigmas two.

84. CAREX CRYPTOCARPA, C. A. Meyer, Mem. Acad. St. Petersb. i. 226, t. 14.

C. Scouleri, Torr. Monogr. 399.

C. filipendula, Drej. Rev. Crit. Car. 46.

C. salina, Boott, Hook. Fl. Bor.-Am. ii. 219.

Culm two feet or more high, sharply angled, smooth or rough just below the spikes; leaves ordinary, narrow and flat: spikes all drooping on filiform peduncles from one to three inches long, a half-inch or more of the apex staminate, rather lax-flowered, especially at the base, very dark brown or black, two inches or less in height, and varying from broadly oblong (one inch by one third inch) to narrowly cylindrical (two inches by one fifth inch): staminate spikes two or three, the lateral ones usually peduncled: perigynium oval or oboval, yellowish, lightly nerved, contracted into a very short and entire beak, twice or thrice shorter than the lanceolate dark brown or black scale. Variable. Not well understood. — Oregon to Alaska; Greenland. Adjacent Asia. Norway.

85. CAREX SITCHENSIS, Prescott, in Bongard's Obs. Sitcha in Mem. Acad. St. Petersb. ser. 6, ii. 168.

Larger and much stouter than the last, two to five feet high, the culm very sharply angled, rough above or throughout on the angles: leaves very long and rigid and carinate: spikes long and thick (three or four inches long and one third inch thick), often bending over, more densely flowered and comparatively shorter peduncled: lateral staminate spikes sessile: perigynium nerveless and hard: scales much as in the last, only blunter. The aspect of the spikes is variable, owing to the size of the scales. They often closely resemble thick spikes of *C. crinita.* — Along the coast, from San Francisco to Alaska.

86. Carex Barbaræ, Dewey, Bot. Mex. Bound. 231.

C. Schottii, Dewey, l. c.

C. Prescottiana, Olney, Bot. King's Rep. 369; W. Boott, Bot. Calif. ii. 244.

Slender and lax but mostly erect, two feet or more high, glaucous: leaves surpassing the culm: bracts leafy: pistillate spikes four or more, very long-linear (three to eight inches long), cernuous, more or less slenderly peduncled: scales dark, obtuse or muticous: perigynium small, appressed, pale, more or less attenuated below, abruptly contracted into a short and entire beak, nearly nerveless, shorter than the scale. Known only from a few imperfect and immature specimens. Its lax habit and very much prolonged linear spikes are its best known characters. The Oregon plant is the most mature of any. Its scales are narrower than in the other specimens. — "Banks of streams, Santa Barbara, Cal.," *Parry*, 1850, the original station for *C. Barbaræ* and *C. Schottii;* Los Angeles, Calif., *Prof. Wood*, ex. Herb. Dewey; Nasqually, Oregon, *Wilkes Exped.* 308; and according to Olney (King's Rep. 369), "Indian Territory on the False Washita, between Fort Cobb and Fort Arbuckle, Dr. Palmer." One of Hayden's Nebraska plants was named *C. Barbaræ* by Dewey, but Olney declares that it is not the same as the original species. I have seen this plant, and although it appears to accord with the description of *C. Barbaræ* it is probably a large immature *C. Jamesii.*

87. Carex maritima, Müller, Fl. Dan. t. 703.

C. paleacea, Wahl. Köngl. Acad. Handl. xxiv. 164.

Salt marshes along the coast, from Boston to Newfoundland and Hudson's Bay. Europe.

88. Carex crinita, Lamarck, Dict. de Bot. iii. 393.

C. paleacea of authors, not Wahl.

C. crinita, var. *paleacea*, Dewey, Sill. Journ. x. 270.

C. Mitchelliana, M. A. Curtis, Sill. Journ. xliv. 84.

C. crinita, var. *minor*, Boott, Ill. 18.

C. Porteri, Olney, Exsicc. fasc. v.

C. crinita, var. *angusta*, Olney, l. c.

Canada to Florida and Texas.

Var. gynandra, Schweinitz & Torrey, Monogr. 360.

C. gynandra, Schwein. An. Tab.

C. crinita, var. *Caroliniana*, Olney, Exsicc. fasc. iii. no. 8.

Too near the species. — New England to Michigan and Florida.

89. Carex verrucosa, Muhl. Descr. Gram. 261.

C. glaucescens, Ell. Sk. Bot. ii. 553.

C. glaucescens, var. *androgyna*, Curtis, Sill. Journ. xliv. 84, and var. *polystachya*, Sill. Journ. 2d ser. vii. 410.

Margins of ponds, mostly in pine barrens, Virginia to Florida and Texas.

90. Carex Ehrenbergiana, Boeckeler, Linnæa, xli. 175.

"Somewhat glaucous-green: culm strict and very rigid (one to two and a half feet high and as thick as a fowl's quill), acutely angled, scabrous above: leaves very rigid, shorter than the culm (one to two and a half lines wide), shortly acuminate, carinate, many striate, rough above, the margins somewhat revolute: spikes 7–10, red-ferruginous, all more or less peduncled, narrowly cylindrical, acutish, densely flowered (one to four feet long and two to two and a half lines wide), the upper two or three staminate, crowded and nodding with the two lowest of them often short, the others approximate, androgynous, with the staminate flowers borne on the prolonged apex, borne in twos or threes (the lowest solitary), and long exsertly peduncled, some of the lower ones more or less branched at the base: bracts leafy, nearly sheathless, the lower about equalling the culm: scales broadly ovate or oval, obtuse or muticous, or the keel sometimes prolonged into a short cusp, dark-colored, spreading, as are also the perigynia: perigynium small (scarcely a line long), shorter than the scale, smooth and nerveless, broadly obovate or nearly orbicular, attenuated at the base, pale straw-colored, punctate with resinous dots, ending abruptly in a short, nearly entire beak: stigmas three or two." Transition to the Polystachyæ. — Mexico, C. Ehrenberg.

91. Carex scaberrima, Scheele, Linnæa, xxii. 345.

Known only from Scheele's description: —

"Culm a foot or eighteen inches high, lax, triquetrous, striate, rough above: leaves flat, glabrous, elongated, three-nerved, striate, narrowly acuminate, the mid-nerve very rough, the sheaths transversely rugose-plicate: spikes five, linear-cylindrical, remote, the two upper short, obtuse, sessile, and staminate, the others longer, androgynous, and acute: androgynous spikes peduncled, densely many-flowered, staminate at the top, the lowest sub-radical, very long, the remainder very short, pedunculate: uppermost bract small, setaceous, the second long-awned with a green mid-nerve, shorter than the spike: pistillate scales ovate at the base, white-hyaline, lanceolate, the nerve excurrent, cuspidate-aristate, longer than the perigynium: staminate scales narrow, oblong, whitish, membranaceous, nerve green, very short, mucronate: perigynium rhomboid-obovate or rhomboid-oblong, glabrous, orifice toothed: stigmas two. Habit of *C. strigosa*, Huds. — Neu-braunfels, Texas, Roemer."

E. *Ferrugineæ*, Tuckerman, Enum. Meth. 12. (*Fuliginosæ*, Tuckerm. l. c. *Frigidæ*, Fries, Summa, 70.) Plants smaller and more slender than in the preceding groups; spikes small, an inch or less long, the upper ones often androgynous; perigynium tapering into a conspicuous point, often rough on the angles, dark-colored; bracts conspicuously sheathing; stigmas usually three. — A well-marked and peculiar group.

92. Carex frigida, Allioni, Fl. Ped. ii. 270.

C. sempervirens, Olney, Prelim. Cat. Wheeler's Surv.

Varies in the width of the leaves, thickness, and disposition of the spikes. Perigynium sometimes smooth. The American representatives of this species are not well understood. — Utah, Cottonwood Cañon, *Watson* 1255? "Pacific slope," *Parry*, 347; Oregon, *Hall* 600 and 601, *Henderson* (Mt. Hood), *Howell;* mountains about the head of Sacramento River, California, *Pringle.* Watson's 1255 may belong to *C. luzulæfolia.*

93. Carex luzulæfolia, W. Boott, Bot. Calif. ii. 250.

Distinguished from the last by its stouter culm and usually greater height (fifteen to thirty inches), its heavier spikes, and especially by the very numerous, loosely sheathing straw-colored thick and broad radical leaves (one fourth to one half inch broad), and the more leafy bracts. Perhaps a large form of the last. — California, in the Sierra Nevada at high altitudes: Summit Camp, *Dr. Kellogg*, Ebbett's Pass and northward, *Brewer*, nos. 2019, 2131, 1701, Yosemite, *Bolander* 6219; S. E. Oregon, *Cusick.*

94. Carex luzulina, Olney, Proc. Am. Acad. vii. 395.

Distinguished from *C. frigida* by the aggregated and sessile spikes, only the lower being distinct and exserted, and by the very broad-based and short bracts: perigynium apparently less spreading and broader than in *C. frigida.* — Mendocino City, California, *Bolander* 4740.

95. Carex gynodynama, Olney, Proc. Am. Acad. vii. 394.

Scales very broad and obtuse or the mid-nerve excurrent, mostly shorter than the perigynium, which is broader than that of *C. frigida*, very short-beaked and hairy on the upper half. — Mendocino City, California, *Bolander* 4700.

96. Carex petricosa, Dewey, Sill. Journ. xxix. 246, f. 70.

Founded upon very young specimens; consequently the characters are unknown. Five to eight inches high, rigid, culm smooth: leaves narrow (about a line wide), long-pointed, about the length of the culm: spikes three to five, oblong, erect, (four to ten lines long, one to two lines wide), the upper ones contiguous, the lowest one or two on exserted peduncles, the one or two uppermost all staminate or staminate at the apex: scales ovate, obtuse or nearly so, purple with a green rib: perigynium slightly hairy above, very short-beaked. The intermediate spikes often have staminate flowers at base or apex. — "Summit of the Rocky Mts.," *Drummond* 283 (lat. about 59°).

97. CAREX FRANKLINII, Boott, Hook. Fl. Bor.-Am. ii. 217, t. 218.

Culm stiff and tall (thirty inches or more high), obtusely angled, smooth or very nearly so, far surpassing the narrow and loose upright leaves: spikes six to eight, the five or six uppermost linear and crowded, either staminate at the apex or throughout, the two or three lowest ovate, more or less exserted, staminate at the apex: bracts short and narrow: perigynium ovate, very short-beaked, hairy on the angles above, longer than the broad and more or less obtuse scale. A fine species. Bears the name of the unfortunate Sir John Franklin. — Rocky Mountains, about lat. 59°, *Drummond.*

98. CAREX MISANDRA, R. Brown, Suppl. Parry's Voy. 283.

C. fuliginosa, Sternb. & Hoppe, Act. Soc. Bot. Ratisbon. i. 159, t. 3.

C. fuliginosa, var. *misandra*, Lang, Linnæa (1851), xxiv. 597.

C. misandra, var. *elatior*, Lange, Fl. Grœn. 140.

C. misandra is the more recent name, but Sternberg & Hoppe applied the name *C. fuliginosa* to this species thinking it to be the *C. fuliginosa* of Schkuhr, which is *C. frigida* of Allioni. The species was first distinguished by Robert Brown. — Varies greatly in height, from one inch to a foot, and in the shape and color of the spikes. Two or three spikes are sometimes borne in the upper sheath. — Gray's Peak, Colorado, *M. E. Jones*, *Patterson* ("in dense sod"), and throughout Arctic America.

99. CAREX ATROFUSCA, Schkuhr, Riedgr. 106, f. 82.

C. ustulata, Wahl. Köngl. Acad. Handl. xxiv. 156.

C. ustulata, var. *minor*, Boott, Ill. 71, t. 194.

Distinguished at once from *C. misandra* by the very flat and broadly ovate and abruptly beaked perigynium, which is usually broader and longer than the scale: spikes short and thick, mostly ovate or ovate-oblong, on peduncles an inch or less long: terminal spike staminate or androgynous. — Greenland according to Boeckeler. N. Europe.

F. *Pendulinæ,* Fries, Corp. 190. (*Limosæ* and *Ustulatæ,* Tuckerman, Enum. Meth. 12.) Differs from the last group in habit and in the sheathless bracts and whitish, more or less granulated, nearly pointless perigynium.

100. Carex podocarpa, R. Brown, App. Frank. Nar. ed. ii. 36.

C. macrochæta, C. A. Meyer, Mem. Acad. St. Petersb. i. 224, t. 13.

C. spectabilis, Dewey, Sill. Journ. xxix. 248, f. 76.

Culm one to two feet high, rather weak, roughish: leaves mostly shorter than the culm, the lower ones an inch or two long or reduced to mere sheaths at the base of the culm: spikes three to five, the staminate one or two, the others sometimes staminate at the top, an inch and a half or less long, and a fourth or a third inch thick, the lower one or two nutant on long peduncles, the upper ones more or less erect: scales black, usually produced into a long whitish thread-like awn (which is often a half-inch long!): perigynium elliptic-lanceolate (two to two and a half lines long and half a line or more broad), scarcely beaked, entire at the orifice, nerved, whitish and sprinkled with purple dots: stigmas often three. A very distinct species. *C. podocarpa*, Bot. Calif., is *C. invisa*, Bailey. Transition to the Cryptocarpæ. — Mountains of British America to Alaska. Adjacent Asia.

101. Carex Magellanica, Lamarck, Dict. de Bot. iii. 385.

C. irrigua, Smith in Hoppe, Caric. 92.

C. limosa, var. *irrigua*, Wahl. Köngl. Acad. Handl. xxiv. 162.

C. limosa, var. *irrigata*, Wahl. Fl. Lapp. 243, t. 15.

C. paupercula, Michx. Fl. Bor.-Am. ii. 172.

C. lenticularis, Dewey, Sill. Journ. vii. 273.

C. cernua, Phil. Linnæa, xxix. 83.

In peat bogs, Newfoundland, *La Pylaie*, to Pennsylvania, *Porter*, to Michigan and Minnesota; Uinta Mts., N. Utah, *Watson;* Arctic America according to Boott. S. America. Europe.

102. Carex rariflora, Smith, Engl. Bot. t. 2516.

C. limosa, var. *rariflora*, Wahl. Köngl. Acad. Handl. xxiv. 162.

Greenland, *Warming* & *Holm*, *Krumlein*, etc.; Labrador, *Allen*, *Storer;* Mt. Katahdin, Me., *Goodale;* St. Louis Co., Minnesota, *Sandberg*. Europe.

103. Carex limosa, Linn. Sp. Pl. 977.

C. laxa, Dewey, Sill. Journ. xxvi. 376.

C. limosa, var. *Painei*, Dewey, Sill. Journ. 2d ser. xxix. 71.

Peat bogs from Arctic America to New Jersey and Ohio; Rocky

Mts. of British America; Pend d'Oreille River, Idaho, *Lyall;* N. W. Coast, fide Boott. Europe.

Var. STYGIA.

C. stygia, Fries, Mant. iii. 141.

Spikes mostly thicker and more drooping: scales very black, longer pointed. — Alaska, *Dall, Mertens, Bischoff,* Shumagin I., *Harrington.* Finmark.

Section IV. VIGNEASTRÆ, Tuckerman, Enum. Meth. 10. Peduncles branching (producing spikelets) or two or more borne in one axil; spikes or spikelets all staminate at the top; perigynium mostly compressed and slender; stigmas usually three. — A singular section, peculiar to warm climates. It reaches its highest development in India and adjacent regions. None of the species have been found within the limits of the United States.

A. *Polystachyæ*, Tuckerman, l. c. 10. Habit much like that of the Debiles; spikes and spikelets long and slender, mostly all long-peduncled, usually two or more simple ones from each sheath. — Tall species, represented in Atlantic countries by the species which follow, and *C. elata*, Lowe, of Madeira.

104. CAREX SPILOCARPA, Steudel, Plant. Cyper. 195.

C. maculata, Liebm. Mex. Halv. 80, not Boott.

"Culm two to three feet high, triquetrous, glabrous; leaves shorter than the culm, broadly linear (four to five lines wide), carinate, rigid, glaucous, the margins and keel rough above, the sheaths membranaceous, flaccid: spikes seven to ten, usually two from the axil of one bract, the uppermost solitary, lowest remote, all erect, becoming pendulous, one to one and a half inches long, densely flowered, cylindrical, long-peduncled, the peduncles filiform, flexuose and scabrous (one to four inches long): bracts equalling the spikes, the sheaths withered in front, the orifice cut: staminate scales broadly ovate, obtuse, the mid-nerve carinate and yellowish green, the lateral nerves nearly dark purple, margin hyaline: pistillate scales spreading, ovate, about equalling the perigynium: perigynium slightly compressed, plano-convex, elliptical, short-beaked, nerved, the angles acute and slightly scabrous, the upper side and apex spotted with dark purple, otherwise fuscous, sides roughly granulate, beak bifid: achenium elliptic-trigonous, sides convex, very slightly punctulate." — Orizaba, South Mexico, at 8,000 to 10,000 feet, Sept., Liebmann.

105. CAREX CORTESII, Liebmann, Mex. Halv. 80.

"Culm two to two and a half feet high, triquetrous, rough on the angles: leaves longer than the culm, glaucous green, carinate below, nerved above, rough on the margins, sheaths light cinnamon-color in front, thinly membranaceous: spikes numerous (about 20), three in the axils of the bract, long-peduncled, two inches long, flexuose, nearly cylindrical, acute, densely flowered: bracts very long, sheathing, the sheaths deeply cut, the upper setaceous, shorter than the spike: peduncles filiform, scabrous, the lowest three inches long, the others shorter: staminate scales ovate-lanceolate, acute, one-nerved, nerve carinate and green, margin hyaline: pistillate scales spreading, oblong-ovate, concave, shortly mucronate, mucro rough, mid-nerve green, margin above ciliolate: perigynium equalling the scale, narrowly elliptical, trigonous, slightly compressed, biconvex, 3-ribbed, dull straw-colored, glabrous. beak bifid: achenium elliptical, trigonous, yellowish, smooth, sides slightly convex." — Named in memory of Hernando Cortez, the early explorer, discoverer of Mt. Sempoaltepec. — Cerro de Sempoaltepec, Oaxaca, South Mexico, at 10,000 feet, June and July, Liebmann.

106. Carex chordalis, Liebmann, l. c. 81.

"Culm a foot and a half high, triquetrous, rough on the angles above: leaves longer than the culm (two feet long or more), narrowly linear, convolute, carinate, pale green, nerved above, margins scabrous, the sheaths in front thinly membranaceous, light cinnamon in color: spikes many (20–30), long-peduncled and long-bracted, three or four in the axil of each bract, three inches long, slender, flexuose, densely flowered: bracts very long (two and a half feet), the upper becoming shorter and setaceous, sheathing, the sheaths in front membranaceous, reddish, cut: peduncles filiform, scabrous, flexuose, two to three inches long: staminate scales oblong, acute, one-nerved, the nerve straw-colored: pistillate scales twice smaller than the staminate, long-ovate, short-mucronate, mid-nerve green, lateral nerve dark purple: perigynium elliptical, oblique, slightly compressed, smooth, dull straw-colored, sides convex, beak bifid: achenium obovate and trigonous, sides slightly convex." — Hacienda de Castresana in Oaxaca, South Mexico, at 7,500 feet, June 1, Liebmann.

107. Carex melanosperma, Liebmann, l. c. 82.

"Culm three to three and a half feet high, triquetrous: leaves two feet long, four lines wide, carinate, nerved above, margins scabrous, the sheaths thin-membranaceous, brownish, fibrillose: spikes about twenty, three or four in an axil, shortly peduncled, two inches long and flexuose, densely flowered: lower bracts very long and sheathing at the base, the sheaths in front cut and membranaceous, the upper bracts much shorter: peduncles one to one and a half inches long, triquetrous, scabrous: staminate scales oblong, shortly mucronate, carinate, nerves fuscous, the margins pale: pistillate scales lanceolate and squarrose, reddish, furnished with a rough-ciliate mucro: perigynium about equal to the scale, ovate-elliptic, oblique, the beak recurved, slightly trigonous, nerved, smooth, straw-colored, beak slightly bifid: achenium obovate, trigonous and obtuse, black, sides convex and very slightly punctulate." — Between Huitamalco and Tiuzultan in Puebla, South Mexico, at 5,000 feet, May 1, Liebmann.

108. Carex viridis, Schlecht. & Cham. in Linnæa, xi. 30.

Culm strict but slender, about two feet high: leaves crowded, rigid, rough: peduncle exserted, branched outside the sheath or sometimes simple: spikes lax, usually nodding, loosely flowered, often dark-colored, very much longer than the short bracts: perigynium one and a half to one and three fourths lines long, oblong-lanceolate, trigonous, with dorsal angle obtuse and the lateral ones acute, the faces somewhat convex, lightly many-nerved, green or variegated with dull purple, smooth, straight or slightly curved above, produced into a lightly toothed beak a half-line long, exceeding the scale: scale ovate-lanceolate, obtuse or nearly so, hyaline on the margins. — South Mexico, Schiede; Volcan de Barba, Costa Rica, Hoffmann.

109. Carex tuberculata, Liebmann, l. c.

"Stoloniferous, the stolons emitting many yellow roots: culms two to three feet high, trigonous, rough on the angles above: leaves equalling the culm, three to four lines wide, revolute, nerved, bright green, rigid and carinate, rough on the margins, the sheaths thin-membranaceous, bright ferruginous, the orifice oblique: spikes numerous, exsertly peduncled, three in an axil, two to three inches long, cylindrical and flexuose, very densely flowered: peduncles triquetrous, scabrous, two inches long or shorter above, bearing one or two or three spikes one or other of which is very short, lateral, and sessile: bracts usually exceeding the culm, serrulate on the margins and keel, base amplectant, the orifice roundish-cut, the upper ones shorter and setaceous: staminate scales oblong, mucronulate, 3-nerved, fuscous, sides somewhat hyaline: pistillate scales twice smaller, ovate-lanceolate, shortly mucronulate, yellow, 3-nerved, margins pale yellowish-red: perigynium equalling the scale, turgid, obovate, round-trigonous, short-beaked, angles conspicuous, the side dull ferruginous and tuberculate, beak paler and bifid: achenium ovate, trigonous, violet-chestnut-colored, slightly granulate." — Chinantla in Puebla, South Mexico, at 7,000 feet, May 1, Liebmann.

110. Carex Jamesoni, Boott, Linn. Trans. xx. 124.

C. Galeottiana, C. A. Meyer, Bull. Acad. Brux. ix. part ii. 248.

Culm stout, three to four feet high, triquetrous, scabrous: leaves rigid, carinate, equalling the culm: bracts purple at the base, the lowest two or three feet long and short-sheathed, the upper ones becoming scale-like: peduncles three to six inches long, scabrous: spikes dark purple, lax, the uppermost subsessile and single and often crowded, the middle ones fasciculate with two or three from a sheath, the lowest compound, long-exserted, and nutant: spikelets half an inch to three inches long and one to four lines broad: perigynium lanceolate (two and a half lines or less long and nearly a half-line broad) or lance-oval, glabrous, nerved, dark purple, produced into a cylindrical bidentate and ciliate-mouthed beak, about equal to the lanceolate and mucronate purple white-margined scale. Variable.— Peak of Orizaba, South Mexico, at 12,500 feet, Galeotti, Linden. Colombia and Ecuador.

B. *Indicæ*, Tuckerman, l. c. Peduncles all branched (simple in *C. Schiedeana*), the spikelets short and surrounded at the base by a spathella or modified perigynium; perigynium small, mostly excurved.—Curious species with the aspect of grasses, very poorly represented in the New World.

111. Carex cladostachya, Wahl. Köngl. Acad. Handl. xxiv. 149.

C. Mexicana, Presl, Reliq. Hænk. i. 204.

C. Hartwegii, Boott, Benth. Pl. Hartw. 96.

C. polystachya, var. *minor*, Boott, Ill. 157.

Boeckeler, in Linnæa, xl. 362, cites under *C. cladostachya* the text and figures of Boott made as *C. polystachya* (Ill. 152, tt. 490–492), but I find no reason for so doing. Boott admits that he does not know the distinctions between *C. cladostachya* and *C. polystachya*, and I am not able from either his description or figures to tell which species he had.—Culm very slender, one to two feet high, equalled by the very flaccid and rough-margined leaves: spikelets green, scattered and loosely spreading, a fourth inch or less in length: perigynium elliptic, triquetrous, small (one and three fourths lines long, one half-line broad), conspicuously nerved, smooth, produced into a very slender bidentate beak, twice longer than the ovate mucronate scale.—South Mexico: Valley of Cordova and near Orizaba, *Bourgeau*, Orizaba, *Botteri*, Mirador, *Liebmann*, Jalapa, Schiede, Vera Cruz, Linden; Guatemala, near city of Guatemala, Hartweg, Baños de los Padres, Bernoulli; Costa Rica, Hoffman; Jamaica, Swartz. Colombia.

112. Carex polystachya, Wahl. Köngl. Acad. Handl. xxiv. 149.
C. cladostachya, Wright & Sauvalle, Fl. Cubana, 189.

Differs from *C. cladostachya* in its strict culm, much stiffer and nearly smooth leaves, more numerous spikes which are fulvous in color and more or less crowded and appressed, and in its longer beaked perigynium. — Cuba, from two stations, *Wright* 3421; "In summis montibus Jamaicæ," Swartz.

113. Carex acrolepis, Liebmann, Mex. Halv. 83.

"Culm a foot high, slender, triquetrous, smooth: leaves shorter than the culm, narrowly linear and grass-like, margins and keel scabrous, the sheaths short, fuscous, fibrillose in front: spikes androgynous, disposed in terminal and axillary long-peduncled panicles, staminate at top, shortly pedicelled, furnished at the base with a setaceous and scabrous spathella about four lines long: bracts (of the panicles) very long, overtopping the panicles, the sheaths rough in front and the orifice scariose and cut: lower peduncles three inches long, rough, the upper shorter, bearing about three spikes: scales lanceolate and long-mucronate, nerved, the mucro rough, green on the back, dull straw-colored on the sides: perigynium longer than the scale, fusiform, trigonous, nerved and glabrous, green, the beak bifid: achenium elliptical, triquetrous, stipitate, sides plane and dark, the margins yellowish." — Candelaria, Costa Rica, January, Oersted.

114. Carex Oerstedii, Liebmann, l. c. 84.

"Culm two to two and a half feet high, slender and flexuose, triquetrous, smooth, leafy: leaves shorter than the culm, narrowly linear, nerved, keel and margins scabrous: panicles distant, axillary and terminal, long-peduncled: bracts surpassing the culm, often eight to nine inches apart, the sheaths glabrous, membranaceous, and scariose orifice auricled: peduncles one or two from each axil, the lowest six inches long, the upper shorter, all compressed, smooth below and scabrous above, 4–5-spiked at the top: spikes subsessile, two-ranked, androgynous with the staminate flowers above, six to eight inches long, the spathella setaceous and scabrous, shorter than the spike: staminate scales short, mucronate, imbricated: pistillate scales broadly lanceolate, spreading, long-mucronate, many-nerved, reddish-striped and straw-colored, puberulent, carinate, the mucro and keel scabrous: perigynium longer than the scale, elliptical, triquetrous, fuscous, nerved, the beak angled and sparsely ciliolate, smooth below, orifice bifid: achenium stipitate, elliptical, triquetrous, sides plane and dull black, very slightly granular." — Named for Anders S. Oersted, Professor of Botany at Copenhagen, and co-worker with Liebmann on the Central American Flora. — Near Cartago, Costa Rica, January 1, Oersted.

115. Carex scabrella, Wahl. Köngl. Acad. Handl. xxiv. 149.

Aspect of a small form of *C. cladostachya:* spikes small, often simple, never much compound, the lowest on long filiform peduncles, sometimes radical and shorter stalked: perigynium short-beaked, hairy. — Eastern Cuba, *Wright* 728; Jamaica, *Herb.*

116. Carex Schiedeana, Kunze, Suppl. Riedgr. 119, t. 30.

Cespitose: culm about a foot high, erect, three-angled, roughish, shorter than the convolute, slender, roughish and long-pointed leaves: spikes four or five, terminal one sometimes staminate throughout, more or less scattered, sessile or very nearly so, an inch or less long and narrow, erect: bracts conspicuous and leafy, the lowest five or six inches long, sheathless: perigynium oval or ovate-oval, round-trigonous, very lightly nerved, hispid, stipitate, the beak short, straight, and very lightly toothed; scale oblong-acuminate, acute, roughish on the nerves, usually a little longer than the perigynium. Affinity doubtful. — South Mexico, Schiede, Ehrenberg.

Section V. HYMENOCHLÆNÆ, Drejer, Symb. Car. 10. Perigynium mostly light green or whitish, thin and membranaceous in texture, mostly somewhat inflated or at least loosely investing the achenium, commonly smooth and shining and slender or oblong, tapering gradually into a distinct or long minutely toothed straight beak (or beakless or nearly so in the Virescentes and *C. gracillima*); pistillate spikes several or many, mostly loosely flowered and on filiform nodding or widely spreading peduncles; bracts leaf-like; staminate spike usually peduncled; stigmas three. — Mostly rather tall and slender species of uplands. The perigynium is more or less hairy in some of the Virescentes and in *C. venusta*, one variety of *C. debilis*, *C. Assiniboinensis*, *C. Saskatchawana*, and immature specimens of *C. cinnamomea*. The spikes in the Virescentes, *C. Cherokeensis*, *C. juncea*, *C. cinnamomea*, and *C. Mendocinensis*, are usually nearly erect. I have not been able to identify *C. Saskatchawana.*

A. *Virescentes*, Kunth, Enum. Pl. ii. 429. Terminal spike pistillate at the top; pistillate spikes oblong or cylindrical, densely flowered, erect; perigynium ovate or obovate, nearly or quite beakless, often hairy.

117. Carex virescens, Muhl.; Willd. Sp. Pl. iv. 251.

C. costata, Schwein. An. Tab.

C. virescens, var. *elliptica*, Olney, Exsicc. fasc. iii. no. 21.

Variable in size. Transition to the Gracillimæ. — New England to North Carolina and the Indian Territory, *Butler*. South America.

118. Carex triceps, Michx. Fl. Bor.-Am. ii. 170.
C. hirsuta, Willd. Sp. Pl. iv. 252.
C. viridula, Schwein. & Torr. Monogr. 320.
C. hirsuta, var. *pedunculata*, Schwein. & Torr. Monogr. 323.
C. complanata, Torr. & Hook. Monogr. 408.
C. Smithii, Porter; Olney, Exsicc. fasc. i. no. 28.
C. Bolliana, Boeckeler, Flora, 1878, 40.

Very variable. — New England to Florida and to Michigan (rare), and southwestward to Louisiana, *Hale*, Indian Territory, *Butler*, and Texas, *Wright*, *Hall*, *Reverchon*.

119. Carex androgyna.
C. olivacea, Liebmann, Mex. Halv. 79, not Boott.

"Culm one and a half to two and a half feet high, slender and flexuose, triquetrous, glabrous: radical leaves and the lower cauline one shorter than the culm, narrowly linear, long-acuminate, carinate, rough on margin and keel: head of spikes an inch or more long: spikes three to five, appressed, cylindrical, terminal nine to ten lines long, androgynous with the base staminate, the lateral occasionally sessile and androgynous or the lower more remote and short-peduncled, pistillate, some of the upper ones sometimes staminate at base: bracts leafy, carinate, shorter than the culm, the margins and keel scabrous: staminate scales oblong, obtuse, three-nerved on the back, margins scarious; pistillate scales shorter than the perigynium, ovate-lanceolate, acuminate, carinate, concave, three-nerved on the back, the mid-nerve olive-colored and rough above, margins hyaline: perigynium stipitate, somewhat compressed, elliptical-triquetrous, glabrous, olive-colored, lateral nerves plane and the dorsal convex, beak emarginate: achenium broadly elliptic, sides plane, very slightly punctulate, a third shorter than the perigynium." — Peak of Orizaba, South Mexico, at 10,000 feet, Sept. 1, Liebmann.

120. Carex anisostachys, Liebmann, l. c. 78.

Culm six inches high, slender, triquetrous, rough on the angles: leaves usually shorter than the culm (equalling the culm in small specimens), narrowly linear, long-acuminate, carinate, the keel and margins ciliate, sheaths compressed, cinnamon-color: spikes three to four, sessile, appressed, cylindrical, terminal eight lines long, androgynous with the base staminate, the others five lines long, alternate and approximate or the lowest rather remote: bracts leafy-setaceous, rough, shorter than the culm: staminate scales oblong-lanceolate, denticulate above, mid-nerve green, margins hyaline, reddish-punctate; pistillate scales usually shorter than the perigynium, lanceolate, acuminate, the beak and the margins slightly ciliate: perigynium elliptical, trigonous, the beak and nearly entire orifice ciliate, sides concave, nerved, yellowish green: achenium obovate, triquetrous, apiculate, yellowish, smooth, sides concave." — Puebla, South Mexico, at 7,000 feet, May 1, Liebmann.

121. Carex chlorocarpa, Liebmann, l. c. 77.
C. Liebmanni, Walpers, Ann. iii. 705.

"Culm six to eight inches high, slender, triquetrous, rough on the angles: leaves shorter than the culm, narrowly linear, carinate, nerved, rough on margins and keel, sheaths scabrous, ferruginous above, with the orifice truncate: spikes three or four, cylindrical, the terminal androgynous with the base staminate, the remainder alternate, shortly peduncled, appressed, approximate or the lowest often remote, all furnished with leafy-setaceous scabrous bracts which are shorter than the culm: staminate scales oblong, hyaline on the margins, the midnerve green; pistillate scales similar to the staminate, shorter than the perigynium: perigynium stipitate, elliptical, trigonous, six-angled, green, glabrous, the beak bifid: achenium obovate, trigonous, apiculate, glabrous, yellowish, a little concave on the sides, a third shorter than the perigynium." — Parada, Sierra de Oaxaca, South Mexico, at 8,000 to 8,500 feet, June 1, Liebmann.

B. *Sylvaticæ*, Tuckerman, Enum. Meth. 12. Terminal spike all staminate; pistillate spikes mostly long-exserted; perigynium few-nerved, contracted into a cylindrical beak which is longer than the body.

122. Carex longirostris, Torrey, Schwein. An. Tab.
C. Sprengelii, Dewey, Spreng. Syst. Veg. iii. 827.
C. longirostris, var. *minor*, Boott, Phila. Acad. Sc. 1863, 78.
C. longirostris, var. *microcystis*, Boeckeler, Linnæa, xli. 241.

Variable in the size and shape of the spikes, which are sometimes almost globular and at others as slender as in *C. debilis*. — Shady banks from New England to Pennsylvania, *Garber*, and to Michigan, Illinois, *Mead*, and Nebraska, *Bruhin* (St. Helena); Rocky Mts. of Colorado, *Hall & Harbour* 614; Rocky Mts. of British America, Drummond; Saskatchewan and Winnipeg, *Bourgeau*, and Grand Valley, *Macoun*.*

* Carex Michelii, Host, var. ultra (*C. bispicata*, Hook. & Arn. Bot. Beechey's Voy. 118, t. 28; *C. longerostrata*, C. A. Meyer. Cyp. Nov. t. 12; *C. Camtschatcensis*, Kunth, Enum. Pl. ii. 477) may be expected in Alaska. It

123. Carex Assiniboinensis, W. Boott, Bot. Gaz. ix. 91.

Very slender, two feet high: leaves narrow (a line broad), shorter than the stem: staminate spike one, slender, with nearly linear scales: pistillate spikes, or at least the lower ones, on thread-like long peduncles, an inch or less long and very loosely flowered (flowers often a half-inch apart): perigynium few-ribbed towards the base, hairy, gradually contracted into a very slender beak: scale white, awl-shaped, about as long as the perigynium. — British America: Assiniboine Rapids, Lake Manitoba, and Grand Valley, *Macoun*.

C. *Flexiles*, Tuckerman, Enum. Meth. 13. Terminal spike all staminate except in *C. Krausei;* pistillate spikes rather thick (very small in *C. capillaris* and *C. Krausei*), more or less drooping; perigynium beaked, few-nerved or nerveless, tawny or whitish.

124. Carex Cherokeensis, Schweinitz, An. Tab.

C. recurva, Muhl. Descr. Gram. 262.

C. Christyana, Boott, Journ. Bost. Nat. Hist. Soc. v. 5.

C. Brazasana, Steud. Cyper. Plant. 236.

Peculiar in bearing two or three spikes from one sheath. Transition to the Polystachyæ. — "Banks of the Apalachicola River, Florida, to the mountains of Georgia and westward," Chapman. Georgia to Louisiana and Texas. Said by Dr. Boott to have been collected at Santa Rosa Creek, Calif., by Dr. Thurber. Immature specimens collected in California by Bigelow have been referred here.

125. Carex flexilis, Rudge, Linn. Trans. vii. 98, t. 10.

C. blepharophora, Gray, Ann. N. Y. Lyc. iii. 237.

This species was founded upon Newfoundland specimens. — Newfoundland to Central and Northern New York, Salisbury, Conn., *Herb.*, to Lake Superior and N. Minnesota. Rare.

126. Carex capillaris, Linn. Sp. Pl. 977.

C. capillaris, var. *elongata*, Olney, Prel. Cat. Wheeler's Pl. 53.

Greenland, *Vahl*, Newfoundland, *La Pylaie*, New Brunswick, *Herb.*, White Mts., Point de Tour, Lake Huron, *W. Boott*, Saskatchewan, *Bourgeau*, and on the mountains of Colorado, Utah, Wyoming, and Montana. Europe.

127. Carex Krausei, Boeckeler, Engler's Bot. Jahrb. vii. 279.

"Plant bright green, cespitose, the roots capillary: culm five to

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was found by Wright and others near our borders in Kamtschatka. The pistillate spikes are one or two, and 1–6-flowered: perigynium round-obovate below, very abruptly contracted into a cylindrical and slender deeply cut beak as long as the body: leaves flat: a foot high. It has the aspect of *C. Geyeri*.

eight inches high, erect, setaceous, scarcely angled, striate, smooth, few-leaved towards the base: leaves somewhat remote, spreading, much shorter than the mature culm, somewhat pubescent, acuminate, plane, the margins towards the apex minutely dentate, half to two thirds of a line wide and two to three and a half inches long: spikes four or five, pale, long-peduncled, very remote, narrowly cylindrical, nearly equal in length, three and a half to four and a half lines long, scarcely a line broad above, the terminal one androgynous, the others pistillate and pendulous: peduncles very slender, somewhat scabrous: bracts ochreiform: scales hyaline-membranaceous, ochroleucous, ovate-orbicular, obtuse, the midnerve bright green: perigynium minute, straight, pellucid-membranaceous, olive-colored, about as long as the scale (one and a third to one and a half lines long), very shortly stipitate, oblong-trigonous, attenuated above, nerveless, smooth, very slightly striate, the orifice entire." — Alaska, Krause.

D. *Debiles*, Carey, Gray's Man. 1848, 558. Terminal spike all staminate (occasionally pistillate above in *C. venusta*); pistillate spikes very narrow and slender, long-exserted and nodding, mostly very loosely flowered; perigynium rather small, not turgid. The types of the group are *C. debilis* and *C. arctata*.

128. Carex juncea, Willd. Enum. Pl. Hort. Berol. 63.
C. miser, Buckley, Sill. Journ. xlv. 173.

Transition to the *Ferrugineæ*. — Roan Mt. and Black Mt. Range, N. Carolina, *Herb.* "Mountains of N. Carolina and Georgia," Boott.

129. Carex arctata, Boott, Hook. Fl. Bor.-Am. ii. 227.
C. sylvatica, Dewey, Sill. Journ. x. 40.

Distinguished from all forms of *C. debilis* by its short-ovate very short-beaked perigynium which is abruptly contracted at the base and stipitate, and by its pointed or short-awned scales which are nearly as long as the perigynium. The radical leaves are usually short and broad. — Meadows and copses, New England to Pennsylvania and Ontario and Michigan, and northwestward to N. Minnesota and Dakota "along the Missouri at Fort Pierre," Dewey.

C. arctata × formosa? (*C. Knieskernii*, Dewey, Sill. Journ. 2d ser. ii. 247). New York at Oriskany, *Knieskern*, Rome, *Vasey;* Woods near Kakabeka, Lake Superior, *Macoun*. Sterile.

130. Carex debilis, Michx. Fl. Bor.-Am. ii. 172.
C. tenuis, Rudge, Linn. Trans. vii. 97, t. 9.
C. flexuosa, Muhl.; Willd. Sp. Pl. iv. 297; Schkuhr, Riedgr. Nachtr. 74, f. 124.
C. debilis, var. β, Boott, Ill. 92.

Variable. The perigynium is sometimes short (the var. β of Boott) and much like that of *C. arctata* (which see). — Moist meadows and copses, Norway House, British America, Richardson, to Nova Scotia, *Macoun*, and southward through New York and New England to the mountains of N. Carolina and Georgia.

Var. PUBERA, Gray, Man. 5th ed. 593.

C. venusta, var. β, Boott, Ill. 51.

Perigynium elongated, much attenuated at both ends, hairy. (See *C. venusta.*) — Bear Meadows, Centre Co., Pennsylvania, *Porter*, and N. Carolina, Curtis, according to Boott. Imperfectly known. It suggests *C. Assiniboinensis.*

Var. PROLIXA.

C. debilis, var. γ, Boott, Ill. 92.

Leaves often very long and loose: spikes thicker and more densely flowered: perigynium more inflated, much elongated (four to five lines long), with a very slender beak. — Florida, *Chapman*, to Louisiana, Drummond, *Hale*, *Langlois.*

C. DEBILIS × VIRESCENS? Revere, Mass., *C. E. Faxon.*

131. CAREX VENUSTA, Dewey, Sill. Journ. xxvi. 107, f. 62.

Distinguished at once from all forms of *C. debilis* by the dulness and thicker texture of the perigynium which is scarcely beaked but rather narrowed gradually into a point, and the many-nerved or ribbed character of the perigynium. — "Low banks of streams, Florida to N. Carolina," Chapman.

Var. GLABRA.

C. glabra, Boott. Ill. 93.

C. venusta, var. γ, Boott, Ill. 51.

I can distinguish no permanent character to separate this from *C. venusta* other than the smoothness of the perigynium. The terminal spike is occasionally pistillate at the top in both this and the species. —Oneida Co., N. York, Knieskern; near Philadelphia, *Smith*; Cape May Co. and Camden Co., N. Jersey, "in sphagnous swamps, growing with *C. subulata*, *C. folliculata*, and *Juncus asper*," *Parker*; Mobile, Alabama, *Sullivant.* Evidently rare.

132. CAREX CINNAMOMEA, Olney, Proc. Am. Acad. vii. 396.

Culm slender, eighteen inches to two feet high, smooth, exceeding the narrow rough-margined leaves (which are barely more than a line wide): bracts leafy, bearing short sheaths: spikes an inch or inch and a half long, the lower long-peduncled, the upper sessile or nearly so, all erect, cinnamon-colored, compactly flowered or the lowest loosely flowered at the base: perigynium elliptic-ovate, hairy when young, abruptly contracted into a short minutely toothed beak, lightly nerved, longer and broader than the very obtuse and erose-margined scale. — California in the Red Mountains, Mendocino Co., *Bolander* 6477; "Upland marshes and springs," near Kerbyville, Oregon, *Howell*.

133. CAREX MENDOCINENSIS, Olney; W. Boott, Bot. Calif. ii. 249.

Much like the last: leaves broader (two lines or more) and longer: spikes longer and very slender, alternately flowered at the base: scale acute or muticous. Not sufficiently known. — In swamps near Mendocino City, Calif., *Bolander* 4701; *Kellogg* & *Harford* 1082.

134. CAREX SASKATCHEWANA, Boeckeler, Linnæa, xli. 159.

Perhaps a member of this group: — "Rhizome elongated, slender, the fibrils long and capillary: culms several, fasciculate, strict, setaceous-capillary, triangular, rough above, one and a half to two inches high: leaves yellowish green, spreading, firm, linear, shortly attenuate, rather obtuse, plane and striate, a line wide, roughish towards the apex on the margins, the upper ones and the bracts filiform and much longer than the culm (two inches long): spikes three or four, erect, peduncled, very slender, terete, somewhat densely flowered, yellowish white, before flowering approximate: staminate spike linear-oblong, few-flowered, three to four lines long: pistillate spikes filiform, 8 to 12-flowered, five to six lines long: peduncles capillary, exserted: scales pellucid-membranaceous, white above and dull yellow towards the base, the middle pale green, broadly ovate, obtuse or slightly acute: perigynium (young) equalling the scale, oblong-linear, straight, slightly attenuated, triangular, nerveless, very lightly striolate, the margins lightly ciliate, whitish above and yellowish-green at the base, the orifice obtuse and entire. — Saskatchewan, Douglas."

E. *Gracillimæ*, Carey, Gray's Man. 1848, 552. Terminal spike usually pistillate at the top; pistillate spikes habitually thicker than in the Debiles; perigynium ovate-oblong, more or less turgid.

135. CAREX ÆSTIVALIS, M. A. Curtis, Sill. Journ. xlii. 28.
C. Rugeliana, Kunze, Suppl. Riedgr. 189, t. 48.
C. virescens, var. *æstivalis*, Olney, Exsicc. fasc. iii. no. 22.

In the mountains from Saddle Mt., W. Massachusetts to N. Carolina. Evidently local.

136. CAREX GRACILLIMA, Schweinitz, An. Tab.
C. digitalis, Schwein. & Torr. Monogr. 324, t. 27.

Wet meadows and woodlands from Norway House, Richardson, and Saskatchewan, *Bourgeau*, to New England and N. Carolina.

C. GRACILLIMA × PUBESCENS (*C. Sullivantii*, Boott, Sill. Journ. xlii. 29). Columbus, Ohio, *Sullivant*; Yonkers, N. York, *Howe*; Stanton, Delaware, *Commons*. An exact medium between the two species, and growing with them wherever found. Sterile.

137. CAREX OXYLEPIS, Torrey & Hooker, Monogr. 409.

Much the aspect of *C. venusta*. — "Low ground, Florida and westward," Chapman. Santee Canal, S. Carolina, *Ravenel*; Chattahoochee, W. Florida, *Curtiss*; Alabama, *Buckley*; Louisiana, *Hale*, *Carey*; Texas, *Wright*, *Hall*.

138. CAREX FORMOSA, Dewey, Sill. Journ. viii. 98.

Central and Western N. York; Michigan; Belleville, Ontario, *Macoun*. Evidently local. This species is credited to Massachusetts in Gray's Manual. The only authority I know for its occurrence there is a plant collected at Stockbridge by Prof. Dewey. I have seen in Herb. Olney such a plant from Prof. Dewey, but it is *C. gracillima*.

139. CAREX DAVISII, Schweinitz & Torrey, Monogr. 326.

C. aristata, Dewey, Sill. Journ. vii. 277.

C. Torreyana, Dewey, l. c. x. 47.

Named for Prof. E. Davis of Westfield, Mass. — Wet meadows, Massachusetts to Minnesota and Indian Territory, *Butler*, and south to the mountains of Georgia, Chapman.

F. *Griseæ*. Terminal spike staminate; perigynium more or less turgid, often glaucous, scarcely beaked, finely striate; spikes erect.

140. CAREX GRISEA, Wahl. Köngl. Acad. Handl. xxiv. 154.

C. laxiflora, Schkuhr, Riedgr. Nachtr. 69, f. 141.

C. grisea, var. *minor*, Olney, Hall's Pl. Tex. 25.

Throughout the Northern United States east of the Mississippi; also Texas, *Berlandier*, *Wright*, *Hall*; S. Utah, probably, *Palmer*, an immature specimen. Florida?

Var. ANGUSTIFOLIA, Boott, Ill. 35.

C. laxiflora, Ell. Sk. Bot. ii. 549.

"*C. cryptandra*, Schwein. in Herb. Ell.," Olney in Hall's Pl. Tex. 25.

The prevailing Southern form of the species: very slender, the leaves long and narrow: staminate spike peduncled; pistillate spikes looser flowered: perigynium more tawny, scarcely tumid, three-angled and more or less pointed. It sometimes counterfeits *C. oligocarpa* (which see). — Sellersville, Penn., *C. D. Fretz*; Florida, *Chapman;* W. Louisiana, *Hale,* the perigynia not typical; E. Texas, *Hall.*

141. Carex glaucodea, Tuckerman; Olney, Proc. Am. Acad. vii. 395.

C. grisca, var. *mutica,* Carey, Gray's Man. 1848, 522.

C. flaccosperma, Gray's Man. 5th ed. 587; Boott, Ill. t. 88; not Dewey.

Very glaucous throughout: culm lax, six to eighteen inches high: leaves flat, two to four lines wide: spikes nearly the same as in *C. granularis:* perigynium ovoid-oblong (one and a half to two lines long), mostly obtuse, mostly longer than the white awn-pointed scale. — Distinguished at once from *C. granularis* and *C. grisea* by its glaucousness. In aspect it is little like *C. grisea.* Its nearest ally is *C. flaccosperma,* from which it is readily distinguished by its shorter perigynium, awned scale, and narrower leaves. — Summit of Mt. Holyoke and Mt. Tom, on trap rocks, *Tuckerman;* Wethersfield, Conn., *Wright;* New Jersey, Austin, *Knieskern,* at Haddenfield, *Diffenbaugh;* Pennsylvania, at Easton and Bethlehem, *Porter,* woods near Philadelphia, *Smith,* Lancaster Co., *Fiot;* Delaware, at Wilmington, *Canby,* and Centreville, *Commons;* New Albany, Indiana, *Dr. Clapp.*

142. Carex flaccosperma, Dewey, Sill. Journ. 2d ser. ii. 245.

C. laxiflora, var. (?) *mutica,* Torr. Monogr. 414.

C. xanthosperma, Dewey, Sill. Journ. 2d ser. xlii. 10 (Index Car.).

Somewhat glaucous: leaves very broad and flat (often a half-inch wide): perigynium two lines or more long, cylindrical, rust-colored below, somewhat pointed, thrice longer than the obtuse or muticous scale. — Florida, Dewey; Red River, Louisiana, *Hale;* Texas, *Hall, Wright.*

143. Carex pilosiuscula, Boeckeler, Flora, 1882, 61.

"Cespitose: culm about a foot high, erect, slender but firm, obtusely angled, smooth, leafy below: leaves remote, somewhat pilose, long, narrowly acuminate (one to two lines wide), smooth on the margins, the upper often longer than the culm: spikes more or less crowded at the top of the culm, the lowest somewhat remote, strictly erect: staminate spike yellow, sessile, many-flowered, oblong-linear and acute (seven to nine lines long, one to one and a half lines wide): pistillate spikes three or four, olive-colored, cylindrical or oblong, densely many-flowered (six to ten lines long and two and a half lines wide), the lowest short-peduncled, the others nearly sessile: bracts possessing short sheaths, the two lowest leafy, the upper scarcely surpassing the staminate spike: scales large and somewhat rigid, the staminate broadly ovate, obtuse, muticous or minutely mucronate, yellowish green, the pistillate oval or obovate with the back three-nerved and strongly cuspidate: perigynium (not perfectly mature) exceeding the scale, evidently stipitate, lance-oblong, very slightly beaked, compressed-triangular, many-striate, grayish green, the orifice slightly emarginate (whole perigynium two lines long). — Salt plains of the Rocky Mountains, Dönitz."

Section VI. SPIROSTACHYÆ, Drejer, Symb. Car. 10. Perigynium smooth or minutely granulated or rarely somewhat serrate on the margins, prominently nerved, mostly yellowish, squarrose, mostly beaked, the orifice entire: staminate spike mostly single; pistillate spikes two to five, short (usually an inch or less long), yellow or fuscous, compactly flowered: stigmas three. — Medium-sized species, growing in meadows and grassy swales. *C. pallescens* has an entirely beakless perigynium.

A. *Granulares.* Spikes scattered, cylindrical, the lowest long-stalked; bracts erect, long and leafy; sheaths short or nearly obsolete.

144. Carex longicaulis, Boeckeler, Flora, 1882, 62.

" Plant tall, bright green: rhizome elongated, horizontal, hard and thick, nodose and branched, about the size of a goose-quill, fibrils numerous and rigid: culm two to four feet high, slender, scarcely a line in diameter at the middle, strictly erect, acutely angled, smooth, many-leaved toward the base: sheaths herbaceous, nearly laminiferous: leaves somewhat remote, stiffly herbaceous, long (one to two feet long and one and a half to three inches wide), narrowly acuminate, towards the apex somewhat toothed, the upper not rarely surpassing the culm: spikes four or five, more or less contiguous or the lower one a little remote, the staminate small, sessile (three to eight lines long), somewhat clavate and in color grayish yellow, the pistillate grayish green, short-peduncled, densely flowered, the lowest nearly cylindrical (eight to ten lines long), the upper ones often very short, oblong: bracts leafy-setaceous from yellowish and puberulent sheaths, the lowest scarcely reaching the staminate spike: staminate scales long-oblong, obtusish, slightly mucronate, the margin pale-hyaline: pistillate scales broadly oval or lance-oval, pale, the keel bright green, three-nerved, shortly mucronate: perigynium green, equalling or slightly surpassing the scale (one and three fifths lines long), broadly ellipsoid, triangular, turgid, sides all alike and plane, slightly many-nerved and punctate, short-beaked, the beak hirtellate with a slightly emarginate orifice: achenium obovate, equalling the perigynium, densely punctulate, the angles prominent. — Valley of Mexico, no. 513, Schaffner."

145. Carex granularis, Muhl.; Willd. Sp. Pl. iv. 279.
C. chlalaros, Steud. Cyper. Plant. 231.
C. Haleana, Olney, Exsicc. fasc. iii. no. 14.

In grassy places throughout the States east of the Mississippi; Saskatchewan, *Bourgeau*, *Macoun*.

146. Carex microdonta, Torrey & Hooker, Monogr. 423.
C. alveata, Boott, Journ. Bost. Nat. Hist. Soc. v. 7.
C. Rœmeriana, Scheele, Linnæa, xxii. 346.
C. Wrightii, Dewey, Bot. Mex. Bound. 232.

Distinguished from *C. Crawei* by its greater height and looser habit, its sheathing leaves, more numerous staminate spikes, more slender pistillate spikes which are more or less long-peduncled, and a stronger nerved perigynium. Culm usually a foot or eighteen inches high, rather slender. Leaves often involute when dry. The pistillate spikes are often staminate at the top, and to this form I have no hesitation in referring Scheele's *C. Rœmeriana*. Transition to the Anomalæ. — Texas, *Drummond*, *Wright*, *Hall* ("wet prairies, Houston"), *Lindheimer* ("in patches on low ground"); Louisiana and Arkansas according to Boott.

Var. latifolia.

Leaves short (three to four inches long) and broad and flat (three lines broad), many nerved, long-acuminate, the sheaths loose and conspicuous. — Texas, *Buckley*, "wet prairies at Dallas," *Reverchon*.

Var. controversa.
C. extensa, Boott, Ill. 207, as to Gregg's specimens.

Culm two to four inches high, exceeded by the narrow leaves: perigynium broader and shorter beaked than in the species. — Marshy ground near San Pablo, Mexico, *Gregg*.

147. Carex Crawei, Dewey, Sill. Journ. 2d ser. ii. 246.
C. heterostachya, Torr. Sill. Journ. 2d ser. ii. 248.
C. Crawei, var. *heterostachya*, Dewey, Sill. Journ. 2d ser. xlii. 4 (Index Car.).

Perhaps too near the last. — From Montreal, *Macrae*, to New York and Michigan, and thence northwestward to Winnipeg Valley, *Bourgeau*.

B. *Extensæ*, Fries, Corp. 188. (Tuckerman, Enum. Meth. 13. *Flavæ*, Tuckerman, l. c.) Spikes mostly approximated or aggregated at the top of the culm (becoming remote in *C. extensa*), the lowest one or two subtended by a long and leafy mostly abruptly spreading and nearly or entirely sheathless bract.

148. *Carex extensa*, Goodenough, Linn. Trans. ii. 175.

Coast of Long Island and Coney Island, New York, *Herb.*; Norfolk, Virginia, *McMinn*. Introduced from Europe.

149. Carex flava, Linn. Sp. Pl. 975.

C. lepidocarpa, Tausch. Flora, 1834, 179.

Forms *lepidocarpa* and *androgyna*, Olney, Exsicc. fasc. iii. nos. 26 and 27.

Newfoundland, *La Pylaie, etc.*, to New England and Ohio, and northward to Carlton House, British America; Hudson's Bay Creek, Montana, *Canby*. Europe.

150. Carex Œderi, Retz in Ehrh. Calam. Exsicc. no. 79.

C. flava, var. *Œderi*, Willd. Act. Berol. 1794, 44, t. 1.

C. viridula, Michx. Fl. Bor.-Am. ii. 170.

C. flava, var. *lutescens*, Wahl. Fl. Lapp. 234.

Bears the name of Georg Christian Œder, 1728–91, a Danish botanist. — Newfoundland, *La Pylaie*, to Pennsylvania and Illinois, and northward to the Great Plains, *Macoun*, and Rocky Mts., *Drummond*, of British America; S. Utah, *Parry*. Europe.

151. Carex Urbani, Boeckeler, Engler's Bot. Jahrb. vii. 280.

"Bright green: culm (not fully mature) three to four inches high, smooth, many-leaved at the base: leaves rigid, herbaceous, crowded, subrecurved and spreading, an inch and a half to four inches long, short-acuminate, many-nerved, the margins slightly dentate, one line broad: sheaths membranaceous, whitish, truncate: spikes four, more or less approximate, greenish white, the staminate oblong-linear (seven lines long and a line and a half broad), with the bract scale-like and cuspidate and the keel ciliate, the pistillate (not mature) peduncled, oblong-oval, obtuse, densely flowered (five to six lines long, three lines broad): bracts all elongated and sheathing (two to four inches long): scales large, membranaceous, ovate- or oblong-sublanceolate, obtuse, muticous, three-nerved and green on the broad back, setulose or glabrous, the sides white-hyaline and very slightly reticulated: perigynium (immature) bright green, about the length of the scale, scarcely erect, slightly incurved, turgid, oblong-oval, contracted at the base, costate-nervose, gradually produced into a rather long subglabrous toothed beak." — Alaska, Krause.

C. *Fulvellæ*, Fries, Summa, 70. Spikes scattered, short and thick, oblong (usually a half-inch or less long), the lowest more or less peduncled; bracts conspicuously sheathing, usually not very leafy.

152. CAREX LEMMONI, W. Boott, Bot. Gaz. ix. 93.

C. fulva, Gooden., var. *Hornschuchiana*, W. Boott, Bot. Calif. ii. 250.

Cespitose: culm slender but erect, one to two feet high, smooth, longer than the flat and thin yellowish green rather abruptly pointed leaves: spikes two to five, the terminal staminate and an inch or less long, the others a half-inch long and mostly staminate at the top, with peduncles included, the upper one usually sessile at the base of the staminate spike: lower bracts twice longer than the spikes: perigynium small (one and three fourths lines long and three fourths line or less broad), lance-oblong, triangular below, smooth, thin, produced into a slender minutely toothed often rough-margined beak, about equalling or surpassing the straw-colored obtuse thin-margined scale. — California, Sierra Nevada, *J. G. Lemmon*, Inspiration Rocks, Yosemite, *Bolander* 4905, Mariposa Grove, *Bolander* 4995. *C. spissa* and perhaps *C. ultra* were once distributed as *C. Lemmoni*.

153. CAREX FULVA, Goodenough, Linn. Trans. ii. 177.

C. Greeniana, Dewey, Sill. Journ. xxx. 61.

Goodenough received the original specimens from "America and Newfoundland." *B. D. Greene* found it previous to 1836 by a pond at Tewksbury, Mass., where it was probably introduced. It has not been found since. It may be native in Newfoundland. Europe.

C. lævigata, Smith, was also found at Tewksbury by *B. D. Greene*, but it has not been found again. Europe.

D. *Pallescentes*, Fries, Summa, 71. Spikes globular or short-oblong, obtuse, sessile or short-peduncled, approximate at the top of the culm; bracts short, leaf-like, sheathless; perigynium entire at the orifice, the beak none or very short and stout.

154. CAREX PALLESCENS, Linn. Sp. Pl. 977.

C. undulata, Kunze, Suppl. Riedgr. 23.

C. pallescens, var. *undulata*, Carey, Gray's Man. 1848, 552.

Meadows, New England to Pennsylvania and Lake Superior. Europe.

155. CAREX TORREYI, Tuckerman, Enum. Meth. 21.

C. abbreviata, Boott, Linn. Trans. xx. 141.

New York, *Torrey;* Bethlehem, Penn., Schweinitz; Clear Creek Cañon, near Golden City, Colorado, *E. L. Greene;* Grand Valley, Great Plains, British America, *Macoun;* Carlton House, S. W. of Hudson's Bay, *Richardson.* Very rare. Professor Tuckerman founded the species upon specimens in the herbarium of Sir W. J. Hooker, which were mixed with *C. pallescens* from New York (sent by Dr. Torrey) and Carlton House. The same year Dr. Boott found a plant in Herb. Prescott (*Fielding*) in England with the MS. name *C. abbreviata*, and he published it, supposing that it came from the Altai. In 1849 Professor Tuckerman found the same in Kunze's herbarium, at Leipsic, labelled "*C. abbreviata*, Schweinitz, no. 55," from Bethlehem, Penn. Prescott had evidently received his specimen from Kunze. Schweinitz preserved no specimen in his own herbarium.

Section VII. DACTYLOSTACHYÆ, Drejer, Symb. Car. 10. (*Brachyrhynchæ*, Bailey, Coulter's Man. 328.) Perigynium mostly short and trigonous, with a short and straight or curved beak, green or greenish, scarcely inflated; scales of the pistillate spikes mostly whitish, often small; staminate spike mostly one; pistillate spikes short (seldom exceeding an inch), commonly rather loosely flowered and slender; bracts sheathing, the sheaths often conspicuous and colored. — Undersized and lax or slender species inhabiting meadows and copses. In a few of the less evolved species the perigynium is hairy. In some of the Laxifloræ and some other species the sheaths are not conspicuous.

A. *Oligocarpæ*, Carey, Gray's Man. 1848, 554. Slender and narrow-leaved species with leafy bracts and inconspicuous green sheaths; perigynium rounded on the angles, finely many-striate, often somewhat punctulate as in *C. grisea*, to which the group forms a transition.

156. CAREX CONOIDEA, Schkuhr, Riedgr. Nachtr. 67, f. 168.
C. granularioides, Schwein. An. Tab.
C. tetanica, Schwein. & Torr. Monogr. 347.
C. Illinoensis, Dewey, Sill. Journ. 2d ser. vi. 245.

Staminate spike rarely sessile. — Grassy places, Mass. to mountains of North Carolina and westward to Ohio and Illinois.

157. CAREX OLIGOCARPA, Schkuhr, Riedgr. Nachtr. 58, f. 170.
C. subuniflora, Steud. Cyper. Plant, 234.
C. oligocarpa, var. *Sartwelliana*, Dewey, Sill. Journ. 2d ser. v. 176.

Distinguished from *C. grisea*, var. *angustifolia*, with which it is sometimes confounded, by its smaller perigynium, which is abruptly contracted at its middle into a conspicuous beak. I find that, in general, botanists have not a clear conception of this species. — Dry woods and copses, Canada and W. New England to Pennsylvania, Kentucky, and Illinois.

158. CAREX HITCHCOCKIANA, Dewey, Sill. Journ. x. 274.

Dedicated to the geologist, Edward Hitchcock, and lady, who aided Professor Dewey in securing plates to illustrate his writings in Silliman's Journal. — Same distribution as the last.

B. *Laxifloræ*, Kunth, Enum. Pl. ii. 452. (*Careyanæ*, Tuckerman, Enum. Meth. 15. *Plantagineæ* and *Digitales*, Carey, Gray's Man. 1848, 554.) Slender more or less broad-leaved species with mostly leafy bracts, green sheaths, and loosely flowered spikes; perigynium mostly conspicuously three-angled, with a more or less curved beak. — In *C. Caroliniana* and *C. plantaginea* the sheaths are leafless and more or less colored.

159. CAREX LAXIFLORA, Lamarck, Dict. de Bot. iii. 392.
C. striatula, Michx. Fl. Bor.-Am. ii. 173.
C. anceps, Schwein. & Torr. Monogr. 343, in part.
C. ignota, Dewey, Sill. Journ. 2d ser. vi. 348.

The following key to *C. laxiflora* and its varieties, modified from Dr. Boott, is convenient: —

I. Perigynium elliptic, attenuated at the apex, not prominently nerved; beak not strongly curved.
  1. Leaves narrow.
    a. Spikes narrow, loosely flowered, cylindrical . . . *C. laxiflora.*
    b. Spikes broad, densely flowered, oblong . . . Var. *styloflexa.*
  2. Leaves usually broad and flat. Spikes narrow and loosely flowered. Var. *patulifolia.*

II. Perigynium obovate, abruptly beaked, mostly conspicuously striate; beak short, usually strongly recurved.
  1. Leaves narrow.
    a. Spikes narrow, mostly cylindrical and loosely flowered; plants slender . . . . Var. *intermedia.*
    b. Spikes thick, oblong, densely flowered; plants stouter, the bracts very broad and leafy . . . . Var. *striatula.*
  2. Leaves very broad. — Spikes narrow and loosely flowered. Var. *latifolia.*

Typical *C. laxiflora* is further distinguished by a long-peduncled staminate spike, pistillate spikes an inch or more long and more or less scattered: leaves three lines or less broad. Evidently not common, at least northward. — Connecticut and Michigan (?) to Florida and Texas.

Var. STYLOFLEXA, Boott, Ill. 37.
C. styloflexa, Buckley, Sill. Journ. xlv. 174.
C. fusiformis, Chapm.; Dewey in Sill. Journ. 2d ser. vi. 244.
C. protracta, Steud. Cyper. Plant. 234.

A slender plant with narrower leaves than the type and mostly compact spikes a half-inch long, the lower on filiform peduncles: perigynium slender, mostly triangular-fusiform, the apex curved. — Lancaster Co., Penn., *Porter*, to Florida and Texas.

Var. PATULIFOLIA, Carey, Gray's Man. 2d ed. 524.

C. plantaginea, Schkuhr, Riedgr. Nachtr. 65, f. 195 (excl. f. 70).

C. anceps, var. *patulifolia*, Dewey, Wood's Bot. 1845, 423.

C. laxiflora, var. *plantaginea*, Boott, Ill. 37.

Radical leaves five to eight lines broad: spikes usually longer and more loosely flowered than in the type: perigynium sometimes straight. — New England to Pennsylvania and westward; Alabama, *Beaumont*.

Var. INTERMEDIA, Boott, Ill. 37.

C. heterosperma, Wahl. Köngl. Acad. Handl. xxiv. 151.

C. anceps, Muhl.; Willd. Sp. Pl. iv. 278; Schkuhr, Riedgr. Nachtr. 66, f. 128.

C. anceps, var. *angustifolia*, Dewey, Wood's Bot. 1845, 423.

C. laxiflora, var. *blanda gracillima*, Boott, Ill. 38.

Canada to Florida.

Var. STRIATULA, Carey, Gray's Man. 2d ed. 524.

C. conoidea, Muhl. Descr. Gram. 248.

C. blanda, Dewey, Sill. Journ. x. 45.

C. anceps, var. *striatula*, Carey, Gray's Man. 1848, 554.

Var. *blanda*, and sub-vars. *major* and *minor*, Boott, Ill. 37.

Leaves two to six lines broad. — Throughout the Northern States east of the Mississippi and probably common southward; also in Newfoundland, *La Pylaie*, N. W. Iowa, *Cratty*, Texas, *Wright*. Evidently our commonest form.

Var. LATIFOLIA, Boott, Ill. 38.

Acton, E. Massachusetts, *W. Deane*, to Pennsylvania and Michigan.

160. CAREX HENDERSONI.

C. laxiflora, var. *plantaginea*, Olney, Proc. Amer. Acad. 1872, 407; W. Boott, Bot. Calif. ii. 245.

Distinguished at once from *C. laxiflora*, var. *patulifolia*, by its large perigynium (two and a half to two and three fourths lines long) which is more strongly nerved and more gradually contracted at the ends, its proportionally shorter, blunter, and firmer pistillate scales, and its more closely flowered, approximate, shorter-peduncled spikes. — Lower Frazer River, lat. 49°, *Dr. Lyall;* Oregon, *Hall* 602, bogs at Portland, *L. F. Henderson*, Multnomah Co., *Howell*, and probably

Nuttall's specimens cited by Boott (Ill. 36); Mendocino Co., Calif., *Bolander* 4747.

161. Carex retrocurva, Dewey, Wood's Bot. 1845, 423.

Very glaucous. — New England to Michigan and Virginia.

162. Carex ptychocarpa, Steudel, Cyper. Plant. 234.

C. digitalis, var. *glauca*, Chapm. Flora, 541.

Distinguished radically from *C. retrocurva* by its short culm (two to five inches high and shorter than the leaves), sessile small and inconspicuous staminate spike, contiguous and nearly or quite sessile pistillate spikes (only the lowest one long-peduncled and that radical or nearly so), the broad and elongated leafy bracts, and the narrower and more obtusely angled perigynium. Leaves one third to one sixth inch in width, glaucous. In its larger forms it bears some resemblance to *C. Careyana*, from which it is readily distinguished by the above characters. — Near Lake Hopatcong, N. New Jersey, *Britton;* Delaware, *Canby;* Florida, *Chapman,* "wet springy places in woods, Aspalaga," and "low forest bordering the Apalachicola River at Chattahoochee," *Curtiss* (distributed as *C. retrocurva*); New Orleans, *Drummond.*

163. Carex digitalis, Willd. Sp. Pl. iv. 298.

C. oligocarpa, Muhl. Descr. Gram. 242.

C. Van-Vleckii, Schwein. An. Tab.

C. oligocarpa, var. *Van-Vleckii*, Dewey, Sill. Journ. x. 281.

C. podostachys, Steud. Cyper. Plant. 232.

New England and Michigan to Florida and Louisiana.

164. Carex Caroliniana, Buckley, Sill. Journ. xlv. 173.

I have lately examined Buckley's specimens which are deposited in the Torrey herbarium. The specimens are but two, and imperfect at that, but they appear to possess clear specific characters. The species is allied to *C. plantaginea* and *C. Careyana*. From both these species it differs widely in its narrow leaves (two to six lines wide), and few-flowered (3–6-flowered) pistillate spikes which are exserted on thread-like peduncles one to four inches long. The well marked and leafless sheaths and obtuse scales of the mostly long-peduncled staminate spikes at once distinguish it from all forms of *C. laxiflora*. The perigynia are evidently much smaller than in either *C. plantaginea* or *C. Careyana*. — Table Mountain, South Carolina, *Buckley*. Not since collected.

165. Carex platyphylla, Carey, Sill. Journ. 2d ser. iv. 23.

Massachusetts to Michigan and southward to Virginia, *Curtiss*.

166. Carex Careyana, Torrey; Dewey in Sill. Journ. xxx. 60, f. 88.

New York to Pennsylvania and Washington and westward to Ohio and Michigan. Rare.

167. Carex plantaginea, Lamarck, Dict. de Bot. iii. 392.

C. latifolia, Wahl. Köngl. Acad. Handl. xxiv. 156.

Norway House, S. W. of Hudson's Bay, *Drummond*, to Michigan and New England, and southward in the mountains to North Carolina. A singular species.

C. *Paniceæ*, Tuckerman, Enum. Meth. 15. Mostly stouter narrow-leaved species, with thicker spikes; perigynium often strongly nerved, not conspicuously trigonous, often somewhat turgid; bracts and sheaths various.

168. Carex vaginata, Tausch, Bot. Zeit. 1821, 557.

C. panicea, var. *sparsiflora*, Wahl. Fl. Lapp. 236.

C. phæostachya, Smith, Engl. Fl. 99.

C. sparsiflora, Steud. Nom. Bot. 296.

C. vaginata, var. *alto-caulis*, Dewey, Sill. Journ. 2d ser. xli. 227.

C. panicea, var. *refracta*, Olney, Exsicc. fasc. i. no. 24.

N. Labrador, *Turner*, to Bergen Swamp, Genessee Co., New York, *Paine*, and northwestward to Isle Royale, *Porter*, and Saskatchewan, *Bourgeau*. Local. Europe.

169. Carex polymorpha, Muhl. Descr. Gram. 239.

C. Halseyana, Dewey, Sill. Journ. xi. 313, f. 43.

C. panicea, var. *scariosa*, Olney, Exsicc. fasc. ii. no. 28.

Meadows, Massachusetts to North Carolina, and evidently also *Bolander's* 4741, from Mendocino, California (introduced?). Not common.

170. *Carex panicea*, Linn. Sp. Pl. 977.

Culm smooth: leaves glaucous: spikes colored: bracts an inch or two long: perigynium straw-colored or nearly purple, turgid, the sides scarcely nerved, mostly longer than the obtuse or muticous purple or purple-margined scale, the apex much straighter than in the next. — About Boston, *Herb.*, and Providence, Rhode Island, *Olney*. Introduced from Europe.

171. Carex tetanica, Schkuhr, Riedgr. Nachtr. 68, ff. 100 and 207.

C. refracta, Willd. Sp. Pl. iv. 297, in part; Schkuhr, Riedgr. Nachtr. 62 (excl. fig.).

C. Woodii, Dewey, Sill. Journ. 2d ser. ii. 249.

C. panicea. var. *tetanica*, Olney, Exsicc. fasc. i. no. 23; fasc. ii. no. 26.

C. panicea, var. *Woodii*, Olney, Exsicc. fasc. ii. no. 27.

C. panicea, var. *Bebbii*, Olney, Exsicc. fasc. i. no. 22.

C. Meadii, var. *Bebbii*, Arthur, Contr. Fl. Iowa, vi.

Culm slender, scabrous, at least above: leaves narrow, green: spikes pale, mostly greenish, mostly thin and loosely flowered, attenuated below: bracts, at least the lower ones, three inches or more in length: perigynium smaller, not turgid, greenish, prominently many-nerved: scale muticous or short-awned. — Meadows and borders of ponds from W. Massachusetts and Pennsylvania to Lousiana and Indian Territory and the Great Plains of British America.

This may be the *C. castanea*, Wahl. Köngl. Acad. Handl. 155 (1803), an American species which its author says (Pl. Lapp. 250) is the same as *C. refracta*, Schkuhr, fig. 136. Schkuhr's figure, with a straight beak, is not the same plant as that described under the same name by Willdenow, whose description he copies. Both Schkuhr and Willdenow record *C. refracta* as a native of Mt. Cenis, but Sprengel (Syst. Veg. iii. 825) declares that they were both mistaken. The specimens found in Willdenow's herbarium by Schlechtendal (Linnæa, x. 266) were sent from Pennsylvania by Muhlenberg. It is evident that a plant from Mt. Cenis became mixed with the original specimens and was figured by Schkuhr (f. 136). This Mt. Cenis plant is evidently *C. vaginata*, Tausch. Wahlenberg's *C. castanea* can scarcely be referred to *C. vaginata*, as he describes the leaves as hirsute, a character, however, which exists in some weak forms of *C. tetanica*. Until a final disposition is made of this *C. castanea*, the *C. castanea* of Elliott should hold its later name, *C. Elliottii*, Schw. & Torr.

Willdenow's Species Plantarum, in which *C. refracta* is published, dates a year earlier than Schkuhr's Riedgräser, where *C. tetanica* is published; but many if not all of Schkuhr's plates were published before the Species Plantarum, and there is a constant cross reference between the two authors.

Var. Meadii.

C. Meadii, Dewey, Sill. Journ. xliii. 90.

C. panicea, var. *Meadii*, Olney, Exsicc. fasc. i. no. 21.

C. panicea, var. *Canbyi*, Olney, Exsicc. fasc. ii. nos. 24 and 25.

C. panicea, Olney, l. c., in part.

Differs from the last in its stiffer culm, thicker and densely flowered spikes, the upper one or two sessile or nearly so, and not attenuated at the base: perigynium larger. Bears the name of the late Dr. S. B. Mead, of Augusta, Illinois. —Wet meadows and borders of ponds; Providence, Rhode Island, *Olney;* Delaware Co., Pennsylvania, *Canby;* North Carolina, *Hunter;* Georgia, Chapman; Houston, Texas, *Hall;* Ohio and Michigan to Nebraska, *Bruhin* (St. Helena), and northward through Iowa to the Great Plains of British America, *Macoun.* Evidently rare east of New York.

172. CAREX LIVIDA, Willd. Sp. Pl. iv. 285.

C. limosa, var. *livida*, Wahl. Köngl. Acad. Handl. xxiv. 162.

C. Grayana, Dewey, Sill. Journ. xxv. 141.

C. livida, var. *radicalis*, Paine; Dewey in Sill. Journ. 2d ser. xli. 329.

Peat bogs and pine barrens from New Jersey and New York to Labrador and Lake Superior and high northward; Alaska; also at Mendocino City, California, Bolander, according to W. Boott. Europe.

D. *Bicolores*, Tuckerman, Enum. Meth. 12. Small species with a beakless, more or less round or pyriform perigynium, which is commonly glaucous; terminal spike androgynous or all staminate.

173. CAREX AUREA, Nuttall, Gen. N. Amer. Pl. ii. 205.

C. mutica, R. Br. Frank. Narr. App. 763.

C. pyriformis, Schwein. An. Tab.

C. aurea, var. *androgyna*, Olney, Exsicc. fasc. i. no. 15.

C. concinna, Olney, Bot. King's Report, 372, as to Watson's specimens.

Variable. — Throughout the continent from Pennsylvania and Utah northward.

174. CAREX BICOLOR, Allioni, Fl. Ped. ii. 267.

Differs from the last in its somewhat larger size, glaucous appearance, white-nerved scales which do not cover the white perigynia, beakless perigynia, and shorter, broader leaves. Closely resembles small and androgynous forms of *C. aurea*, from which it is easily distinguished by the compressed perigynia, which are not fleshy, and the dark white-nerved scale. — Greenland and Labrador according to Dr. Boott. Mountains of Europe.

175. CAREX RUFINA, Drejer, Rev. Crit. Car. 28.

Very densely cespitose: culm short (one to four inches high), often curved, surpassed by the leaves: spikes four or five, approximate, oblong or elliptic, the terminal androgynous, staminate at the base: lowest bract much surpassing the culm: perigynium obovate, stipitate, short-beaked, covered by the uniformly colored reddish scale: stigmas two. — Greenland, *Vahl.* Norway.

E. *Digitatæ*, Fries, Corp. 187. Low species with ordinary leaves; sheaths membranaceous or hyaline and colored, either not prolonged into a bract or the bract very short and not foliaceous; perigynium more or less three-angled, often hairy, the beak straight or nearly so. — The sheaths are very short and easily overlooked in *C. concinna*, and in *C. Boottiana* they rarely occur, as the spike is one and terminal.

176. Carex eburnea, Boott, Hook. Fl. Bor.-Am. ii. 226, t. 225.
C. alba, Dewey, Sill. Journ. vii. 266.
C. alba, var. *setifolia*, Dewey, Sill. Journ. xi. 316.

Kentucky and Missouri northward to Mackenzie's River, and New England.

177. Carex concinna, R. Brown, Frankl. Narr. App. 763.
C. ornithopoda, Torr. Monogr. 412.

Saskatchewan, *Bourgeau*, Rocky Mts. of British America, according to Boott, and northward. I inserted this species in Coulter's Manual upon the authority of Olney (Bot. King's Report, 372), but I have since examined the specimen from the Wahsatch there referred to *C. concinna* and find it to be a small and immature *C. aurea*.

178. Carex melanocarpa, Chamisso; Trautv. in Middend. It. I. part 2, pp. 7, 14, and 21, t. 4.

Cespitose: leaves linear, shorter than the culm: staminate spike solitary; pistillate spikes one or two, erect, very small, few-flowered, the upper one close to the staminate spike and sessile, the lowest remote, with the short peduncle included in the sheath of the bract: bract muticous or cuspidate, that and the scales orbicular-elliptic, rounded at the apex, dark purple and slightly puberulent on the back: perigynium oval, compressed, surpassing the culm, beakless, slightly puberulent, the orifice entire. Trautvetter's figure represents a peculiar plant with slender culm (three to six inches high) much surpassing the leaves, conspicuous staminate spike, and very obtuse scales to both staminate and pistillate spikes. — St. Lawrence Isl., off Alaska, Chamisso.

179. Carex Richardsoni, R. Brown, Frankl. Narr. App. 763.

Named for Sir John Richardson of Arctic exploring fame. — Near Rochester, New York, Dewey, Central Michigan, Wheeler, Illinois and northwestward to Arctic America; N. W. Coast, Douglas; perhaps also *Bolander's* 6478, from Mendocino Co., California.

180. Carex pedunculata, Muhl.; Willd. Sp. Pl. iv. 222.

Lancaster Co., Pennsylvania, *Porter*, to New England and northwestward to Norway House, British America, *Drummond*. Not common.

181. Carex Baltzellii, Chapman, List of Fla. Plants, 1845.

First detected in 1835 by Dr. Geo. F. Baltzell. — Dry sandy soil in Middle Florida. Rare.

182. Carex Boottiana, Bentham; Boott in Journ. Bost. Nat. Hist. Soc. 1845, v. 112.

C. picta, Steud. Cyper. Plant. 184.

Differs from the last in its diœcious inflorescence, solitary and thicker spike which is very densely flowered, more uniformly brown pistillate scales, straight, smoother, and emarginate perigynium, and narrower leaves. I refer this to the Digitatæ because its resemblance to *C. Baltzellii* is so close, and because empty and conspicuous sheaths sometimes occur. — Dr. Francis Boott, the greatest of caricographers, author of the monumental "Illustrations of the Genus Carex." — New Orleans, *Drummond;* N. W. Alabama; Lawrence Co., *Peters*, and Winston Co., *Mohr*. Rare.

183. Carex truncata, Boeckeler, Flora, 1858, 649.

"Bright green, cespitose: rhizome very short, the fibrils slender and pale: culms erect, four to ten inches high, flatly triquetrous, leafy, the basal sheaths leafless, lanceolate, and dull ferruginous, roughish above: leaves little longer than the culm, firm, plane, acuminate, nerved, the margins above and the nerves rough (one to two lines wide): spikes greenish white, densely many-flowered, the staminate linear-oblong, acute (six to seven lines long and a line wide), short-peduncled, furnished with a scale-like aristate bract, the pistillate about three, remote, erect (in flower), slender, cylindrical, subulate-acuminate, the upper short, short-stalked (four lines long), and near the staminate spike, the others rather long-peduncled and six to seven lines long: lower bracts leafy and sheathing, the lowest far surpassing the culm: scales small, hyaline and whitish with a green back, broadly obovate, the staminate obtuse and abruptly short-pointed, the pistillate amplectant, lightly 3-nerved, the apex truncate-emarginate and rough-aristulate: perigynium (young) about equalling the scale, obovate, nearly trigonous, green, beakless, the apex obtuse and slightly recurved, smooth: style deeply trifid. — New Orleans, Drummond, 423." *C. Baltzellii?*

Section VIII. SPHÆRIDIOPHORÆ, Drejer, Symb. Car. 9. Perigynium mostly short and rounded, three-angled in the Triquetræ, the beak straight and usually bifid, firm or hard in texture, not inflated, hairy or scabrous (smooth in *C. Whitneyi*); staminate spike one; pistillate spikes short (an inch or less long), usually globular or short-oblong, more or less sessile and approximate or the longer ones radical; bracts sheathless, short or obsolete; stigmas rarely two. — Low species of dry ground, with leaves all radical. The perigynia of *C. filifolia* are thin in texture, and in both that species and *C. scirpoidea* the spike is single.

A. *Filifoliæ*, Tuckerman, Enum. Meth. 8. (*Scirpinæ*, Tuckm. l. c.) Spike one, androgynous or in *C. scirpoidea* commonly unisexual.

184. CAREX SCIRPOIDEA, Michx. Fl. Bor.-Am. ii. 171.

C. Michauxii, Schwein. An. Tab.

C. Wormskioldiana, Hornem. Fl. Dan. t. 1528.

C. Wormskioldii, Drejer, Rev. Crit. Car. 18.

C. scirpina, Tuckerman, Enum. Meth. 8.

High mountains of N. New England and northward to Greenland, and N. Michigan and northwestward; mountains of Colorado, Utah, Nevada, Montana, etc. Adjacent Asia. Norway.

185. CAREX FILIFOLIA, Nuttall, Gen. N. Am. Pl. ii. 204.

Uncinia breviseta, Torr. Monogr. 428.

Kobresia globularis, Dewey, Sill. Journ. xxix. 253.

Dry plains, Colorado to California and northward into British America.

Var. VALIDA, Olney, in herb.; Bailey, Coulter's Man. 374.

Colorado. *C. filifolia*, var., Boott, Proc. Acad. Philad. 1863, 77.

Var.? MISER.

C. Lyoni, Olney, Bot. King's Rep., et al., not Boott.

Low, usually two to four inches high, the leaves very rigid: pistillate portion of the spike not conspicuous: pistillate scales much narrower than in the species, the margins scarcely hyaline: perigynium much smaller and flatter, entirely concealed under the scale, oblong-obovate, smooth. — Alpine: Clover Mts., Nevada, alt. 10,000 ft., *Watson* 1220; Berthoud Pass, Col., *Vasey* 591, Twin Lakes, *Wolfe* 1001, and *Parry* 442, coll. of 1862, lat. 39°–41°. Fully mature specimens are a desideratum. *C. rupestris* is at once distinguished from this by its flat leaves.

B. *Montanæ*, Fries, Corp. 188. Spikes two to several, the lowest occasionally long-peduncled and radical; perigynium rounded, contracted above and below, mostly bearing two prominent ribs. — A puzzling group, best illustrated by *C. Pennsylvanica*, *C. umbellata*, and their immediate allies.

* *Perigynium abruptly rounded above, bearing a more or less prominent rib on each side.*

186. CAREX PENNSYLVANICA, Lamarck, Dict. de Bot. iii. 388.

C. marginata, Muhl.; Willd. Sp. Pl. iv. 261.

C. lucorum, Willd. Hort. Berol. Suppl. 63.

Stoloniferous, forming large patches: leaves usually as long as the slender culms (which are commonly less than ten inches high), narrow, soft and grass-like: spikes one to three, approximate or usually contiguous (the two lowest very rarely more than a half-inch apart), globose, all sessile, commonly more or less dark-colored. Forms occasionally occur in which the beak is nearly as long as the body of the perigynium. Upon this form Willdenow founded his *C. lucorum.* — New England to Georgia and across the continent.

187. CAREX VARIA, Muhl.; Willd. Sp. Pl. iv. 259.

C. varia, var. *pedicillata*, Dewey, Sill. Journ. xi. 163.

C. collecta, Dewey, l. c. 314.

C. Pennsylvanica, var. *Muhlenbergii*, Gray, Gram. & Cyper. Exsicc.

C. Pennsylvanica, Torr. Monogr. 410.

C. varia, var. *minor*, Boott, Ill. 97.

Not stoloniferous: stouter, leaves broader (one and a half to two lines broad), usually shorter than the more or less prolonged culms (which range from ten inches to two feet in height), rather rigid and pale: spikes three to five, globose or oblong, scattered (from one half to an inch and a half apart), mostly light colored, the lowest often peduncled and commonly subtended by a conspicuous bract. In the large forms, which are rare, the spikes are all oblong and more or less peduncled. — Dry hillsides, Canada to Georgia. Less common than the last.

188. CAREX RIGENS, Bailey, Bot. Gaz. ix. 117.

C. varia, var., W. Boott, Proc. Am. Acad. xviii. 172.

C. varia, var. *Arizonica*, Bailey, Carex Cat.

Stoloniferous: rough throughout: culm six to twelve inches high, stiff, mostly longer than the stiff and rough long-pointed leaves, their bases surrounded by the fibrous remains of leaves: lowest bract green, nearly as long as the culm, the upper ones awl-pointed and little longer or shorter than their spikes: staminate spike an inch long, short-peduncled: pistillate spikes about three, pale, sessile, not aggregated, one fourth inch or less long or sometimes prolonged and staminate at the top: perigynium obovoid, large, angled, many-nerved, very gradually contracted into a stout base, gradually narrowed into a short entire or slightly toothed beak, thinly hairy, mostly shorter than the very acute thin scale: achenium obovoid. — S. Arizona, Tanner's Cañon, *Lemmon* 2904; Mexico, San Luis Potosi, *Schaffner* 547, *Parry* & *Palmer* 917.

189. CAREX TURBINATA, Liebmann, Mex. Halv. 77.

"Culm eight to twelve inches high, slender, trigonous, angles rough: leaves shorter than the culm, narrowly linear, carinate, margins rough:

head of spikes an inch long: spikes 4, the terminal half an inch long, staminate, the remainder pistillate, as long as the terminal, subsessile or shortly peduncled, oblong, approximate, few-flowered, furnished with bracts, the lowest one of which is leafy and surpassing the culm: staminate scales lanceolate, acute, compressed, mid-nerve green, side nerves reddish brown, margin thin: pistillate scales similar: perigynium stipitate, turbinate, ventricose, margined, beaked, many nerved, hispid, light green, often surpassing the scales, orifice of the beak bifid: achenium depressed-obovate or pear-shaped, apiculate, yellowish, smooth, base attenuated. — Southern Mexico, Central Cordillera of Oaxaca in the temperate region, June 1, Liebmann."

190. CAREX EMMONSII, Dewey, Torr. Monogr. 411.
C. alpestris, Dewey, Sill. Journ. vii. 268.
C. Davisii, Dewey, l. c. x. 279.
C. Novæ-Angliæ, var. *Emmonsii*, Carey, Gray's Man. 1848, 556.
C. lucorum, var. *Emmonsii*, Chapm. Flora, 539.
C. Emmonsii, var. *elliptica*, Boott, Ill. 97.

Dr. Ebenezer Emmons, 1798–1863, professor of natural history in Williams College, afterwards a professor in the Albany Medical College, one of the geologists of the New York State survey, and later geologist of North Carolina. — Canada to New Orleans and Texas, *Hall*, and Indian Territory, *Butler*.

191. CAREX NOVÆ-ANGLIÆ, Schweinitz, An. Tab.
C. deflexa, Hornem. Plantel. ed. 3, ii. 938.
C. pilulifera, L., var. *deflexa*, Drejer, Rev. Crit. Car. 54.
C. brevipes, W. Boott, Bot. Calif. ii. 246.
C. globosa, var. *brevipes*, W. Boott, Bot. Calif. ii. 485.
(See Bot. Gaz. x. 207.)

Its nearest ally is *C. varia*. Rare eastward in the United States. — Dry mountains from Massachusetts and New York to Greenland; Lake Tahoe to Bear Valley, California, *Kellogg;* E. Oregon, *Cusick;* Washington Terr., Brandegee; head of Yukon River, *Lieut. Schwatka*.

It is probable that another disposition of the Western specimens will need to be made when more material accumulates. They will probably need to be designated as var. *deflexa* of the species.

Var. ROSSII, Bailey, Bot. Gaz. x. 207.
C. Rossii, Boott, Hook. Fl. Bor.-Am. ii. 222.

Named for Sir John Ross, the Arctic explorer. — Mountains from New Mexico to British America.

192. CAREX PHYSORHYNCHA, Steudel, Cyper. Plant. 219.

C. rhynchophysa, Liebm. Mex. Halv. 76, not C. A. Meyer.

"Culm two to five inches high, slender, triquetrous, rough on the angles: leaves short, narrowly linear, flat or reflexed, rough on the margins: head of spikes a half-inch long: spikes 3–4, the terminal staminate, the remainder pistillate, contiguous, sessile, few-flowered, furnished with bracts the lowest one of which is leafy and equalling the culm: staminate scales ovate-lanceolate: pistillate scales narrower, strongly acuminate, carinate, the nerve green, the side of the scale bordered by a narrow zone of dark purple: perigynium stipitate, elliptical, ventricose, round-trigonous, nerved, the beak slightly puberulent, glandulose-pilose below, the beak compressed, lightly toothed with the margins ciliate: achenium obovate, obtuse, trigonous, angles prominent, sides a little convex and slightly punctate. — So. Mexico, Chinantla in Puebla at 7,500 to 8,000 feet, May 1, Liebmann."

193. CAREX FLORIDANA, Schweinitz, An. Tab.

C. lucorum, var. *Floridana*, Chapm. Flora, 539.

C. nigro-marginata, var. *subdigyna*, Boeckeler, Linnæa, xli. 220.

Santee Canal, South Carolina, *Ravenel*, to Florida and Texas, *Reverchon*.

194. CAREX NIGRO-MARGINATA, Schweinitz, An. Tab.

C. lucorum, var. *nigro-marginata*, Chapm. Flora, 539.

Dry hillsides from New Jersey to North Carolina, *Curtis*.

195. CAREX UMBELLATA, Schkuhr, Riedgr. Nachtr. 75, f. 171.

C. umbellata, var. *vicina*, Dewey, Sill. Journ. xi. 317.

Dry knolls and hillsides, New England to Pennsylvania and Illinois and Indian Territory, *Butler*, and northwestward into British America; Oregon, *Henderson*.

Var. BREVIROSTRIS, Boott, Ill. 99, t. 294.

C. globosa, W. Boott, Bot. Calif. ii. 246; in part.

(See Bot. Gaz. x. 206.)

Mogollon Mts., New Mexico, *Greene;* near Golden City, Colorado, *Greene;* California, Cisco, *Kellogg*, Plumas Co., *Mrs. Austin;* British America, *Herb.*

196. CAREX GLOBOSA, Boott, Linn. Trans. xx. 125.

Transition to the Phyllostachyæ. — California, Nuttall; Oakland, *Bolander* 20 and 2298; Yosemite, *Bolander* 6196.

197. *Carex præcox*, Jacquin, Fl. Austr. v. 25, t. 446.

C. stolonifera, Ehrh. Calam. Exs. no. 99.

C. verna, Vill. Pl. Dauph. ii. 204; Dewey, Sill. Journ. xi. 314.

Dry fields, Salem, Ipswich, and Dedham, E. Massachusetts. First found in this country in 1826, at Salem, by Dr. C. Pickering. Introduced from Europe.

* * *Perigynium various, usually gradually beaked, the ribs not prominent or none.*

198. Carex inops.

Culm slender but rigid, sharply angled, roughish, a foot high, from long and erect root-stalks, twice longer than the numerous, narrow, long-pointed and rigid leaves: spikes three or four, all aggregated and sessile at the top of the culm, the lowest subtended by a sheathless bract of about its own length, the terminal spike staminate and an inch long, the others half as long and staminate at the top: perigynium small, elliptic, nerveless or nearly so, brown below, very abruptly produced into a white straight and deeply cut beak, scabrous below, hairy on the shoulders and beak, about the length of the brown-centred, broad, acute scale. — Sandy grounds on subalpine slopes of Mt. Hood, Oregon, July, 1884, *L. F. Henderson.* In aspect much like *C. Pennsylvanica.* It lacks the ribbed and hardened character of the perigynia of that species and its allies, and the beak is straighter and more deeply cleft.

199. Carex Halleriana, Asso, Syn. Pl. Arag. 135, t. 9, f. 2.
C. alpestris, All. Fl. Ped. ii. 270.
C. gynobasis, Vill. Pl. Dauph. ii. 206.
C. planostachys, Kunze, Suppl. Riedgr. 138, t. 35.
C. umbellata, var. *vicina*, Dewey, Bot. Mex. Bound. 232.

Culms slender, erect, rough on the angles above, shorter or longer than the narrow, revolute, rough and rather rigid leaves, which are sometimes somewhat recurved: staminate spike single, sessile or more commonly peduncled, slender, an inch or less long: pistillate spikes loosely few-flowered, those on the culm sessile or short-peduncled, the radical ones long-peduncled: perigynium obovate or elliptic, very strongly three-angled, green, much attenuated below, the short beak often recurved, very strongly many-nerved, puberulent, shorter than or equalling the green-backed and white-margined acute scale. A well-marked species with much the aspect of loose *C. umbellata.* All the European specimens which I have examined have broader and blunter scales than our plants. Dr. Boott, however, figures an Algerian specimen with very acute scales. — Texas: dry uplands at Dallas, *Reverchon;* hills at Houston, *Hall* 753; woods on the Colorado, *Wright;* Upper Guadaloupe, *Lindheimer;* So. Mexico, Schiede. Europe.

C. *Triquetræ*, Carey, MSS.; Olney in Proc. Am. Acad. 1868, 395. Plants taller; spikes mostly approximate at the top of the culm, oblong or cylindrical; perigynium conspicuously three-angled.

200. CAREX CHAPMANI, Sartwell, Exsicc. no. 113.

C. tenax, Chapm.; Dewey, in Sill. Journ. 2d ser. xix. 254.

Aiken, South Carolina, *Canby*, to Middle Florida, *Chapman*.

201. CAREX DASYCARPA, Muhl. Descr. Gram. 236.

Shady woods, South Carolina, Elliott, to Florida.

202. CAREX PUBESCENS, Muhl.; Willd. Sp. Pl. iv. 281.

Meadows and moist woods from New England to Kentucky and Fort Pierre, Dakota, Hayden.

203. CAREX COULTERI, Boott, MSS.; Hemsley in Bot. Biolog. Cent.-Am. iii. 473.

Differs from *C. pubescens* in its longer and narrower leaves, dentate orifice of the perigynium, and in its muticous scales which are pubescent on the back. Dr. Thos. Coulter, of Dublin, was an early botanical explorer in Mexico and California, and the first to reach the deserts of the Colorado. — So. Mexico, Zimapan, Coulter 1620; Santa Fé, Valley of Mexico, Bourgeau 671.

204. CAREX TRIQUETRA, Boott, Linn. Trans. xx. 126.

C. monticola, Dewey, Bot. Mex. Bound. 229.

Culm six to eighteen inches high, stiff, smooth, mostly longer than the flat smooth leaves: lower bract equalling or exceeding the culm, conspicuously sheathing: spikes rather loosely flowered, an inch and a half or less long, the lowest commonly more or less remote and peduncled: perigynium large, broadly oval or oboval, very sharply angled, almost beakless, few and indistinctly nerved, sparsely pubescent, much broader and usually longer than the green conspicuously brown-margined obtuse or muticous scale. — Transition to the Dactylostachyæ. — California, Nuttall; San Diego, *Parry*, *Pringle*; Lassen Co., *Mrs. Austin*; Sierra Madre, *Nevins*; Ojai, *Peckham*.

205. CAREX WHITNEYI, Olney, Proc. Am. Acad. vii. 394.

Differs from the last in its hairy leaves, sheathless bracts, thinner and more slender perigynia, which are smooth, prominently nerved and beaked (the orifice erose), and shorter than the whitish chaff-like acuminate scale. The spikes upon large specimens resemble small heads of barley. Transition to the Secalinæ of the Old World. Named for Prof. J. D. Whitney, director of the Geological Survey of California. — California: Mt. Shasta, *Pringle*; Yosemite, *Brewer* 1639, *Bolander* 6198; Lassen Co., *Mrs. Austin*.

Section IX. PHYLLOSTACHYS, Carey, Gray's Man. 1848, 538. Perigynium much as in the Montanæ; spike one, staminate above; pistillate flowers few, often remote, usually on a more or less zigzag rhachis; scales prolonged and leaf-like (scarious and often short in *C. Geyeri*). — A singular section, to be regarded, probably, as an offshoot from the Montanæ. It is connected with the Laxifloræ by *C. multicaulis*, which is related to *C. Hitchcockiana*.

A. *Bractoideæ*, Bailey, Bot. Gaz. x. 208. Culms mostly much shorter than the leaves; staminate flowers inconspicuous; perigynium small, the beak produced to half its length or more; scales very green and much dilated, often concealing the perigynia, and readily mistaken for bracts.

206. CAREX WILLDENOVII, Schkuhr, Riedgr. Nachtr. 33, f. 145.
C. Willdenovii, var. *pauciflora*, Olney, Hall's Pl. Tex. 25.

Karl Ludwig Willdenow, 1765–1812, Professor of Botany in Berlin. — New England to North Carolina and Texas.

207. CAREX STEUDELII, Kunth, Enum. Plant. ii. 480.

Ernst Gottlieb Steudel, 1783–1856. — New York to Kentucky and Illinois. "Florida and westward," Chapman.

208. CAREX BACKII, Boott, Hook. Fl. Bor.-Am. ii. 210, t. 209.

Sir George Back, an Arctic explorer. — Mt. Tom, W. Massachusetts, *Whitney*, to Ohio and Michigan and northwestward to the Saskatchewan, *Bourgeau*, and Cumberland House, *Richardson;* Colorado, *Hall* & *Harbour* 612.

B. *Phyllostachyæ*, Bailey, Bot. Gaz. x. 208. Culms all as long or nearly as long as the leaves; staminate flowers conspicuous; pistillate flowers very few and large; beak very short.

209. CAREX GEYERI, Boott, Linn. Trans. xx. 118.

Karl Andreas Geyer, 1809–53, a German botanist who travelled in this country from 1834 to 1845. — Colorado, Utah, Montana, and E. Oregon, *Cusick.*

210. CAREX MULTICAULIS, Bailey, Bot. Gaz. ix. 117.
C. Geyeri, Boott, Ill. t. 105, in part.

Culms very numerous, one to three feet high, stiff and wiry, terete or in weak specimens obtusely angled, smooth or minutely scabrous beneath the flowers, their sheaths leafless or produced into stiff and appressed tips an inch or so long, or on the barren culms three to six inches long and spreading: scales, at least the lower ones, leaf-like and prolonged into a slender tip often exceeding the culm, their bases dilated and hyaline-margined: pistillate flowers two to six, the lower one often remote: perigynium very large (three to four lines long), strongly triquetrous, the sides at maturity cross-wrinkled and often concave, much contracted into a stipitate base, very finely many-nerved (rarely the nerves obsolete below), tightly enclosing the minutely punctate perigynium, the very short orifice entire. A singular plant. The culms remain a year after fruiting. — California: Yosemite, *Torrey* 544; Ukiah, *Bolander* 39; Big Trees, *Brewer* 1635 and 2306; Plumas Co., *Mrs. Ames;* Duffield's Ranch, *Bigelow;* Alamandon, S. W. Oregon, *Howell.*

Section X. LAMPROCHLÆNÆ, Drejer, Symb. Car. 10. (*Deflexocarpæ*, Bailey, Coult. Man. 373, in part.) Perigynium smooth (rarely minutely serrate on the margins), firm in texture or even horny, mostly glossy or shining brown or black, lightly nerved or nerveless, bearing a short beak; scales mostly obtuse with hyaline margins; spike one (except *C. pedata*, *C. obesa*, and *C. Schaffneri*), small, staminate above; stigmas mostly three. — Small species, mostly boreal or alpine.

A. *Pulicares*, Tuckerman, Enum. Meth. 7. Perigynium spindle-shaped or narrowly ovate, stipitate, deflexed or widely spreading at full maturity.

211. Carex Pyrenaica, Wahl. Köngl. Acad. Handl. xxiv. 139.
C. micropoda, C. A. Meyer, Cyp. Nov. 210, t. 6.
Callistachys Pyrenaica, Heuffl. Flora, 1844, 528.

Colorado, *Hall & Harbour* 608, *Vasey* 590, *Brandegee*, *Englemann;* Utah, Uintas, *Watson* 1218; S. E. Oregon, *Cusick*; Alaska, Meyer. Europe.

212. Carex nigricans, C. A. Meyer, Cyp. Nov. t. 7.

Colorado, *Hall & Harbour* 609, *Vasey;* Utah, Bear River Cañon, *Watson* 1217; Mt. Shasta, Calif., *Brewer* 1379; Oregon, *Hall* 569, *Howell*, *Henderson;* Alaska, *Chamisso.* Adjacent Asia.

213. Carex Schaffneri, Boeckeler, Flora, 1878, 39.

"Glaucous green, shining: culms usually two, erect, three to six inches high, filiform, compressed-triangular, striate, smooth, very leafy at the base: leaves crowded and spreading, rigid, much shorter than the culm (one to one and a half inches long), twice longer than the last year's sheathing fascicles, setaceous, straight or slightly curved, canaliculate, margins above serrulate: spikes two, androgynous (probably staminate at the top), unequal, crowded at the top of the culm, chestnut-colored, oblong-ovate or ovate, acutish, 10–15-flowered (three to four lines long): bracts short, scale-like and cuspidate: scales broadly ovate, obtuse, broadly amplectant at the base, the keel green, somewhat 3-nerved, mucronate, the sides light chestnut-colored, the margins paler and membranaceous: perigynium (immature) little longer than the scale, sessile, oblong-lanceolate, compressed-trigonous, smooth, the orifice obliquely truncate and reddish yellow: stigmas three. — So. Mexico, Valley of Mexico, Dr. J. G. Schaffner.

B. *Rupestres*, Tuckerman, Enum. Meth. 8. (*Obtusatæ*, Tuckm. l. c.) Perigynium mostly ovate and appressed to the rhachis.

214. Carex pedata, Wahl. Fl. Lapp. 239, t. 14.

Densely cespitose: culms stiff, one to five inches high, very obtusely angled, smooth, longer than the numerous erect or recurved leaves: spikes two to four, the terminal staminate and a fourth inch or less long, the others pistillate and contiguous, very small, one to five-flowered, sessile or very nearly so, borne in the axil of a very short bract which has a dilated, colored, and loosely clasping base: perigynium small, broadly round-ovate, rather thin in texture, nerveless, pale below, abruptly contracted into a stout purple often hyaline-tipped beak, usually a little longer than the very obtuse purple and thin margined scale. Transition to the Digitatæ. The *Carex pedata* of Linnæus, Sp. Pl. ed. iii. 1384, is not identified. — Greenland, *Fries*, *Andersson*. N. Europe. Asia.

215. Carex obesa, Allioni, var. minor, Boott, Ill. 161, t. 535.
C. supina, Willd.; Wahl. Köngl. Acad. Handl. xxiv. 158.
C. Schkuhrii, Willd. Sp. Pl. iv. 264.
C. sphærocarpa, Willd. l. c. 265.

Distinguished from the last by its mostly larger size, sharply angled culm, thicker pistillate spikes, hard and conspicuously angled perigynium, which is usually shorter than the acute scale. — Bear Lake, British America, *Richardson*, and Saskatchewan, Bourgeau, according to Boeckeler; Greenland, *Herb.* Europe. Asia.

216. Carex obtusata, Liljeblad, Köngl. Acad. Handl. 1793, 69, t. 4.
C. spicata, Schkuhr, Riedgr. 11, f. 15.
C. microcephala, C. A. Meyer, Ledeb. Fl. Alt. iv. 205.
C. affinis, R. Br., Frankl. Narr. App. 763.
C. Backiana, Dewey, Sill. Journ. xxix. 250.
C. obesa, var. *monostachya*, Boeckeler, Linnæa, xli. 185.

Colorado, *Hall & Harbour* 606; South Park, *Wolf* 1003; Georgetown, *Patterson*; Little Belt Mts., Montana, 7,500 ft. alt., *Scribner*; Saskatchewan, *Bourgeau*, *etc.*, and northward.

217. Carex rupestris, Allioni, Fl. Ped. ii. 264, t. 92, f. 1.
C. petræa, Wahl. Köngl. Acad. Handl. xxiv. 139.

C. attenuata, R. Br. Frankl. Narr. App. 763.
C. Drummondiana, Dewey, Sill. Journ. xxix. 251.
C. rupestris, var. *Drummondiana*, Bailey, Carex Cat.

High mountains of Colorado, Hall & Harbour 273, Sierra Blanca, Hooker & Gray, Gray's Peak, *Patterson*, and northward to Greenland, *Herb.* Europe.

Section XI. LEPTOCEPHALÆ. Perigynium thin in texture, green, oblong or lanceolate or linear in general outline, beakless or nearly so; spike one, staminate above, thin and slender; stigmas mostly three. — Small and slender grass-like North American species.

218. Carex polytrichoides, Muhl. in Willd. litt. in Wahl. Kongl. Acad. Handl. xxiv. 139; Willd. Sp. Pl. iv. 213.
C. leptalea, Wahl. l. c.
C. microstachya, Michx. Fl. Bor.-Am. ii. 169.

Florida and Texas to Newfoundland and Oregon.

219. Carex Lyoni, Boott, Hook. Fl. Bor.-Am. ii. 209, t. 208.

Culm very short (one to two inches): leaves rigid, canaliculate, almost needle-like, their points callous and shining and truncate, surpassing the culm; scales narrow, rather acute, about the length of the lanceolate, smooth, slightly toothed perigynium. — Founded upon very immature specimens collected by *Drummond* in the Rocky Mts. of British America.

220. Carex leiocarpa, C. A. Meyer, Cyp. Nov. 208, t. 5.
C. anthoxanthea, Presl, Reliq. Hænk. 203, fide Boeckeler.

Culm slender, erect, six to fifteen inches high: leaves flat but narrow, lax, about as long as the culm: spike about an inch long, commonly either wholly staminate or wholly pistillate: perigynium lance-linear (about two lines long), pointed, nerved at least below, commonly entirely smooth, ending in a blunt and perfectly entire orifice, usually twice longer than the obtuse scale: stigmas three. Habitually taller and laxer than the next. — Alaska, *Dall*, *Mertens;* Nootka Sound, Vancouver's Isl., Presl.

221. Carex circinata, C. A. Meyer, l. c. 209, t. 6.

Culm slender, two to ten inches high, often curved: leaves filiform, firm, equalling or surpassing the culm, usually curved: spike half an inch to an inch long: perigynium nearly linear (nearly three lines long), produced very gradually to a 2-lipped orifice, somewhat rough on the margins, lightly nerved, exceeding the linear purple-margined obtuse and white-tipped scale: stigmas three or two. — Alaska, *Dall*, *Bongard.*

Section XII. PHYSOCEPHALÆ. Spike one, globular or short-oblong, staminate at the apex; perigynium straw-colored, paper-like, more or less inflated; stigmas three. — Aside from the three species which follow, the section is represented in the Caucasus by the remarkable *C. physodes*, Bieb.

222. CAREX FRASERI, Andrews, Bot. Rep. t. 639.
C. Fraseriana, Sims, Bot. Mag. t. 1391.
Mapania sylvatica, Pursh, Fl. i. 47.
C. lagopus, Muhl. Descr. Gram. 265.

A rare and remarkable plant, bearing little general resemblance to the next two, though agreeing with them in general characters of inflorescence and perigynium. A rhacheola is often found within the perigynium. Named for John Fraser, 1750–1811, an ardent English botanist who visited America three times, in his last expedition discovering this singular Carex. — Near Wytheville, Virginia, *Shriver;* Little Doe River near Roan Mt., Tennessee, *Dr. Gray;* near Morgan Town and Table Mt., Fraser in 1808, and Grandfather Mt., *Gray et al.*, N. Carolina.

223. CAREX BREWERI, Boott, Ill. 142, t. 455.

Culm three to ten inches high, obtusely angled, rigid, smooth, exceeding the filiform stiff leaves: spike a half inch to an inch long, ovate or globular, the pistillate portion more conspicuous: perigynium bladder-like, about as broad as long, exceeding the scale. — California in the Sierras, Mt. Shasta, *Brewer*, *Pringle*, *et al.*, Mt. Dana, *Bolander*, Lassen's Peak, *Brewer;* Oregon, *Hall*, Mt. Hood, *Henderson.*

224. CAREX ENGELMANNI.

Culms slender but erect, four to six inches high, about the length of the numerous very slender bristle-like leaves: spike small, nearly globular, two to three lines broad, the staminate flowers inconspicuous: perigynium lanceolate, about two lines long, very delicate in texture, flat, somewhat shining, nerveless, the long apex empty, the beak entire or nearly so, about the length of the thin brown acute scale. — Alpine slopes, Colorado, 1874, *Dr. George Engelmann*, probably near Colorado Springs.

SUBGENUS II. VIGNEÆ, Koch, Syl. Fl. Germ. 748. *Vignea*, Beauvois, Lestib. Fam. Cyper. Staminate flowers few and inconspicuous, borne at the base or apex of the pistillate spikes. Pistillate flowers in short and sessile spikes (or spike single in some cases), which are commonly more or less aggregated into heads or even panicled. Cross-section of the perigynium plano-convex in outline. Styles two and achenium lenticular. — The spikes, especially the uppermost, usually have contracted bases when the staminate flowers are borne below the pistillate ones, and empty scales at the top when the staminate flowers are borne above.

Section XIII. ACROARRHENÆ, Fries, Summa, 73. Staminate flowers borne at the top of the spikes (or, in the *Multifloræ* and *Arenariæ*, spikes often wholly staminate and the plants occasionally diœcious).

A. *Fœtidæ*, Tuckerman, Enum. Meth. 10. (*Curvules*, Tuckm. l. c. in part. *Chordorhizeæ*, Fries, Summa, 73.) Spikes tawny or brown, not elongated, very densely aggregated into a continuous globose somewhat chaffy head; perigynium ovate or ovate-lanceolate, nerveless or nearly so, mostly thin in texture.

225. Carex incurva, Lightfoot, Fl. Scot. 544, t. 24, f. 1.
C. juncifolia, All. Fl. Ped. ii. 264, t. 92, f. 4.
C. psammogæa, Steud. Plant. Cyper. 187.

Colorado, Gray's Peak, *Patterson*, alpine ridge near Middle Park, *Parry*; Rocky Mts. of British America, *Drummond*, and northward to Kamtschatka, *Wright*, and Greenland, *Vahl*. Europe.

226. Carex chordorhiza, Ehrhart, Phyt. no. 77.
C. fulvicoma, Dewey, Sill. Journ. xxix. 249.

Cold bogs from Vermont to Illinois and Iowa, and northward to Hudson's Bay. Not common. Europe.

227. Carex fœtida, Allioni, Fl. Ped. ii. 265.

Mountains of Colorado, Wyoming, and Utah, and in California, *Brewer* 2066 and 2304, Summit Camp, *Dr. Kellogg*.

228. Carex stenophylla, Wahl. Köngl. Acad. Handl. xxiv. 142.
C. juncifolia, Schkuhr, Riedgr. 26, f. 32.
C. duriuscula, C. A. Meyer, Cyp. Nov. 214, t. 8.
C. pachystylis, Gay, Ann. Sci. Nat. x. 301.
C. Deinbolliana, Gay, Ann. Sci. Nat. xi. 183.

Emmet Co., Iowa, *Cratty*, to Colorado and northward to the Saskatchewan.

229. Carex Hoodii, Boott, Hook. Fl. Bor.-Am. ii. 211, t. 211.

A dubious species founded upon immature specimens from the Columbia, collected by *Scouler*. Subsequent specimens collected in California have been referred to it, but they belong to *C. Brongniartii*, var. *densa*, and *C. muricata*, var. *confixa*, which see for further notes on *C. Hoodii*. It is probable that Scouler's plant is *C. muricata*, var.

confixa. Meyer's *C. congesta* from Kamtschatka, referred here by Dr. Boott, has staminate flowers at the base of the spikes, and is to be referred to *C. festiva.* *C. Hoodii* is probably the same as *C. anthericoides,* Presl, Reliq. Hænk. 204, an older species.

B. *Vulpinæ*, Kunth, Enum. Plant. ii. 383; Nym. Consp. Fl. Eur. 781. (*Vulpinoideæ*, Kunth, l. c. 381. *Muricatæ*, Fries, Summa, 73, in part.) Spikes mostly yellow or tawny when mature, densely aggregated or sometimes somewhat scattered below or even panicled; perigynium thick in texture, spongy at the base, mostly stipitate, bearing very conspicuous nerves which converge below, and which are especially prominent on the outer side.

* *Beak shorter than or about the length of the body of the perigynium.*

230. CAREX NERVINA, Bailey, Bot. Gaz. x. 203, t. iii. ff. 6, 7, 8.

Culm flat and weak, smooth, striate, about eighteen inches high from a woody root: leaves ample, broad, striate above and minutely nodulose below, the upper equalling the culm, the lower short (one half to three inches long) from loose truncate sheaths: spikes densely aggregated into a fulvous head which is one half or three fourths inch long and subtended by one or two setaceous bracts of half its length: perigynium lanceolate, spongy and compressed at the base, firm in texture, marginless and smooth throughout, about the length of the very thin acute scale: achenium oval. — Summit Camp, California, July 10, 1870, *Dr. Kellogg.*

231. CAREX CONJUNCTA, Boott, Ill. 122.

C. vulpina, Carey, Gray's Man., 1848, 512, not Linn.

Ohio, Kentucky, and Illinois; said by Dewey to have been found by Hayden at Fort Pierre, Dakota. Rare. Readily distinguished by its flat culm.

232. CAREX MACROCEPHALA, Willd. in Herb.; Sprengel, Syst. iii. 808.

Leaves a foot or more long, stiff, rough on the edges: culm a foot or less long, very stiff, three-angled, smooth, shorter than the leaves: head very large (two inches or more long and an inch or more broad), dense, chaffy, comose from the conspicuous points of the perigynia, subtended by slender bracts shorter than itself: perigynium about a half-inch long and nearly a quarter-inch broad, bearing thin margins which are often serrate, the slender beak about the length of the body, a little longer than the very sharp scale. — A remarkable species, growing in sand on the sea-shore of Oregon and Washington Territory, sending a hard root-stock perpendicularly into the ground. Japan.

* * *Beak twice or more the length of the body of the perigynium.*

233. Carex stipata, Muhl.; Willd. Sp. Pl. iv. 233.

C. vulpinoidea, Torr. Monogr. 390.

C. stipata, var. *maxima*, Chapm. Flora.

Florida to Newfoundland, *La Pylaie*, and British America, Oregon, *Hall*, *Henderson*, California, Sierra Valley, *Lemmon*, and New Mexico, *Fendler*.

234. Carex crus-corvi, Shuttleworth; Kunze, Riedgr. Suppl. 128, t. 32.

Forms *orthoclados* and *orthostachys*, Kunze, l. c. 166, 167, t. 42.

C. siccæformis, Boott, Journ. Bost. Nat. Hist. Soc. v. 113.

C. Halei, Dewey, Sill. Journ. 2d ser. ii. 248.

Florida to Texas and Indian Territory, *Butler*, and northward to Illinois, Wisconsin, and Red Wing, Minnesota, *Sandberg*.

C. *Multifloræ*, Kunth, Enum. Pl. ii. 387. (*Paniculatæ*, Kunth, l. c. 389, Nym. Consp. Fl. Eur. 781. *Bracteosæ*, Kunth, l. c. 378. *Siccatæ*, Carey, Gray's Man. 1848, 539, in part. *Intermediæ*, Nym. Consp. Fl. Eur. 782. *Distichæ*, Christ, Cat. Eur. Car. 8.) Heads various, mostly loosely flowered, sometimes a panicle, yellow or tawny; spikes short (rarely longer than broad); staminate flowers sometimes occupying whole spikes in the middle or at the apex of the head; perigynium mostly small and short and nearly nerveless, or in some species becoming nearly lanceolate and more or less prominently nerved, firm in texture, usually numerous.

* *Spikes conspicuously panicled.*

235. Carex decomposita, Muhl. Descr. Gram. 264.

C. paniculata, var. *decomposita*, Dewey, Sill. Journ. x. 275.

Florida to W. Louisiana and northward to New York, Michigan, and Illinois. Not common.

* * *Spikes in a simple or nearly simple head.*

236. Carex Gayana, Desvaux, Fl. Chili, 205.

Plant nearly or quite diœcious. The species is very little understood. Colorado to Sonora Pass, California, *Brewer* 1865, and southward. South America.

Var.? hyalina.

Differs from the species in bearing an interrupted slender head (an inch long and nearly linear), the lowest spike of which is entirely distinct and subtended by a conspicuous short bract, and in the very thin hyaline scales which are obtuse or very shortly mucronate. The perigynium is rather large, less coriaceous, not shining. Probably a distinct species, but I have fragmentary specimens which appear to be intermediate between this and the type of the species. Evidently diœcious. Resembles *C. prægracilis.* — Sonora, Mexico, *Dr. Geo. Thurber.*

237. Carex marcida, Boott, Hook. Fl. Bor.-Am. 212, t. 213.

Often diœcious, or nearly so. Imperfectly understood. — Colorado to California and northward into British America.

Var. debilis.

Small and slender (a foot or less high), the culms mostly somewhat exceeding the very narrow and long-pointed leaves: head narrow, a half-inch or less long: perigynium smaller, more contracted at the base. — Harney Valley, Oregon, *Howell.*

238. Carex teretiuscula, Goodenough, Linn. Trans. ii. 163, t. 19.

C. teretiuscula, var. *major*, Koch, Fl. Germ. 867.

New England to Pennsylvania and northwestward to the Saskatchewan, *Hb. Hooker;* S. California, *Parish.*

Var. ramosa, Boott, Ill. 145.

C. prairea, Dewey, Wood's Bot. 1861, 750.

C. paradoxa, Boott, Hook. Fl. Bor.-Am. ii. 213.

Head slender and interrupted, often branched below; perigynium longer and usually thinner in texture than in the species. — From New York to Oregon, *Henderson.*

239. Carex alopecoidea, Tuckerman, Enum. Meth. 18.

C. alopecoidea, var. *sparsi-spicata*, Dewey, Sill. Journ. viii. 350.

C. cephalophora, var. *maxima*, Dewey, Sill. Journ. xliii. 92.

"Woods, W. New York to Pennsylvania, Michigan, etc.," Gray's Manual. I have seen typical specimens only from Penn Yan, New York, *Sartwell*, Ludlowville, New York, *Lord*, and Lansing, Mich. Rare.

240. Carex vulpinoidea, Michx. Fl. Bor.-Am. ii. 169.

C. microsperma, Wahl. Köngl. Acad. Handl. xxiv. 144.

C. multiflora, Muhl.; Willd. Sp. Pl. iv. 243.

C. setacea, Dewey, Sill. Journ. ix. 61.

C. scabrior, Sartw. Exsicc. no. 72.

C. vulpinæformis, Tuckerman, Enum. Meth. 9.

Throughout the States east of the Mississippi, especially northward, and northward to Winnipeg, *Bourgeau*, and perhaps farther westward. Exceedingly variable.

Var. platycarpa, Olney, Hall's Pl. Texanæ, 25; Bailey, Coulter's Man. 392.

C. vulpinoidea, var. *Drummondiana*, Boeckeler, Linnæa, xxxix. 96.

Louisiana to Texas and Indian Territory.

241. CAREX BRONGNIARTII, Kunth, Enum. Pl. ii. 380.

C. hypoxanthus, Steud. Plant. Cyper. 193.

C. glomerata, authors, not Thunb.

Distinguished from *C. vulpinoidea* by the looser flowered and chaffy spikes, the large perigynium, the short and straw-colored heads (usually an inch and a half or less long), and the absence (or nearly so) of conspicuous bracts. The Pacific slope representative of *C. vulpinoidea.* — Arizona; California, *Kellogg* & *Harford* 1068; wet meadows, Mendocino City, *Bolander* 4808; Oakland Slough, *Bolander* 6204; Oregon, *Hall.* Chili.

Var. DENSA.

C. Xalapensis, Kunth, Enum. Pl. ii. 380.

C. Hoodii, Boott, Ill. 17, as to Californian specimens.

C. Brongniartii, Boott, Ill. t. 402.

C. paniculata, W. Boott, Bot. Calif. ii. 232, not Linn.

Heads more dense, mostly thickest at the base (often nearly an inch in width): perigynium broad-lanceolate (much longer than in the type), long beaked and very prominently nerved. — California, *Palmer* 389 (San Diego Co.), *Bigelow*, *Brewer*, and others. I suspect that *C. anthericoides*, Presl, and most of *C. Hoodii*, Boott, are to be referred here.

242. CAREX LEIORHYNCHA, C. A. Meyer, Mem. Acad. St. Petersb. i. t. 9.

Aspect of ordinary forms of *C. vulpinoidea*: lowest bract leafy, prolonged: head interrupted, narrow, an inch to three inches long, pale: perigynium oblong-ovate, membranaceous, nerved, whitish, very smooth throughout, the beak sharply toothed, longer than the ovate-elliptic long-mucronate one-nerved scale. — Along the coast, probably from Oregon northward. Siberia. Little known in America.

243. CAREX DISTICHA, Hudson, Fl. Angl. 403.

C. intermedia, Gooden. Linn. Trans. ii. 154.

C. modesta, Gay, Ann. Sci. Nat. x. 304.

C. Sartwellii, Dewey, Sill. Journ. xliii. 90.

C. schedonautos, Steud. Plant. Cyp. 189.

Mostly in dry places from New York to Utah and northward into British America. Europe.

D. *Arenariæ*, Kunth, Enum. Pl. ii. 376; Tuckerman, Enum. Meth. 9. Spikes longer than in the last section, linear or nearly so, aggregated into short, almost globose heads; perigynium lanceolate or ovate-lanceolate, mostly larger and more delicate in texture; scales awn-pointed or very acute. Staminate flowers variously situated.

244. Carex Potosina, Hemsley, Biol. Cent.-Am. iii. 474.

C. Schaffneri, W. Boott, Proc. Am. Acad. xviii. 172, not Boeckl.

C. fuscolutea, Boeckeler, Engler's Bot. Jahr. vii. part iii. 278.

"Rootstock creeping, branching, clothed with imbricated brown scales that become fibrous: culm about a foot high, slender, scabrous above on the sharp angles: leaves about equalling the culm, one line broad, attenuated into a long and filiform extremity, flat or conduplicate above: head about an inch long, of three or more oblong sessile clusters of lanceolate androgynous spikes, the upper clusters crowded, the lowest distinct and rarely borne on a long radical peduncle: spikes five or six lines long, staminate above: bracts filiform from an ovate several-nerved green-keeled hyaline-margined clasping base, the lowest much longer than the head, the next one or two often exceeding it: scales hyaline, pale chestnut-colored with a green keel, ovate, acute or roughly awn-pointed, exceeding the perigynia which are pale brown, ovate or lanceolate (two lines long), tapering at the base, covered with irregular yellowish somewhat scurfy tubercles, obliquely cut at the top and ending in two long subulate rough teeth, serrate on the green margins." — San Luis Potosi, Northern Mexico, *Schaffner* 546, 221.

245. Carex Douglasii, Boott, Hook. Fl. Bor.-Am. ii. 213, t. 214.

C. Nuttallii, Dewey, Sill. Journ. xliii. 92.

C. Meekii, Dewey, l. c. 2d ser. xxiv. 48.

C. Douglasii, var *minor*, Olney, Bot. King's Rep. 363.

C. Fendleriana, Boeckeler, Linnæa, xxxix. 135.

A singular plant, of which mature perigynia are rarely if ever seen. Wyoming to New Mexico, California, and Oregon.

Var. brunnea, Olney, Bot. King's Rep. 363.

Carson City, Nevada, *Watson* 1226; California, *Bolander* 4549 and 4550.

246. *Carex arenaria*, Linn. Sp. Pl. 973.

Extensively creeping: culm about a foot high, scabrous on the angles above: spikes rather numerous, those at the apex of the head staminate, the intermediate ones staminate at the summit, the lowest pistillate: perigynium ovate-oblong or ovate-lanceolate, the upper half produced into a conspicuous serrate wing-border, nerved, the beak sharply bifid. — Protected sea-beaches near Norfolk, Virginia, July, 1870, *McMinn*. The well-known Sand Carex of Europe.

E. *Muhlenbergianæ*, Tuckerman, Enum. Meth. 9. Spikes green or nearly so when mature, aggregated or scattered, never in compound heads; perigynium mostly short-ovate, in most cases not conspicuously nerved. Staminate flowers uniformly borne at the top of the spike.

* *Plants slender* (except *C. sparganioides*) *and the spikes more or less scattered* (except in *C. muricata*, var. *confixa*).

247. Carex tenella, Schkuhr, Riedgr. 23, f. 104.

C. disperma, Dewey, Sill. Journ. viii. 266.

C. gracilis, Gray, Sill. Journ. 2d ser. iv. 19.

From New Jersey to California and northwestward into British America.

248. Carex rosea, Schkuhr, Riedgr. Nachtr. 15, f. 179.

Labrador, *Storer*, and the Northeastern States to Lake Winnipeg, *Bourgeau*.

Var. radiata, Dewey, Sill. Journ. x. 276.

C. neglecta, Tuckerman, Enum. Meth. 19.

C. disperma, Kunze, Riedgr. Suppl. 131, t. 33.

C. rosea, var. *minor*, Boott, Ill. 81.

Throughout the States east of the Mississippi and those bordering it on the west, north of North Carolina. More common than the species, from which it differs chiefly in its slenderness and few-flowered spikes.

Var. retroflexa, Torrey, Monogr. 389.

C. retroflexa, Muhl.; Willd. Sp. Pl. iv. 235.

C. bicostata, Olney, Exsicc. fasc. iv. no. 17.

Throughout the States east of the Mississippi, and Limestone Gap, Indian Territory, *Butler*. Evidently more common southward.

249. Carex vallicola, Dewey, Sill. Journ. 2d ser. xxxii. 40.

"Culm six to twelve inches high, very slender, slightly scabrous: leaves half a line broad, shorter than the stem: bracts roughly cuspidate from a broad hyaline-margined base, the lowest equalling or exceeding its spike: head half an inch to an inch long, linear-oblong, composed of four to seven narrowly oblong contiguous sessile spikes which have a conspicuous column of staminate flowers at the apex: scales chestnut-colored, membranaceous with very broad hyaline margins, clasping at the base, broadly ovate, acute or the scabrous keel prolonged into a short mucro: perigynium pale brown, obovate, abruptly attenuated to the base and to the obliquely cut entire beak, convex on the outer side and concave on the inner, nerveless, sparsely serrate above on the obtuse margins, about as long as and narrower than the scale." — Southeastern Idaho, Hayden; part of *Bolander's* no. 4746, from near Mendocino City, California, is referred here by Wm. Boott. I am not yet able to draw characteristic distinctions between this species and *C. muricata*, var. *gracilis*.

250. *Carex muricata*, Linn. Sp. Pl. 974.

Introduced into old fields in Eastern Massachusetts, where it is common; also in Ohio according to Boott, Cincinnati, *Lloyd*, Kentucky according to Boott, and Ocean View, Virginia, *Ward*. Europe.

Var. AMERICANA.

C. muricata, Olney, Bot. King's Rep. 362, in part; W. Boott, Bot. Wheeler's Surv. 277; Bailey, Coulter's Man. 390.

Perigynium smaller and more abruptly contracted above than in the species, the scales mostly longer and the spikes commonly smaller: heads usually brownish. — Colorado to New Mexico and Arizona; Santa Rita Mts., Arizona, *Pringle*.

Var. GRACILIS, Boott, Ill. 193.

C. Hookeriana, Dewey, Sill. Journ. xxix. 248, f. 75.

Colorado and Utah to California and Oregon, and northward into British America. Perhaps specifically distinct.

Var. CONFIXA, Bailey, Bot. Gaz. x. 203.

C. Hoodii, W. Boott, Bot. Calif. ii. 232, in part.

Very like Boott's figure of *C. Hoodii*. It also approaches forms of *C. cephaloidea*. *C. Hoodii*, as I understand the species, is characterized by its much stouter culms, its much heavier, browner, and more compact heads, which are made up of many-flowered, chaffy, linear or ovate more or less pointed spikes, and more upright perigynia, which are covered by the large scales. The brown and green and truncate characters of the spikes of the var. *confixa* are characteristic. — N. W. Wyoming, Utah to California and Oregon, and northward into British America.

251. CAREX SPARGANIOIDES, Muhlenberg; Willd. Sp. Pl. iv. 237.

C. cephalophora, β, Torr. Monogr. 389.

C. sparganioides, var. *minor*, Boott, Ill. 123.

C. muricata, var. *cephaloidea*, Dewey, Sill. Journ. xli. 330.

Throughout the Northern States east of the Mississippi.

* * *Plants stouter and the spikes aggregated.*

252. CAREX MUHLENBERGII, Schkuhr, Riedgr. Nachtr. 12, f. 178.

C. pinetorum, Willd.; Schlecht. in Linnæa, x. 265.

Readily distinguished by its stiff culm and nearly orbicular, narrowly winged and strongly nerved perigynium. — Throughout the States east of the Mississippi; "on the Missouri below Ft. Pierre," Dewey.

Var. ENERVIS, Boott, Ill. 124.

Perigynium nerveless or very nearly so. — Fishkill Landing, Highlands, N. Y., *J. L. Russell;* rocks near Wilmington, Delaware, *Canby*.

Var. AUSTRALIS, Olney, Hall's Pl. Texanæ, 25.

Heads denser than in the species: spikes globular or nearly so: bracts more dilated at the base: perigynium less prominently nerved and much broader. Aspect of typical forms of *C. straminea.* — Wet prairies at Houston, Texas, *Hall.* Some specimens which were distributed for this by Olney are *C. Muhlenbergii.*

253. CAREX CEPHALOIDEA, Boott, Ill. 123.

C. sparganioides, var. *cephaloidea*, Carey, Gray's Man. 1848, 513.

Large and stout, with broad and long flat leaves (about a quarter-inch wide): perigynium large, broadly ovate, entirely nerveless, wing-margined: heads tawny. Nearest ally is *C. Muhlenbergii.* — Illinois to Dakota and Wyoming, *McShea.*

254. CAREX CEPHALOPHORA, Muhl.; Willd. Sp. Pl. iv. 220.

Throughout the States east of the Mississippi, and on the Great Plains of British America, *Macoun;* Indian Territory, *Butler.*

Var. ANGUSTIFOLIA, Boott, Ill. 123.

C. Leavenworthii, Dewey, Sill. Journ. 2d ser. ii. 246.

Lower, and leaves short and narrow: heads oblong, tawny: perigynium mostly smaller. Distinct in appearance. — Ranges with the species, but evidently not common.

F. *Dioicæ,* Tuckerman, Enum. Meth. 7. (*Nardinæ,* Tuckerman, l. c. *Capitatæ,* Christ, Cat. Eur. Car. 11.) Spike one, small; plants small and slender, often diœcious.

255. CAREX CAPITATA, Linn. Sp. Pl. ed. ii. 1381.

Alpine summits of the White Mountains to Hudson's Bay, Labrador, and Greenland. Europe.

256. CAREX ALASKANA, Boeckeler, Engler's Bot. Jahrb. vii. part iii. 277.

"Cespitose: culms few, filiform-setaceous, erect, one and a half to three and a half inches high, nearly terete, smooth, many-leaved at the base: leaves crowded, longer or shorter than the culm, rigid, setaceous, more or less curved, nearly obtuse, canaliculate below, partially plane above with denticulate margins: sheaths short, narrow, and nerved, fusco-ferruginous: spike androgynous, oblong-linear becoming oblong-lanceolate (three and a half to four lines long), 8–12-flowered the four to six upper ones staminate: scales thin-membranaceous, small, orbicular-ovate, short-acuminate, the keel one-nerved: perigynium (immature) small, erect, green, about equalling the scale, short-stipitate, oblong, attenuated both ways, the orifice membranaceous, emarginate, the angles above rough. — Alaska, Krause."

257. Carex nardina, Fries, Mant. ii. 55.

C. Hepburnii, Boott, Hook. Fl. Bor.-Am. ii. 209, t. 207.

Upper Marias Pass, Montana, *Canby*, and northward to Greenland and Kamtschatka; Cascade Mts., Oregon, Lyall, according to Boott. Europe.

258. Carex gynocrates, Wormskjold in herb.; Drejer, Revis. Crit. Car. 16.

C. Redowskiana, C. A. Meyer, Cyp. Nov. t. 4.

C. dioica, Torr. Monogr. 387.

C. Fischeriana, Gay, Ann. Sci. Nat. x. 286.

C. monosperma, Macoun in herb.; Bailey, Carex Cat.

Pennsylvania and New York to Arctic America; South Park, Colorado, *Wolf*. Europe.

259. Carex dioica, Linn. Sp. Pl. 972.

C. Linnæana, Host, Gram. iii. 51, t. 77.

Maukschia lævis, Heuff. Flora, 1844, 527.

Perigynium broader and more sharply angled than in the last: tips of the leaves smoother. — Said to occur in Greenland.

260. Carex exilis, Dewey, Sill. Journ. xiv. 351.

Along the coast from New Jersey to Newfoundland, *La Pylaie*; "borders of mountain lakes, Essex County, New York," Gray's Manual.

Section XIV. HYPARRHENÆ, Fries, Summa, 72. Staminate flowers borne at the base of the spikes (or in *C. bromoides* and *C. siccata* variously situated).

A. *Elongatæ*, Kunth, Enum. Plant. ii. 402. (*Tenuifloræ*, Kunth, l. c. 405. *Heleonasteæ*, Kunth, l. c. 393. *Stellulatæ*, Kunth, l. c. 399. *Deweyanæ*, Tuckerman, Enum. Meth. 11. *Canescentes*, Fries, Summa, 72. *Loliaceæ*, Nym. Consp. Fl. Eur. 780, mostly. *Monastes* and *Lagopinæ*, Nym. l. c. 779.) Spikes silvery green or sometimes tawny when mature, distinct, mostly small; perigynium not wing-margined nor conspicuously broadened, mostly nearly flat on the inner surface.

* *Periginium ovate, sharp-margined, firm, often thickened at the base, spreading in open and at maturity stellate spikes.*

261. Carex echinata, Murray, Prodr. Goett. 76.

C. stellulata, Gooden. Linn. Trans. ii. 144.

C. grypos, Schkuhr, Riedgr. Nachtr. 18, f. 193.

C. sterilis, W. Boott, Bot. Calif. ii. 236, excl. descr.

Culms stiff: spikes large, all contiguous or nearly so: perigynium large (usually two to three lines long), much attenuated above. —

Jefferson Co., N. York, *Crawe;* near Mackinaw, Michigan, *Loring*, and northward; California, *Bigelow*, near Mendocino City, *Bolander* 4739, Red Mts., *Bolander*, Coast Range, *Bolander* 6193; Oregon, *Hall*, *Howell;* Alaska, *Mertens*. Europe.

Var. CONFERTA, Bailey, Carex Cat.

C. stellulata, and var. *conferta*, Chapm. Flora, 534.

Differs from the species in the oblong, densely flowered, and more spreading spikes and recurved perigynium. — Along the coast from Florida to Newfoundland, *La Pylaie*.

Var. MICROSTACHYS, Boeckeler, Linnæa, xxxix. 125.

C. stellulata, var. *radiata*, Wahl. Köngl. Acad. Handl. xxiv. 147.

C. scirpoides, Schkuhr, Riedgr. Nachtr. 19, f. 180.

C. sterilis, Willd. Sp. Pl. iv. 208.

C. sterilis, vars. β and γ, Torr. Monogr. 392.

C. stellulata, vars. *scirpoides*, *sterilis*, and *angustata*, Carey, Gray's Man. 1848, 544.

C. echinata, var. *angustata*, Bailey, Carex Cat.

Var. *microcarpa*, Bailey, Coulter's Man. 395 (a clerical error).

More slender: spikes small and more or less scattered: perigynium smaller, less conspicuously beaked, the scales usually shorter in proportion to the perigynium than in the species. Perplexingly variable. — Throughout the States east of the Mississippi and those bordering it on the west; Twin Lakes, Colorado, *Wolf* 1018; Moose Mts., British America, *Macoun*. Europe.

* * *Perigynium ovate or nearly so, not sharp-margined, firm in texture, mostly erect in closely flowered and rounded spikes.*

262. CAREX CANESCENS, Linn. Sp. Pl. 974.

C. curta, Gooden. Linn. Trans. ii. 145.

C. vitilis, var. *pallida*, Olney, Bot. King's Rep. 364, v. s.

From Pennsylvania and Ohio to Arctic America and Oregon. Europe.

Var. DUBIA, Bailey, Bot. Gaz. ix. 119.

C. elongata, Olney, Bot. King's Rep. 365, v. s., not Linn.; Bailey, Coulter's Man. 394, excl. descr.

Uintah Mts., Utah, *Watson*, and Alta, Wahsatch Mts.,.*Jones*.

Var. ALPICOLA, Wahl. Fl. Lapp. 232.

C. Gebhardii, Hoppe, Caric. t. 30.

C. curta, var. *brunnescens*, Pers. Syn. ii. 539.

C. Richardii, Michx. Fl. Bor.-Am. ii. 170.

C. vitilis, Fries, Mant. iii. 137.

C. canescens, var. β, Torr. Monogr. 393.
C. canescens, var. *sphærostachya*, Tuckerman, Enum. Meth. 10.
C. Buckleyi, Dewey, Sill. Journ. xlviii. 143.
C. sphærostachya, Dewey, l. c. xlix. 44.
C. canescens, var. *vitilis*, Carey, Gray's Man. 2d ed. 514.
C. canescens, vars. *minor* and *brunnescens*, Boott, Ill. 220.
C. vitilis, var. *brunnea*, Olney, Bot. King's Rep. 364.
C. Bolanderi, vars. *minor* and *sparsiflora*, Olney, Proc. Am. Acad. 1872, 407.

Exceedingly variable. At times it counterfeits forms of *C. echinata*, var. *microstachys*. — Throughout the continent north of N. Carolina.

Var. POLYSTACHYA, Boott, Rich. Journ. ii. 344.
C. arcta, Boott, Ill. 155, t. 497.
C. leiorhyncha, Kunze, Suppl. Riedgr. t. 21, not C. A. Meyer.
C. Kunzei, Olney, Proc. Am. Acad. 1872, 407.

Spikes approximated or densely aggregated into a head, the lower ones often subtended by a short bract, which is dilated at the base; perigynium longer-pointed than in the species, nerved, stipitate and spreading. — Ashland, Massachusetts, *Morong;* Vermont, Barnet, *Blanchard*, Alburgh, *Pringle;* Maine, Porter; Canada, McCrae, and westward to Oregon, *Hall*, *Howell*, and *Henderson*.

263. CAREX HELVOLA, Blytt; Fries in Bot. Notiser, 1848, 58.

Differs from *C. canescens*, var. *dubia*, which may not be distinct, chiefly in its broader scales and entirely smooth and nerveless perigynium. — Said by Boeckeler to occur in Greenland.

264. CAREX PRÆGRACILIS, W. Boott, Bot. Gaz. ix. 87.

Culm exceedingly slender (over two feet high and scarcely half a line broad), naked, stiff and erect, rough on the angles above: leaves thread-like and convolute: head a half-inch long, a line broad, composed of three or four small contiguous spikes, the uppermost of which is conspicuously staminate-flowered at the base: bracts possessing a clasping base and tapering into a rough somewhat spreading awn which exceeds its spike: scales similar to the bracts, but shorter and broader, covering the perigynia: perigynium brown, ovate-acuminate, obscurely nerved, somewhat rough on the margins above. — San Diego, California, *Miss Scott*.

265. CAREX TRISPERMA, Dewey, Sill. Journ. ix. 63.

Maryland and Pennsylvania to Newfoundland, *La Pylaie*, and Great Plains of British America, *Macoun*, and Carlton House, *Drummond*.

266. Carex remota, Linn. Sp. Pl. 2d ed. 1383.

Resembles tall and lax forms of *C. canescens*, but differs in the much scattered spikes (an inch or more apart) which are subtended by long and lax leafy bracts (one to four inches long). — Newfoundland according to Gay, and Sitka according to Flora Rossica. Europe.

267. Carex tenuiflora, Wahl. Köngl. Acad. Handl. xxiv. 147.

Cold swamps from Central New York and Northern New England to Northern Minnesota and Hudson's Bay. Rare. Europe.

268. Carex phyllomanica, W. Boott, Bot. Calif. ii. 233.

"Culm six to eighteen inches high, smooth: leaves rigid, a line or two broad, attenuated into a sharp triangular summit, much exceeding the stem: lowest bract filiform, often far exceeding the culm, the others scale-like and shorter than their spikelets: head chestnut-colored, oblong (three fourths inch long), composed of from three to six spikes which are contiguous or the upper ones crowded, the uppermost one the largest (three or four lines long) and linear-club-shaped, the others ellipsoidal: scales broadly ovate or roundish, obtuse, chestnut-colored with green mid-nerve and hyaline margins: perigynium lance-ovate, obtuse at the base, gradually tapering into an obliquely cut nearly entire beak, the orifice and long fissure on the outer side reddish brown, serrate above on the acute margins, not nerved, a little longer than the scale." — In sphagnous swamps near Mendocino City, California, *Bolander* 4746.

269. Carex Norvegica, Schkuhr, Riedgr. 50.

Wells, Maine, *Blake*, and northward. Evidently rare in America. Europe.

270. Carex heleonastes, Ehrhart; Linn. fil. Suppl. 414.

C. Carltonia, Dewey, Sill. Journ. xxvii. 238.

C. marina, Dewey, l. c. xxix. 247.

Culm stiff, rough on the angles, about a foot high, longer than the rigid involute leaves: spikes brown, globular, aggregated into an oblong head a half-inch or less long: perigynium broadly elliptical, plump, marked with slender brown nerves, about the length of or longer than the acute brown scale. Resembles some of the stiff alpine forms of *C. canescens*, var. *alpicola*. — Norway House and York Factory, *Herb.*, and Kicking Horse Lake, Rocky Mts., *Macoun*, British America. Europe.

271. Carex lagopina, Wahl. Köngl. Acad. Handl. xxiv. 145.

Smaller than the last, the leaves flat: spikes mostly oblong, narrowed below: scales abruptly acute. Too near the last and the next (see Coulter's Man.). — Uinta Mts., Utah, according to Olney; near Ebbett's Pass, Calif., Brewer 2063, according to Olney and W. Boott; Rocky Mts. of British America, *Drummond;* maritime rocks, Labrador, *Allen;* Greenland. Kamtschatka. Europe.

272. Carex glareosa, Wahl. Köngl. Acad. Handl. xxiv. 146.

Perigynium short-beaked and almost like that of *C. canescens:* scales acute, about as long as the perigynium: culms weak: leaves narrower: otherwise like the last. — Greenland, *Vahl, Fries,* etc., to Behring Straits, *Wright,* and Shumagin Isl., Alaska, Harrington. Kamtschatka. Europe.

Var. cæspitosa, Boeckeler, Linnæa, xxxix. 76.

C. ursina, Dewey, Sill. Journ. xxvii. 240.

C. glareosa, var. β, Boott, Ill. 153.

C. glareosa, var. *ursina,* Bailey, Carex Cat.

Small (an inch or two high) and densely cespitose: culms often curved: heads smaller. — Greenland, *Fries, Warming & Holm.* Spitzbergen. Kamtschatka.

* * * *Perigynium ovate-lanceolate or nearly linear, mostly in loose spikes.*

273. Carex bromoides, Schkuhr, Riedgr. Nachtr. 8, f. 176.

Swamps and wet places from Florida and Louisiana to Canada and westward to Colorado and California, *Hillebrand* 2315.

274. Carex brizoides, Linn., var. nemoralis, Wimmer, Fl. Siles. 401.

Creeping: culm one to two feet high, flaccid, mostly a little longer than the narrow and lax light-colored leaves: spikes three to six, linear (four to five lines long), yellow, contiguous in a small and open chaffy head: perigynium lanceolate, greenish, nerved, rough on the thin margins, about the length of or a little longer than the thin and appressed muticous scale. — Arctic America, according to Boeckeler. Europe.

275. Carex Deweyana, Schweinitz, An. Tab.

Named in honor of Professor Chester Dewey, 1784–1867, author of forty-two articles in Silliman's Journal on American Carices, embracing the years between 1824 and 1866. — Northern States northward and westward to California and Oregon; New Mexico, *Wright.* Variable.

Var. Bolanderi, W. Boott, Bot. Calif. ii. 236.

C. Bolanderi, Olney, Proc. Amer. Acad. vii. 393.

California to Washington Territory.

B. *Ovales*, Kunth, Enum. Plant. ii. 394. (*Cyperoideæ*, Tuckerman, Enum. Meth. 8.) Spikes tawny or dark, rather large, sometimes crowded; perigynium with a more or less thin or winged margin, which is mostly incurved at maturity, rendering the perigynium concave inside.

* *Perigynium ovate-lanceolate or narrower, with conspicuous wing-margins.*

276. Carex siccata, Dewey, Sill. Journ. x. 278.
C. pallida, C. A. Meyer, Mem. Acad. St. Petersb. i. 215, t. 8.
C. Liddoni, Carey, Gray's Man. 1848, 545, not Boott.
C. siccata, var. *hispida*, Olney, Exsicc. fasc. iv. no. 25.

Distinguished by its irregular and indistinct spikes, the lower ones small and all or in part staminate, only the terminal one conspicuous, and by the abrupt contraction of the perigynium just above the achenium. — New England to Illinois, and northward and westward to Colorado, California, and Kamtschatka; Arizona, *Rusby*.

277. Carex Liddoni, Boott, Hook. Fl. Bor.-Am. ii. 214, t. 215.
C. adusta, var. *congesta*, W. Boott, Bot. Calif. ii. 238.

This species has been much confounded with others, especially the next. Its erect and thick rusty head and very large and comparatively firm brown perigynium distinguish it. See Coulter's Man. 397 for further characters. — Sixteen-Mile Creek, Montana, *Scribner;* Summit Camp, California, *Kellogg;* and along the Columbia, *Scouler*.

278. Carex pratensis, Drejer, Rev. Crit. Car. Bor. 24.*
C. adusta, var. *minor*, Boott, Ill. 119.
C. adusta, W. Boott, Wheeler's Rep. 277.

Distinguished at once from the last by its well-defined spikes, which are silvery brown and more or less narrowed at the base, and by the smaller and very thin translucent green perigynium. Mature heads either erect or nodding. Often distributed for *C. Liddoni*. I have heretofore referred to that species specimens collected by Macoun and others. — South Park, Colorado, *Wolf;* Yellowstone Falls, Wyoming, *Letterman;* Silver City, Moose Jaw, and Long Lake, British America, *Macoun;* Saskatchewan and L. Winnipeg, *Bourgeau;* N. Minnesota, *Bailey;* E. Oregon, *Cusick;* and Hood River, Wasco Co., Oregon, *Henderson;* Pic River, Lake Superior, *Loring;* Middle Bay, Labrador, *Allen;* Greenland. — Commoner than the last.

* * *Perigynium mostly ovate-lanceolate, scale-like, with little distinction between the margin and the body, mostly greenish.*

279. Carex arida, Schweinitz & Torrey, Monogr. 312.
C. scoparia, var. *Muskingumensis*, Tuckerman, Enum. Meth. 17.

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* *C. pratensis*, Phillippi, Linnæa, xxix. 81, from Chili, being a more recent species, should be known as C. Phillippii.

Ohio and Kentucky to Wisconsin. Said by W. Boott to have been collected in the Sierra Nevada Mts., California, by Dr. Kellogg.

280. CAREX TRIBULOIDES, Wahl. Köngl. Acad. Handl. xxiv. 145; Fl. Lapp. 250.

C. lagopodioides, Schkuhr, Riedgr. Nachtr. 20, f. 177.

C. scoparia, var. *lagopodioides*, Torr. Monogr. 394.

C. lagopodioides, var. *composita*, Olney, Exsicc. fasc. ii. no. 10.

Throughout the States east of the Mississippi and the States bordering it on the west; New Mexico, *Fendler*. Abundant northward.

Var. CRISTATA.

C. cristata, Schwein. An. Tab.

C. straminea, var. *cristata*, Tuckerman, Enum. Meth. 18.

C. lagopodioides, var. *cristata*, Carey, Gray's Man. 1848, 545.

C. mirabilis, Dewey and auth., in part.

C. Bebbii, Olney, Exsicc. fasc. ii. no. 12.

Open swales and meadows, Pennsylvania to New England and Canada, and northwestward to the Saskatchewan.

Var. REDUCTA.

C. scoparia. var. *moniliformis*, Tuckerman, Enum. Meth. 17.

C. lagopodioides, var. *moniliformis*, Olney, Exsicc. fasc. ii. no. 8; Bailey, Bot. Gaz. x. 380.

Culm slender, especially above, where it surpasses the long-pointed and lax leaves: spikes two to ten, small, nearly globular (usually less than three lines in diameter), all distinct, the lowest separated, mostly bright straw or rust colored, the points of the spreading perigynium conspicuous. — Massachusetts to Vermont and New Brunswick, *Fowler*; S. Louisiana, *Langlois*, *Joor*.

281. CAREX SCOPARIA, Schkuhr, Riedgr. Nachtr. 20, f. 175.

C. scoparia, var. *minor*, Boott, Ill. 116, t. 369.

C. lagopodioides, var. *scoparia*, Boeckeler, Linnæa, xxxix. 114.

States east of the Mississippi and on its western borders, and high northward, and westward to Colorado and the Great Plains of British America.

Var. FULVA, W. Boott, Bot. Calif. ii. 237, in part.

Stouter: head lighter-colored, very dense. Little known. — California.

* * * *Perigynium ovate or ovate-orbicular, mostly tawny or brown, thickened in the middle, the mostly conspicuous wing-margins more or less incurved* (very narrowly winged in *C. Bonplandii*).

282. CAREX ADUSTA, Boott, Hook. Fl. Bor.-Am. ii. 214.

C. argyrantha, Tuckerman in Herb. distr. 1859.

C. albolutescens, Olney, Exsicc. fasc. i. no. 8.
C. albolutescens, var. *argyrantha*, Olney, Exsicc. fasc. i. no. 9.
C. albolutescens, var. *sparsiflora*, Olney, Exsicc. fasc. v. no. 11.
C. adusta, var. *argyrantha*, Bailey, Carex Cat.

Maryland, *Smith*, to Lake Superior, *Macoun*. Not common.

Var. GLOMERATA, Bailey, Carex Cat.; Bot. Gaz. ix. 139.
C. albolutescens, var. *glomerata*, Olney, Exsicc. fasc. v. no. 10.

Spikes few-flowered, aggregated into a loose mostly tawny head: perigynium large, almost wingless, nearly filled by the large dark achenium. — Mt. Desert, Maine, *R. W. Greenleaf*; New Brunswick, *Fowler*; N. Minnesota, *Bailey*; Saskatchewan, *Herb. Gray*.

283. CAREX STRAMINEA, Schkuhr, Riedgr. 49, f. 34, and Nachtr. 23, f. 174.
C. festucacea, Willd. Sp. Pl. iv.
C. straminea, var. *brevior*, Dewey, Sill. Journ. xi. 158.
C. straminea, var. *minor*, Dewey, l. c. 318.
C. straminea, var. *Schkuhrii*, Gay, Ann. Sci. Nat. x. 363.
C. straminea, vars. *intermedia* and *festucacea*, Gay, l. c. 364.
C. straminea, var. *festucacea*, Tuckerman, Enum. Meth. 18; Boott, Ill. 120, t. 386.
C. hyalina, Boott, Journ. Bost. Nat. Hist. Soc. v. 112.
C. tetrastachys, Scheele, Linnæa, xxii. 347.
C. festucacea, var. *tenera*, Carey, Gray's Man. 1848, 545.
C. tenera, Sartwell, Exsicc. no. 45, Carey, Olney, et al., not Dewey.
C. straminea, var. *tenera*, Boott, Ill. 120, t. 384; and vars. *Crawei* and *Meadii*, Boott, Ill. 121, tt. 388, 389.
C. fœnea, var. *β*, Boott, Ill. 118, t. 376.
C. fœnea, var. (?) *ferruginea*, Gray, Man. 5th ed. 580.
C. straminea, var. *hyalina*, Gray, Man. 5th ed. 580.
C. tenera, var. *suberecta*, Olney, Exsicc. fasc. ii. no. 16.
C. straminea, var. *typica*, Gray, Man. 5th ed. 580.
C. tenera, forma *erecta*, Olney, Exsicc. fasc. ii. no. 14.

Culm erect, one to two feet high, mostly stiff, much longer than the erect long-pointed stem leaves: spikes three to eight, all distinct, ovoid or globose, rusty or straw-colored, mostly approximated in an erect head: perigynium orbicular or ovate-orbicular, often cordate at the base, few-nerved, thin, very broadly winged, spreading, abruptly

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C. heptastachya, Boeckl., Linnæa, xxxix. 114, is probably from Merida, Venezuela, instead of Merida, Costa Rica, as recorded. (*Vide* Hemsl. Bot. Biol. Cent.-Am. iii. 473.)

contracted into a smooth or nearly smooth beak which is not longer than the body, much wider and usually longer than the acute scale. — Florida and Texas to Canada, and westward to Colorado and Oregon. Extremely variable.

Var. MIRABILIS, Tuckerman, Enum. Meth. 18.

C. mirabilis, Dewey, Sill. Journ. xxx. 63, mostly.

C. festucacea, var. *mirabilis*, Carey, Gray's Man. 1848, 545.

C. cristata, var. *mirabilis*, Gray, Man. 5th ed. 578, mainly.

C. lagopodioides, var. *mirabilis*, Olney, Exsicc. fasc. ii. no. 9.

Distinguished from the species by its long and lax culm and leaves (culm often four feet high), loosely flowered green spikes, and much narrower and thinner perigynium. — Mostly in the shade, throughout the Northern States westward to Nebraska and Iowa.

Var. CONGESTA, Boott; Olney, Proc. Am. Acad. vii. 393.

Spikes densely aggregated into an ovoid or globose head. — California and Oregon. Resembles *C. Liddoni*, from which it is separated by its broad perigynia.

VAR. MAXIMA.

C. Wrightii, Olney, Exsicc. fasc. ii. no. 21.

Spikes few, globular and very large (one half to three fourths inch in diameter!), contiguous, rusty: perigynium very broad and very abruptly contracted into a long beak which is conspicuously spreading. — Texas, *Buckley*, *Wright*.

Var. ALATA, Bailey, Carex Cat.

C. alata, Torr. Monogr. 396.

C. alata, var. *pulchra*, Olney, Exsicc.

Spikes green or pale, narrowed towards the top; perigynium very broad, the point conspicuous: culm and leaves much like those of *C. lagopodioides*. — Michigan to Massachusetts and southward along the coast to Louisiana. Apparently rare far inland.

Specimens from Massachusetts and northward with numerous spikes aggregated into bunchy heads are evidently to be referred here. They closely resemble forms of *C. lagopodioides*.

Var. FŒNEA, Torrey, Monogr. 395.

C. fœnea, Willd. Enum. Pl. Hort. Berol. 957.

C. straminea, var. *β*, Gay, Ann. Sc. Nat. x. 362.

C. leporina, var. *bracteata*, Liebm. Mex. Halv. 76.

C. straminea, var. *chlorostachys*, Boeckeler, Linnæa, xxxix. 118.

Distinguished from the species chiefly by the silvery-green spikes, which are oblong, erect, contracted below, and very dense with appressed perigynia. From var. *alata* it is distinguished by the stiff culm, the more appressed and narrower spikes which are mostly narrowed below, and the narrower appressed perigynia. — Along the coast from New Brunswick to Mexico.

Var. *fœnea* forms a transition to *C. tribuloides.* Vars. *alata*, *fœnea*, *mixta*, and *moniliformis* form a sub-species which is distinguished from other varieties by the green or silvery aspect of the spikes. Although extremes of all these varieties appear to be remarkably distinct from *C. straminea*, I am yet unable to trace a single character which has any permanence. In fact, the intermediate forms which I cannot refer satisfactorily to any variety are as numerous as the types. The distinctions between vars. *alata* and *fœnea* are especially inconstant. Var. *mixta*, when better known, may be found to possess specific characters.

Var. MIXTA.

C. lagopodioides, W. Boott, Bot. Calif. ii. 237.
C. adusta, W. Boott, l. c. 238.
C. cristata, var. *mirabilis?* W. Boott, l. c.
C. scoparia, var. *fulva*, W. Boott, l. c., in part.

Culm stout, longer than the leaves: spikes silvery, ovoid, not often conspicuously narrowed below, approximate: perigynium much smaller than in the species, silvery green, nerved, narrowly but conspicuously winged. Runs into many forms, some of which bear small and much crowded spikes. The Pacific coast representative of var. *fœnea.* Its characters are imperfectly determined. — California, *Bolander* 50, 3864, 6216, *Brewer* 1642, part of *Torrey's* 551 from near Merced River, Summit Camp, *Kellogg*, *Bigelow's* specimens which were distributed as *C. lagopodioides*, San Bernardino, *Parish*, *Hillebrand* 2305, 2317; Oregon, *Hall* 589.

Var. MONILIFORMIS, Tuckerman, Enum. Meth. 17.

C. adusta, Carey, Tuckerman, et al., not Boott.
C. fœnea, var. γ, Boott, Ill. 118, t. 377.
C. fœnea, var. (?) *sabulonum*, Gray, Man. 5th ed. 580.
C. silicea, Olney, Proc. Am. Acad. vii. 393.
C. straminea, var. *silicea*, Bailey, Carex Cat.

Spikes five to eight, silvery, all distinct and conspicuously narrowed below (clavate), disposed in a loose and slender mostly nodding head: otherwise nearly like var. *fœnea.* Transition to *C. adusta.* Several different plants were early distributed as var. *moniliformis*, but a recent letter from the late Prof. Tuckerman says that the variety was proposed to include the maritime plant here designated. — Sands of the sea-shore from Maine to New Jersey.

Var. APERTA, Boott, Ill. 120, t. 385.

C. tenera, Dewey, Sill. Journ. viii. 97, f. 9 (immature specimen).

C. festucacea, Sartwell, Exsicc. no. 44.

C. tenera, var. *major*, Olney, Exsicc. fasc. ii. no. 15.

C. straminea, var. *tenera*, Bailey, Bot. Gaz. x. 381.

Spikes four or five, heavy, globular or broadly conical, separated, bright tawny or rusty, disposed in a loose nodding head: perigynium inclining to be narrower than in other varieties. Transition to *C. scoparia*, with which it is often confounded, but from which the globular and distinct spikes at once separate it. — Bogs and meadows from Massachusetts to Oregon. Common eastward. Usually growing in stools.

Var. INVISA, W. Boott, Bot. Gaz. ix. 86.

Spikes small (about two lines broad), ovate, tawny, variously disposed in dense or open heads, the lowest often very remote or on a long subradical peduncle, the lower ones of the head subtended by long and thread-like bracts (two to five inches long). Transition to *C. scoparia*. — Common about Boston, Mass.; Mt. Desert, Maine, *W. Boott*; salt marshes, Bombay Hook, Delaware, *Commons*.

284. *Carex leporina*, Linn. Sp. Pl. 973.

C. ovalis, Gooden. Linn. Trans. ii. 148.

Distinguished from erect forms of typical *C. straminea* by the oblong or cylindrical appressed spikes which are contiguous in a short head (about an inch long), and the narrow and thin appressed perigynium which somewhat resembles that of *C. scoparia*. Aspect intermediate between *C. straminea* and *C. scoparia*. — Said by W. Boott to be established on Long Island in Boston Harbor. Europe.

Var. AMERICANA, Olney, Proc. Amer. Acad. 1872, 407.

C. petasata, Dewey, Sill. Journ. xxix. 246.

C. leporina, Bailey, Coulter's Man. 396.

Distinguished from the species by the narrow involute leaves, longer perigynium, and general aspect. From the small and loose-headed forms of *C. festiva* it is distinguished by its narrow and rigid leaves, which are much shorter than the culm. — Colorado, Utah, Oregon, and British America.

285. CAREX BONPLANDII, Kunth, Enum. Plant. ii. 380.

C. Purdiei, Boott, Ill. 26, t. 67.

C. tenuirostris, Olney in Parry's Botan. Obs. in W. Wyoming, Amer. Naturalist, 1874, 24.

N. W. Wyoming, *Parry* 284; Summit Valley, Sierra Nevada, California, *Pringle*. South America.

Var. ANGUSTIFOLIA, Boott, Ill. 115.

Var. *minor*, Olney, Bot. King's Rep. 365.

Mountains of Colorado and Utah. South America.

286. CAREX SUBFUSCA, W. Boott, Bot. Calif. ii. 234.

Culm two feet and more high, smooth, slender but stiff, longer than the long-pointed narrow leaves: spikes four to six, well defined, small (about three lines long), rusty, aggregated into a small loose naked head a half or three fourths inch long: perigynium very small and thin (a line and a half or less long), densely packed, but the points conspicuous. Distinguished from *C. festiva*, var. *gracilis*, by its rounded and well-defined spikes which are lighter colored, its short and nearly obtuse scales, and its much smaller and abruptly slender beaked perigynium. — Summit Camp, California, *Kellogg*.

287. CAREX FESTIVA, Dewey, Sill. Journ. xxix. 246.

C. oreades, Meyer, Bull. Acad. Brux. ix. part ii. 248.

C. Orizabæ, Liebm. Mex. Halv. 75.

C. pinetorum, Liebm. l. c.

From Colorado westward and high northward, and southward to Mexico. Variable. N. Europe.

Var. HAYDENIANA, W. Boott, Bot. Calif. ii. 234.

C. Haydeniana, Olney, Bot. King's Rep. 366.

Mountains from Utah northward.

Var. GRACILIS, Olney, Proc. Am. Acad. 1872, 407.

Very slender, often two feet or more high, the spikes small and mostly indistinct and either somewhat scattered or loosely aggregated. As at present received, it probably includes more than one variety or species. — California, in the Sierras.

288. CAREX ATHROSTACHYA, Olney, Proc. Am. Acad. vii. 393.

Colorado and Montana to California and Oregon; British America.

289. CAREX SYCHNOCEPHALA, Carey, Sill. Journ. 2d ser. iv. 24.

C. cyperoides, Dewey, Sill. Journ. iii. 171, not Linn.

Central New York to Canada, and westward to the Great Plains of British America. Rare.

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IV.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

Presented by Josiah P. Cooke, Director, June 16, 1886.

I.—ANALYSIS OF MICA FROM LEON CO., TEXAS.

By George W. Leighton, B. S. 1886.

This mica, submitted to our examination by Professor Cooke, was received by him from Dr. A. E. Foote, of Philadelphia, who identifies it as the Joakumite of the Texas Academy of Sciences. The mineral attracted notice, as it presented characteristics intermediate between those of the vermiculites and the muscovites, and it was hoped that an analysis might add to our knowledge of the relations between these species.

Description. — The mica is opaque except in thin laminæ, and has obviously undergone alteration. Cleavage basal eminent, laminæ flexible, but brittle and non-elastic. Lustre pearly. Color brownish to yellowish green. Double refraction negative. Biaxial; with bisectrix nearly if not absolutely normal to the cleavage, the optical angle in air measuring about 37½°, but could not be measured accurately on account of opacity. In blow-pipe flame the laminæ separate, swelling to more than double the original thickness, and melting on the edges, showing fusibility 5–6. Blow-pipe flame strongly colored with potash, barely tinged with soda, and with traces of lithia. No fluorine could be detected by the usual tests.

The Analysis was made in the usual way, fusing with Na_2CO_3 for the silica, decomposing with HF for the alumina, iron, and magnesia, and by Lawrence Smith's method for the alkalies. The iron was all in the ferric condition, and was determined volumetrically after weighing Al_2O_3 and Fe_2O_3 together. The potash was weighed as chloroplatinate, and the water was determined by ignition. In the following table, the results of our analysis are given in Column I. In Column II. are the corresponding per cents of oxygen, and in Column III.

are given for comparison the results of an analysis of a mica from Hirschburg, taken from Dana's System of Mineralogy, last edition, and classed by him among the muscovites.

	I.	II.	III.
SiO_2	48.95	26.11	49.04
Al_2O_3	25.17	11.73	29.01
Fe_2O_3	9.40	2.82	5.56
MgO	1.69	0.67	0.75
CaO	trace.	. . .	0.17
Na_2O	trace.	. . .	0.50
K_2O	11.08	1.88	11.19
H_2O	4.31	3.83	4.65
	100.60		100.87

Oxygen Ratios. — Bases with water to silica are as 4 : 5 nearly. Bases without water to silica are as 2 : 3 approximately.

$$RO + H_2O : R_2O_3 : SiO_2 = 5 : 11 : 20.$$

$$RO : R_2O_3 : SiO_2 = 2 : 11 : 20.$$

Conclusions. — Here, then, we have an evident product of alteration, with some of the characters of a vermiculite, which differs in composition from ordinary muscovite mica only in the absence of fluorine, and the presence of a somewhat larger amount of magnesia. Possibly muscovite may pass into vermiculite, and this mica from Texas may represent the first step in the alteration; but if so, intermediate stages must be found, and then this work may help to answer the question. As will be seen, the composition of the Texas mica agrees closely with that of the mica from Hirschburg, the difference in the relative amounts of Al_2O_3 and Fe_2O_3 being unessential.

II. — ANALYSIS OF A CRYSTALLINE SCALE FORMED IN THE MANUFACTURE OF SODIC BICARBONATE BY THE AMMONIA PROCESS, AT SYRACUSE, N. Y.

By George W. Leighton, B. S. 1886.

The material here described was deposited on the inner surface of an iron tank in which vapors consisting of NH_3, CO_2, with small quantities of H_2S, are passed through brine holding in solution NaCl, $MgCl_2$.

$CaCl_2$, and $CaSO_4$. It has the appearance of a boiler scale from one to two inches thick, semitransparent, with a vitreous lustre and of greenish gray color, although sometimes black on the surface. The scale is usually covered with crystal planes, which have at first sight the appearance of octahedral forms projecting from the surface, but on closer examination the planes were found to be the terminations of prisms extending down into the body of the scale. The faces were somewhat curved, and so irregular as to render accurate measurements with the reflecting goniometer impossible. Attempts were made to obtain approximate values by cementing to the faces bits of thin microscope glass, but the results were discordant. The crystals seemed to have a monoclinic habit, and to consist of an oblique rhombic prism terminated by two pairs of planes of the positive and negative hemioctahedrons. For the prismatic angle we obtained 57° 46′, and for the positive and negative octahedral angles an average of 69° and 75° respectively, but with a variation of more than three degrees between measurements on different crystals. We observed a well-marked cleavage parallel to the assumed plane of symmetry; also a second cleavage — inclined to the prismatic edges, and marked by striations on the prismatic planes — parallel to the assumed basal section. There were also indications of both ortho- and clino-domes; and from these features, as well as from the mode of twinning, it is highly probable that the crystallization is monoclinic, but the evidence is not conclusive.

A qualitative analysis showed that the material was composed chiefly of sodium and magnesium in combination with carbonic acid and chlorine, with a small amount of calcium, and a trace only of iron. The scale when pulverized was decomposed by water, all of the sodium salts and part of the magnesium passing into solution upon digestion with a sufficiently large volume of boiling water, but from this solution all the magnesium was thrown down on concentration as carbonate.

In the quantitative analysis, the alkali was determined in two ways; first, by extraction of the sodium salts with water, and the separation of the magnesium by concentration; secondly, by the regular Lawrence Smith method; and concordant results were thus obtained. The magnesium, calcium, and iron were separated in the usual way. Chlorine was determined by precipitation with argentic nitrate from a solution of the scale in nitric acid, and the CO_2 was determined by loss on treating with acid in a small apparatus adapted for the purpose, and also by absorption in potash bulbs. The results are given below.

Substance estimated.	Number of Analysis.							
	1	2	3	4	5	6	7	8
H_2O at 100° C.					0.31	0.39	0.395	
H_2O at 230° C.	0.63	0.63						
CaO			2.02	1.99	1.96	1.96	2.05	
FeO	0.045	0.054						
MgO			14.90	14.77		15.34	15.12	
Na_2O	38.71		38.45	38.57				
Cl	13.45		13.46	13.45				
CO_2	36.24			35.33	35.65	35.46		35.54

Taking now the means of these determinations, and assuming that the chlorine is combined with sodium, while the carbonic acid is distributed among the rest of the base, we obtain as the final average result of the analysis: —

	Found.	Theory.	Diff.
NaCl	22.230	22.23	
Na_2CO_3	40.622	40.28	—0.34
$MgCO_3$	31.569	31.92	+0.35
$CaCO_3$	3.559		
$FeCO_3$	0.080		
H_2O	0.630		
CO_2 in excess	0.645		
	99.335		

It will be noticed that CO_2 is present in slight excess over the amount required to form neutral carbonates, indicating a small admixture of bicarbonate. The water is obviously hygroscopic, and the minute amount of iron an impurity. Excluding also from consideration the small amount of lime whose relations to the mass cannot certainly be determined, it appears that the three chief ingredients of the crystalline scale are present very closely in the proportion of their molecular weights. This is shown in the column headed Theory, which gives the amounts of Na_2CO_3 and $MgCO_3$ corresponding to the amount of NaCl found in the material analyzed, on the assumption that this is a triple salt represented by the symbol $MgCO_3 . Na_2CO_3 . NaCl$.

By comparing the determinations of chlorine which form the basis of this calculation, it will be seen that the amount of NaCl must be known with great accuracy, and the column of differences shows that the calculated values of $MgCO_3$ and Na_2CO_3 differ from results of analysis within the limits of experimental errors. By withdrawing from the total weight the small amount of base assumed to exist as bicarbonate, corresponding to the excess of CO_2 shown by analysis, and making also the very probable assumption that the calcium found replaces the magnesium in the triple salt, we should obtain very nearly the same results as before; but such a calculation would rest on uncertain data, and add nothing to the strength of our general conclusion.

It is evident that the crystalline scale is a double carbonate of magnesium and sodium united in molecular proportions with common salt, and mixed with a small amount of impurity; but the amount of impurity is very small, considering the conditions under which the scale is formed. That the chloride is combined, and not simply mixed, with the carbonate, is shown, not only by the definite proportions, but also by the fact that the material is so slowly acted on by water, which evidently acts as a decomposing agent, and not solely as a solvent. The scale is then a definite crystalline product, having a very interesting constitution not unlike that of several well defined mineral species.

III.—ON THE CONSTANCY IN THE HEAT PRODUCED BY THE REACTION OF ARGENTIC NITRATE ON SOLUTIONS OF METALLIC CHLORIDES.

By Theodore W. Richards, A. B. 1886.

Having observed in some experiments made solely for practice that the heat produced by the precipitation of silver chloride from aqueous solutions of several metallic chlorides was directly proportional to the amount of silver nitrate used, the following investigation was made in order to determine whether this relation was really exact.

A standard solution of argentic nitrate was prepared by dissolving 100 grams of $AgNO_3$ in one litre of water, and diluting to 1250 cc. 50 cc. of this solution diluted to just 250 cc. were used in each determination (except once when twice that amount was used), and the solutions of the various chlorides were made up so that 250 cc. would contain a gram or so more salt than was necessary to precipitate the quantity of silver nitrate used.

As the investigation was a question of comparison rather than of absolute measures, great care was taken to render the conditions as uniform as possible. For this purpose, all the solutions and apparatus were left for twenty-four hours in a room of nearly constant temperature before being used.

The calorimeter was similar in every respect to that described by Berthelot, and the method of operation was exceedingly simple. In every case 250 cc. of the solution of the metallic chloride were poured into the platinum calorimeter, and at the same time 250 cc. of the silver solution (containing 4 grams of $AgNO_3$ as stated above) were poured into a beaker, which had a capacity when filled to the brim of 255 cc. The beaker was rested upon many folds of a non-conducting cloth, and surrounded by a cardboard cylinder with a movable cover.

When the temperatures of the liquids in both the calorimeter and the beaker (which were at first very nearly the same) had become constant after much stirring, they were noted, and the beaker was grasped by a heavily gloved hand and its contents poured rapidly into the calorimeter, the temperature of the resulting mixtures being noted.

Following is an example taken at random from the note-book.

Temperature of NH_4Cl sol. in calorimeter .	17°.220
" " $AgNO_3$ sol. in beaker . . .	17°.280
Mean	17°.250
Final observed temperature	18°.000
Rise of temperature	0°.750

In every case the maximum temperature was attained in 10 to 15 seconds, so that no correction for cooling was necessary.

The water equivalent was always as follows: —

Solutions, 500 grms.; platinum calorimeter, 3.5 grms.; platinum stirrer, 1.5 grms.; thermometer, 5 grms. Total water equivalent = 505.5 grms.

Below is a table of all the results found.

The first column contains the number of the experiment, the second the chloride acted upon, the third the observed rise of temperature, and the fourth the amount of heat evolved in calors, and the last column the difference between the amount in each case and the average amount.

		°		
1	Sodic Chloride NaCl	.760	16,220	+65
2	" " "	.750		
3	Potassic Chloride KCl	.750	16,110	−55
4	" " "	.750		
5	Ammonic Chloride NH_4Cl	.755	16,170	+5
6	" " "	.750		
7	Barium Chloride $BaCl_2$	.750	16,110	−55
8	Cupric Chloride $CuCl_2$	.757	16,270	+115
9	Zinc Chloride $ZnCl_2$	.760	16,320	+165
10	Manganese Chloride $MnCl_2$	.745	16,010	−155
11	Nickel Chloride $NiCl_2$	.755	16,110	−55
12	" " "	.745		
13	Ferrous Chloride $FeCl_2$	.745	16,010	−155
14	Aluminic Chloride Al_2Cl_6	.745	16,010	−155
15	Ferric Chloride Fe_2Cl_6	1.520*	16,320	+165
16	" " "	.760		
17	Chromic Chloride Cr_2Cl_6	.760	16,320	+155
18	Hydrochloric Acid HCl	.760	16,170	+5
19	" " "	.740		
20	" " "	.755		
	Average	.7526	16,165	

It will be seen that all of these results are identical within the limit of error of the process. We may, therefore, draw the conclusion, that the amount of heat evolved by the reaction thus represented,

$$(\tfrac{1}{n} R_m \, Cl_n + AgNO_3 + Aq) = AgCl + (\tfrac{1}{n} R_m (NO_3)_n + Aq),$$

is constant, no matter what R, m, or n may be.

Hence, also, *the difference between the heats of formation of equivalent amounts of nitrate and chlorides in aqueous solution is the same for any metal or basic radical.*

IV. — IS THERE A CONSTANT RELATION BETWEEN THE HEATS OF FORMATION OF CHLORIDES AND SULPHATES IN AQUEOUS SOLUTION?

By Irving W. Fay, A. B. 1886.

The series of results obtained by Mr. Richards, as above described, suggested the inquiry whether a like constant relation might not be found between the heats of formation of the *chlorides* and *sulphates* in

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* In this experiment 8 grms. of $AgNO_3$ were used.

aqueous solution. Accordingly, a series of experiments was made involving this general reaction,

$$\frac{1}{n} R_m (SO_4)_n + BaCl_2 \cdot 2\, H_2O.$$

All work was done in a constant-temperature room. The calorimeter was the one used by Mr. Richards, and the accessories were in every respect the same as those described by him.

The materials required were a standard solution of barium chloride, and a solution of each of the sulphates to be acted upon containing a sufficient excess to insure complete precipitation of the barium. Accordingly, a standard solution of barium chloride was made of the strength represented by the expression,

$$BaCl_2 \cdot 2\, H_2O + 200\, H_2O.$$

From this standard value the required amount of each sulphate was easily calculated.

For every experiment, 250 cc. of the baric chloride and 250 cc. of the sulphate solution were used. Hence this amount of water, increased by the water equivalent of the calorimeter, stirrer, and thermometer, gave the total water equivalent, which was exactly the same for each experiment.

The mode of experimenting was precisely like that in the preceding paper, and the maximum rise of temperature took place in less than fifteen seconds, which rendered unnecessary any correction for cooling. The limit of error did not exceed 0°.02 C., and if any accidental cause of uncertainty arose, a second experiment was made for confirmation.

The following example is taken at random from the note-book: —

Temperature of $BaCl_2$ sol. in calorimeter . .	16°.94
" " Na_2SO_4 sol. in beaker . . .	16°.78
Mean	16°.86
Final observed temperature	17°.50
Rise of temperature	0°.64

The last column of the following table shows the amount of heat produced by the reaction of one molecule (244 grams) of baric chloride upon one molecule of sulphuric acid in combination with a base, both being in aqueous solution. The next column to the left gives the observed rise of temperature; and, since the amount of baric chloride used was the same in every case, the values in either column may be directly compared with each other.

			o	c.
1.	$BaCl_2$ and	Na_2SO_4	.64	5171
2.	" "	Na_2SO_4	.63	5089
3.	" "	K_2SO_4	.68	5594
4.	" "	$(NH_4)_2SO_4$	.70	5556
5.	" "	$MgSO_4$	.70	5556
6.	" "	$ZnSO_4$	.70	5556
7.	" "	$CdSO_4$	.715	5776
8.	" "	$CuSO_4$	.685	5534
9.	" "	$NiSO_4$	.71	5736
10.	" "	$CoSO_4$	.71	5736
11.	" "	$FeSO_4$	.72	5817
12.	" "	$\frac{1}{3}Al_2(SO_4)_3$	.805	6504
13.	" "	$\frac{1}{3}Al_2(SO_4)_3$	.805	6504
14.	" "	$\frac{1}{3}Fe_2(SO_4)_3$	.85	6864
15.	" "	$\frac{1}{3}Fe_2(SO_4)_3$	.85	6864
16.	" "	$\frac{1}{4}K_2Al_2(SO_4)_4$	.83	6704
17.	" "	$\frac{1}{4}K_2Al_2(SO_4)_4$	.81	6544
18.	" "	$\frac{1}{4}K_2Cr_2(SO_4)_4$	.80	6464
19.	" "	$\frac{1}{4}K_2Cr_2(SO_4)_4$	.79	6184
20.	" "	$\frac{1}{4}(NH_4)_2Fe_2(SO_4)_4$	1.02	8240
21.	" "	$\frac{1}{4}(NH_4)_2Fe_2(SO_4)_4$	1.03	8320
22.	" "	H_2SO_4	1.225	9904

The first noticeable fact observed in the above table is, that the difference between the heats of formation of chloride and *sulphate* is *not* the same for all metals, as it was found to be in the case of the chlorides and *nitrates*. It will be noticed, however, that with sulphates of allied bases the agreement is as close as before, but the sesquioxide salts give a larger amount of heat than the protoxide, and the double salts a still larger quantity, and sulphuric acid much the largest of all. It is a singular fact, that in the case of common alum the heat evolved is greater than it is with either of its constituent salts.

V.

A METHOD FOR THE SEPARATION AND ESTIMATION OF BORIC ACID,

WITH AN ACCOUNT OF A CONVENIENT FORM OF APPARATUS FOR QUANTITATIVE DISTILLATIONS.

By F. A. Gooch.

Presented June 16, 1886.

In all successful methods for the estimation of boric acid, its comparative isolation is a necessary preliminary. Fortunately the removal of nearly everything which interferes seriously with the proper execution of methods is not particularly arduous, but, of ordinarily occurring substances, two, silica and alumina, — both very commonly associated with boric acid, — are especially annoying in this regard. In the separation of alumina the trouble lies in the tendency of the precipitated hydrate to carry and retain boric acid,* so that the two cannot be parted by means of ammonia or ammonia salts; with silica, the difficulty is in removing it completely. The volatility of boric acid stands, of course, absolutely in the way of treating with acid and evaporating to dryness, and every chemist knows the vainness of attempting to precipitate silica by means of ammonia, ammonia salts, or zinc oxide in ammonia. In Stromeyer's method † the presence of silica is peculiarly harmful, since in passing to the condition of potassium fluo-silicate this substance nearly quadruples its weight, and to free the potassium fluo-borate from contaminating fluo-silicate requires, according to Fresenius,‡ at least six treatments by solution in boiling water, the addition of ammonia, and evaporation to dryness. Wöhler § recommends evaporating the hydrochloric acid solution to dryness in a flask fitted to a condenser, collecting the distillate, reuniting the latter with the residue, and filtering from silica; and the operation is successful so far as the complete removal of silica is concerned, but the alumina, if

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* Wöhler, Ann. d. Chem. u. Pharm., cxli. 268.

† Ann. d. Chem. u. Pharm., c. 82.

‡ Quant. Chem. Anal., p. 424.

§ Handbook of Mineral Analysis, under Datholite.

present, is still in condition to give annoyance, and the other bases are yet to be separated.

Advantage has long been taken of the volatility of free boric acid with hydrofluoric acid or with alcohol to secure its removal from fixed substances, but so far as I know no attempt has been made heretofore to secure its complete volatilization and estimation in the distillate. The experiments which I proceed to describe are the result of an effort to accomplish this end.

Aside from the difficulties in manipulation and in the construction of apparatus which the use of hydrofluoric acid would involve, this reagent is otherwise plainly inapplicable to the purpose in view, and of other agents with which boric acid is known to volatize freely methyl alcohol seems to present the most desirable qualities. Methyl alcohol, ethyl alcohol, and water are effective in the order in which they are named. Thus, to volatilize 1 grm. of boric acid, — the equivalent, speaking roughly, of about 0.5 grm. of boric anhydride, — two treatments with 10 $cm.^3$ of methyl alcohol and evaporation to dryness in each case were adequate; for the volatilization of 0.2 grm. of boric acid were required two treatments of 10 $cm.^3$ each of ethyl alcohol, succeeding an evaporation with 50 $cm.^3$ of the same alcohol; and the residue of five evaporations of water over 0.4 grm. of boric acid, taking in each case 50 $cm.^3$ of water, followed by ignition, weighed 0.08 grm., or one fifth of the original weight. In the presence of water, methyl alcohol is not equally effective; amyl alcohol and sulphuric acid restrain its action similarly, doubtless by dilution simply, and hydrochloric acid seems to possess no advantage over water alone in developing the volatility of boric acid. As an example, an experiment may serve in which a solution of 0.4 grm. of boric acid in 50 $cm.^3$ of water, after being heated three times successively with 25 $cm.^3$ of methyl alcohol until the boiling point rose in every case nearly to that of water, and then evaporated to dryness, left a large residue which disappeared with a single charge of 25 $cm.^3$ of methyl alcohol applied by itself.

From the residue of the evaporation of borax with hydrochloric, nitric, or acetic acid, methyl alcohol, as would naturally be predicted, volatilizes the boric acid freely, though the presence of foreign material acts to a certain degree protectively and tends to diminish the rapidity with which the alcohol would otherwise effect extraction and volatilization. In case, however, that acetic acid is used to break up the borate, the tendency of sodic acetate to lose acid and become alkaline simply by exposure to evaporation in its aqueous solution makes it necessary to insure the acidity of the residue of evaporation by adding a drop or two of acetic acid before repeating the treatment with methyl alcohol.

On the whole, methyl alcohol shows itself to be an excellent agent by which to secure the volatilization of boric acid.

To retain free boric acid, magnesium oxide naturally suggests itself. According to Marignac * it is effective, and, if in the course of analysis it may have been partly converted to the chloride, it is easily regenerated by the action of heat and moisture. Marignac, it will be remembered, makes use of magnesia mixture — the chlorides of ammonium and magnesium with free ammonia — to fix the boric acid, evaporating the solution to dryness, igniting, extracting with boiling water, filtering, and weighing the residue, while the filtrate is again treated as before to recover traces of the borate which have yielded to the solvent action of the water. During the drying and ignition the magnesium chloride yields hydrochloric acid, and it would seem scarcely possible that the magnesium borate should fail to show some loss of boric acid when both hydrochloric acid and moisture exert their action. Further, the presence of ammonia during evaporation does not prevent the volatilization of boric acid.† and Marignac regards the addition of it from time to time as of doubtful use. So it appears natural to look for some loss under such conditions, and Marignac fully recognizes the fact that the apparent accuracy of his method is due to the balancing of errors, the inclusion of foreign matter by the magnesium borate and the deficiency of the magnesia when precipitated as ammonio-magnesium phosphate together compensating for the loss of boric acid by volatilization. To bring the matter to the test, the following experiments were made. In them and in all succeeding experiments the boric acid was weighed in solution, the standard of this having been fixed by dissolving in a known weight of water a known weight of fused boric anhydride prepared in a state of purity by frequent recrystallization. The magnesium oxide employed was made from the pure chloride by precipitating by ammonium carbonate and igniting, and was free from lime and alkalies, and as far as could be determined otherwise pure. The whole operation of each experiment was conducted in one vessel, so as to avoid transfers. In all cases a weighed platinum crucible of 100 $cm.^3$ capacity received a weighed portion of magnesia, and after ignition and subsequent weighing the weighed solution of boric acid was introduced. In experiments (1) to

* Zeit. für Anal. Chem., i. 406.

† Rose, Pogg. Ann., lxxx. 262.

(4) the magnesia was thoroughly stirred in the solution of boric acid, the evaporation carried at once to dryness, and the crucible and residue ignited and weighed; in experiments (5) to (8), the magnesia was dissolved, after the addition of the boric acid, in hydrochloric acid sufficient in amount to prevent the precipitation of magnesium hydrate on the subsequent addition of ammonia, ammonia introduced in considerable excess in (7) and (8), in distinct excess in (5) and (6), the whole evaporated and ignited, the residue moistened and again ignited, and this last treatment repeated until the residue ceased to yield vapor of hydrochloric acid when heated.

	B_2O_3 taken.	MgO taken.	$MgO+B_2O_3$ found.	B_2O_3 found.	Error.
	grm.	grm.	grm.	grm.	grm.
(1)	0.1734	0.5005	0.6607	0.1602	0.0132—
(2)	0.1804	0.4973	0.6660	0.1687	0.0117—
(3)	0.1793	0.4949	0.6640	0.1691	0.0102—
(4)	0.1794	0.4941	0.6627	0.1686	0.0108—
(5)	0.1807	0.4984	0.6542	0.1558	0.0249—
(6)	0.1789	0.4974	0.6687	0.1560	0.0229—
(7)	0.1806	0.4944	0.6684	0.1740	0.0066—
(8)	0.1789	0.4959	0.6672	0.1713	0.0076—

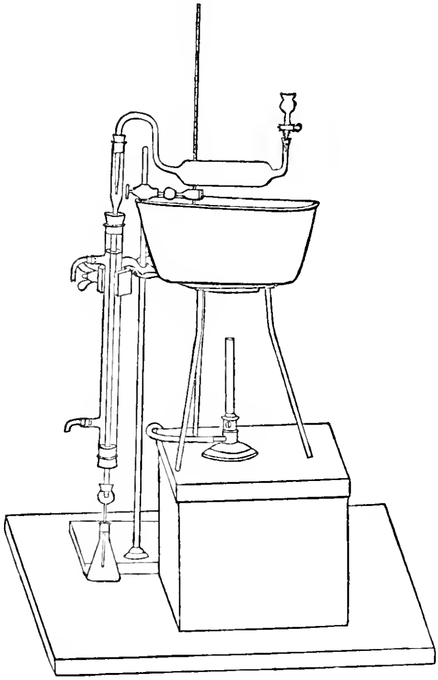
From these results it appears plain that under the conditions of the experiments neither magnesia alone nor the magnesia mixture is efficient in fixing boric acid; but in experiments (7) and (8), in which ammonia was employed in large excess, the loss of boric acid is least, so that it would seem to be the case that though ammonia is not a perfect preventive of volatilization it does exert a restraining action on the boric acid. That the magnesia mixture should be incapable of retaining entirely the boric acid present is, as has been pointed out, not surprising; but that the loss should be so great is rather startling, and more than suggests that the errors of Marignac's process are seriously excessive. The failure of magnesium oxide to hold back boric acid under the conditions of the experiment must be due to a cause other than that which determines the loss during the evaporation and ignition of the magnesia mixture, and for this it is natural to turn to the insolubility of the oxide, — a quality likely to oppose some difficulty in the way of establishing complete contact between the boric acid and the magnesia during a short exposure. Direct tests of this point showed distinctly that mixtures of boric acid in water and magnesia, when submitted at once to distillation, yielded boric acid to the distillate; but that, if the mixtures were permitted to stand some hours before distilling, the oxide passed to the semi-gelatinous condition of the hydrate, and retained the boric acid so firmly that turmeric failed to show the presence of the latter in the distillate. It is plain, therefore, that with sufficient preliminary exposure magnesia might be relied upon to retain boric acid; but inasmuch as long and perhaps somewhat indefinite periods of waiting are objectionable in any analytical process, it was thought best to try the effect of substituting lime for magnesia. Experiments (9) to (12), conducted like the previous ones, excepting only the use of carefully prepared and ignited calcium oxide instead of magnesium oxide, were made with this end in view.

	B_2O_3 taken.	CaO taken.	$CaO+B_2O_3$ found.	B_2O found.	Error.
	grm.	grm.	grm.	grm.	grm.
(9)	0.1810	0.9737	1.1560	0.1823	0.0013+
(10)	0.1819	0.9750	1.1583	0.1833	0.0014+
(11)	0.1808	0.9922	1.1810	0.1818	0.0010+
(12)	0.1833	0.9715	1.1560	0.1845	0.0012+

These figures indicate sufficiently that there is no loss of boric acid by volatilization when its aqueous solution is evaporated in contact with calcium hydrate; but, inasmuch as the comparative solubility of the latter is the quality which makes it effective where magnesia is not, it seemed desirable to test the action of calcium hydrate in alcoholic solutions, in which it is very insoluble. The experiment showed that when the solution of boric acid in methyl or ethyl alcohol is put upon lime and distilled at once loss is apt to take place, and sometimes to a very inconsiderable amount, but that a short period of digestion with occasional stirring — from five to fifteen minutes — is sufficient to obviate danger of volatilization of boric acid.

It appears, therefore, that, free boric acid being easily volatilized by means of methyl alcohol and fixed completely by calcic hydrate, the separation of the acid from almost everything with which it occurs ordinarily and its estimation subsequently depend only upon the practicability of distilling it from its compounds in such company that it may be retained by lime and its amount determined by the increase in the weight of the latter. Unlike magnesium chloride, calcium chloride does not yield its chlorine readily under the action of heat and moisture naturally retained; so that hydrochloric acid must not be present with boric acid which is to be estimated in the manner described. Calcium nitrate and calcium acetate both yield the oxide without difficulty upon ignition, and nitric and acetic acids are suitable agents, therefore, for the liberation of boric acid previous to distillation.

The actual distillation presented at first some difficulty, — for the repeated, thorough, and rapid evaporation of a liquid charged with soluble or insoluble solid matter is apt to involve some mechanical transfer to the distillate of material which should remain in the residue, — but the device of the following description solves the problem successfully.



The apparatus, which is shown in the accompanying cut, consists essentially of a retort, condenser, and bath for heating. For the last I have used a paraffine bath, as being on the whole the most convenient. The condenser is set vertically, to facilitate changing the level of the retort within the bath, and to secure at the same time continual and thorough washing of the tube by its own condensations. The retort, somewhat like the well-known drying tube of Liebig in general shape, is easily made of a pipette by bending the tube at one end to a right angle, at the other to a goose-neck, as shown. To the former end is fitted, by a rubber stopper or section of tubing, a glass funnel-tube provided with a stop-cock; the end of the goose-neck passes tightly through a rubber stopper in the upper end of the condensing tube. This is essentially the apparatus, but it is convenient to attach to receive the distillate a small Erlenmeyer flask which moves with the condenser and is joined to it, in the manner indicated in the figure, by means of a thistle-tube and a rubber stopper grooved to permit the free passage of air. In carrying out a distillation, the liquid to be distilled is introduced into the retort either by the funnel tube or previous to its insertion, the glass cock is closed, the water started through the condenser, and the retort lowered into the hot paraffine, care being taken to begin the operation with the retort not more than half full and so inclined that only the rear dips below the surface of the bath. If the precaution to heat the retort at the start in this manner be overlooked, it may sometimes happen that the sudden and violent expulsion of air through the liquid will carry portions of it bodily into the goose-neck, and even into the condenser. With this point considered, the remainder of the operation presents no difficulty, and requires little care.

The size of the retort may be suited, of course, to the particular case in hand, but for most purposes a 200 cm.^{3} pipette makes a retort of convenient dimensions, neither too large for the distillation of small charges nor too small to permit the treatment of 100 cm.^{3} of liquid comfortably. The tube of the goose-neck should be wide enough to prevent the formation of bubbles in it; 0.7 cm. is a good measure for the interior diameter. It is of advantage to heat the bath to a point considerably above the temperature at which the liquid which is to be distilled boils, — something between 130° C. and 140° C. does very well for water, and is not too high for methyl alcohol, — and under such circumstances, and when the retort is entirely submerged, it often happens that evaporation takes place with extreme rapidity from the surface of the liquid in perfect quiet without actual boiling.

With such an apparatus the following experiments were made. The boric acid was weighed, as before, in solution, and to bring the condition of the experiment to that of an actual analysis, 1 grm. of pure sodium hydrate was added in solution, nitric acid or acetic acid to acidity and a little more, and the whole was introduced into the retort and distilled to dryness.

In those experiments in which nitric acid was employed, the methyl alcohol was introduced upon the residue thus dried in six successive portions of 10 cm.^{3} each, and distilled to dryness; but in order to break up the residue of sodium nitrate, which by its insolubility might effect to some extent the protection of the boric acid from the action of the alcohol, 2 cm.^{3} of water were introduced and evaporated between the second and third, and again between the fourth and fifth distillations.

When acetic acid was made use of to free the boric acid, the six distillations with methyl alcohol were made as before; but, sodium acetate being soluble in methyl alcohol, the intermediate treatments with water were unnecessary. With the fourth portion of methyl alcohol a few drops of acetic acid were added to preserve the acidity of the residue, which, as has been pointed out, tends to become alkaline under the treatment.

The residues of both processes of treatment were found to be free from boric acid by the exceedingly delicate test with turmeric, care being taken in the series of experiments in which nitric acid was used to oxidize nitrites by means of bromine (expelling the latter before making the test), and in the acetic acid series to acidify with hydrochloric acid sufficiently to counteract the tendency of the acetate by itself to brown the turmeric on evaporation.

The lime to retain the boric acid in the distillate was ignited in the crucible in which the evaporation of the distillate was to be made subsequently, and then transferred to the receiving flask attached to the condenser, so that the boric acid might be fixed during the distillation. To prevent the caking of the lime by the action of the alcohol, it was slaked with a little water before the distillation was begun.

In experiments (13) to (16) nitric acid was employed, and in (17) to (20) acetic acid was used, with the precaution noted, to liberate the boric acid.

	B_2O_3 taken.	CaO taken.	B_2O_3+CaO found.	B_2O_3 found.	Error.
	grm.	grm.	grm.	grm.	grm.
(13)	0.1738	0.9647	1.1392	0.1745	0.0007+
(14)	0.1806	0.9639	1.1456	0.1817	0.0011+
(15)	0.1779	0.9665	1.1450	0.1785	0.0006+
(16)	0.1824	0.9739	1.1587	0.1848	0.0024+
(17)	0.1806	1.4559	1.6371	0.1812	0.0006+
(18)	0.1812	0.9720	1.1543	0.1823	0.0011+
(19)	0.1788	0.9986	1.1781	0.1795	0.0007+
(20)	0.1813	0.9527	1.1358	0.1831	0.0018+

In experiments (13) to (16) the mean error amounts to 0.0012+ grm.; in experiments (17) to (18) the mean error is a little more than 0.0010+ grm. Throughout the entire series of experiments the tendency to yield figures slightly larger than the truth is manifest, but the error is quite within legitimate limits. The greatest care was taken to secure similarity of conditions under which the crucible and lime were weighed before and after the evaporation and absorption of boric acid, and the weight after ignition was taken in every case after cooling over sulphuric acid during a definite period of ten minutes in order to eliminate as far as possible the effect of atmospheric condensation upon the large surface of platinum. Ignitions were always finished over the blast-lamp, and constancy of weights secured.

The results of both modes of treatment are on the whole satisfactory, and equally so.

In the presence of chlorides, it is of course impossible to employ nitric acid to free the boric acid. Oxalic, citric, and tartaric acids also liberate hydrochloric acid to a considerable extent from alkaline chlorides. It was found, however, that when acetic acid was distilled over sodium and potassium chlorides only traces of hydrochloric acid passed into the distillate, and experiments (21) to (23) were made to determine whether these amounts are sufficient to vitiate the separation of boric acid from alkaline chlorides by distillation in presence of free acetic acid. The details of treatment were identical with those of experiments (17) to (20), excepting only the addition of 0.5 grm. of sodium chloride to each portion before distillation.

	B_2O_3 taken.	CaO taken.	B_2O_3+CaO found.	B_2O_3 found.	Error.
	grm.	grm.	grm.	grm.	grm.
(21)	0.1834	0.9842	1.1675	0.1833	0.0001—
(22)	0.1831	0.9755	1.1593	0.1838	0.0007+
(23)	0.1761	0.9740	1.1523	0.1783	0.0022+

The mean error of these results is about 0.0009+ grm., and it is plain that the presence of sodium chloride does not materially change the conditions of the experiment. There seems, therefore, to be no reason why boric acid may not be separated by distillation from alkaline chlorides in presence of free acetic acid; but it was found that the presence of any considerable amount of potassium acetate is disadvantageous. Sodium acetate to a reasonable amount does not interfere with the favorable progress of the separation; but potassium acetate appears to require a much higher temperature for the expulsion of its water, and longer distillation.

When, therefore, chlorides are present in the salts from which boric acid is to be removed by distillation, the choice is open between two methods: the distillation may be made directly with an excess of acetic acid; or the hydrochloric acid may be first removed by means of silver nitrate, and the distillation of the filtrate proceeded with at once, or after precipitation of the excess of silver salt by means of sodium hydrate or carbonate, care being taken to acidify again sufficiently with nitric acid after the removal of the silver. Of these two modes of proceeding, I incline to the treatment with nitric acid and the removal of the chlorine by precipitation; and this method has been used with success by others as well as myself, for some months, in the analysis of waters carrying boric acid, and natural borates.

The process in either modification is fairly accurate and easily executed, and admits of very wide application. Insoluble compounds in which the boric acid is to be determined may be dissolved in nitric acid at once, or, if necessary, first fused with sodium carbonate; and, fortunately, nearly everything which is volatile in the subsequent treatment and capable of forming with lime compounds not easily decomposable by heat may be removed by known processes. The combination of fluorine, silica, and boric acid is perhaps most difficult to treat; but the precipitation and removal of the first as calcium fluoride from the aqueous solution of a fusion in alkaline carbonate may, it is believed, be effected with care, and the mode of procedure from that point is simple.

The number of distillations necessary depends, of course, upon the amount of boric acid treated. To remove 0.2 grm. of boric anhydride completely to the distillate, six charges of methyl alcohol, of 10 $cm.^3$ each, proved, as we have seen, to be ample.

The apparatus by the aid of which the distillation processes which have been described were carried out has found useful application in a number of other processes. In the determination of free and albuminoid ammonia in waters which can be boiled quietly with difficulty, in the methods of estimating hydrofluoric acid which involve the expulsion of silicon fluoride from a mixture of the fluoride with sulphuric acid and silica, in the separation of iodine from bromides and chlorides by distilling with ferric sulphate and sulphuric acid, and of bromine from chlorides by means of permanganic acid, it has proved of value, and will doubtless be found convenient in many analytical processes in which quantitative separations by the distillation of liquids liable to spatter or boil explosively are involved.

VI.

A METHOD FOR THE SEPARATION OF SODIUM AND POTASSIUM FROM LITHIUM BY THE ACTION OF AMYL ALCOHOL ON THE CHLORIDES,

WITH SOME REFERENCE TO A SIMILAR SEPARATION OF THE SAME FROM MAGNESIUM AND CALCIUM.

By F. A. Gooch.

Presented June 16, 1886.

For the quantitative separation of lithium from sodium and potassium, Mayer's method,* which is based upon the precipitation of lithium as the tribasic phosphate, and Rammelsberg's † mode of parting the chlorides by means of a mixture of anhydrous alcohol and ether in equal parts have been available.

The method of Mayer grew out of the older process of Berzelius,‡ which consisted essentially in treating the solution of the alkaline salts with phosphoric acid and sodium carbonate in excess, evaporating to dryness, and extracting with cold water. The result of a single analysis of the product thus obtained was the testimony upon which Berzelius rested the belief and statement that the salt was a double phosphate of lithium and sodium, which left upon ignition sodium and lithium pyrophosphates in equal molecules; and on this Berzelius based his process for the estimation of lithium. Rammelsberg,§ however, showed later that it was a tribasic phosphate which was actually obtained, and from his experiments arrived at the conclusion that the proportion of soda and lithia were variable within wide limits, the amounts of the former varying in the special cases investigated from 7.84% to 28.38%; and the same thing in substance was reiterated subsequently ‖ in an account of a repetition of the work suggested by the criticism of Mayer. Mayer,¶ however, was unable to prepare under any conditions the double phosphate of Rammelsberg, and obtained invariably, when the preparation had been washed with suffi-

* Ann. d. Chem. u. Pharm., xcviii. 193.

† Pogg. Ann., lxvi. 79.

‡ Ibid., iv. 245.

§ Loc. cit.

‖ Pogg. Ann., cii. 443.

¶ Loc. cit.

cient care, trilithium phosphate free from sodium; but the point was made, that the phosphate is apt to be contaminated with lithium carbonate when sodium carbonate is employed to bring about alkalinity. Mayer therefore modifies the method of Berzelius by substituting sodium hydrate for the carbonate; and, proceeding, evaporates to dryness, treats the dry mass with as much water as is needed to dissolve the soluble salts with the aid of heat, adds a drop or two of sodium hydrate if necessary to restore alkalinity and then ammonia in volume equal to that of the water already added, sets aside at a gentle heat, filters only after twelve hours, and washes with a mixture of ammonia and water in equal parts. From the filtrate and first washings a small amount of the lithium phosphate is to be recovered by evaporation and the repetition of the former treatment. According to Mayer, the precipitation of the phosphate may be effected with equal completeness by boiling the solution, prepared as before, instead of evaporating it; but the objection to this mode of proceeding is the tendency of the liquid carrying the precipitate to bump explosively. Careful washing, somewhat prolonged, is essential to secure the complete removal of salts of sodium and potassium, and it is remarked that the purity of the precipitate is shown by its failure to cake when strongly ignited.

This is the mode of proceeding by which Mayer separates lithium from sodium and potassium, isolating it as presumably pure tri-lithium phosphate and weighing it as the anhydrous salt. In dealing with mixtures of the chlorides in which the proportion of the lithium salt is relatively small, the removal of the greater part of sodium and potassium chlorides by a preliminary treatment with absolute alcohol is recommended. The following table comprises the results of Mayer's test analyses of lithium carbonate in the first seven, of lithium sulphate in the last two, recalculated with the use of the number 7 — the figure now generally accepted — as the atomic weight of lithium.

Li_3PO_4 equivalent to Salt taken.	Li_3PO_4 found.	Error.
1.3586 grm.	1.3719 grm.	0.0133+ grm.
1.5172 "	1.5088 "	0.0084— "
0.7519 "	0.7580 "	0.0061+ "
0.9561 "	0.9510 "	0.0051— "
1.2651 "	1.2646 "	0.0005— "
1.2197 "	1.2230 "	0.0033+ "
0.8991 "	0.9018 "	0.0027+ "
1.1325 "	1.1236 "	0.0089— "
0.9715 "	0.9665 "	0.0050— "

Fresenius* found on examining the method that several repetitions of the treatment by evaporation and extraction were required to complete the recovery of all lithium phosphate, and advised that the operation be continued until residual lithium phosphate fails to appear. The results of Fresenius's experiments with lithium carbonate, recalculated with the use of the number 7 as the atomic weight of lithium, are given in the table appended.

Li_3PO_4 equivalent to Salt taken.		Li_3PO_4 found. Dried at 100° C.	Ignited.	Error.
grm.		grm.	grm.	grm.
0.7443	after two treatments	0.7243	....	0.0200—
	" three "	0.7385	....	0.0058—
	" four "	0.7433	....	0.0010—
0.9820		0.9861	....	0.0041+
		....	0.9826	0.0006+
1.6341		1.6342	....	0.0001+
		....	1.6305	0.0036—

Thus it will be seen that in the nine experiments of Mayer the error ranges from 0.0133+ grm. to 0.0089— grm., and that of the determinations of Fresenius from 0.0001+ grm. to 0.0041+ grm. for the dried precipitate, and from 0.0006+ grm. to 0.0036— grm. for the ignited precipitate.

If the tendency of lithium carbonate to fall in company with the phosphate were not to assert itself during the evaporations of solutions of salts of lithium in presence of sodium hydrate and in contact with ordinary atmospheric air, it would surely be strange, and this point may be fairly set down as one of the weak ones of the method; but the gravest source of error, and that indicated most unmistakably throughout the whole history of the process, — which has been recounted at some length for the purpose of emphasizing this very matter, — is the impossibility of preparing the lithium phosphate in anything like a condition of freedom from other alkaline phosphates without a careful and prolonged washing which is sure to result in loss of the lithium salt by solution. When it is remembered that according to Mayer's determinations tri-lithium phosphate requires for solution only 2539 parts of water, or 3920 parts of a mixture of ammonia and water in equal portions, it is plain that the success of the method depends upon the ability of the analyst to wash to a condition of purity, and without loss of that which it is the purpose of the

* Zeit. für Anal. Chem., i. 42.

process to save, a precipitate peculiarly prone to retain foreign matter and soluble in the washing mixture in the proportion of ten milligrams to every 40 cm.^{3} of the latter. Of course washings will never be entirely saturated, nor will the precipitate be as soluble at the beginning of the operation as at the end, when the precipitant no longer exerts an action which tends to lessen solubility; but in view of the difficulties which present themselves, it is sufficiently obvious that exact results obtained by Mayer's process owe their apparent accuracy to a fortuitous balance of errors. The difference of 0.0222 grm. between the extremes of Mayer's experimental results should not be surprising; and, at the best, the process is tedious and not entirely trustworthy, — facts of which its author was not unmindful.

In Rammelsberg's method of separating lithium chloride from the chlorides of sodium and potassium the sources of error are, in brief, the solubility of sodium chloride and potassium chloride in the ether-alcohol mixture, the influence which the presence of small amounts of water exerts upon the solubility of these same salts, the difficulty of bringing the chlorides to the anhydrous condition without decomposing the lithium chloride to a greater or less extent, and the mechanical difficulties of transferring the fused or crusted chlorides to a suitable receptacle for digestion and agitation in the solvent, and of extracting perfectly the soluble constituents of closely compacted matter. Of the last two items nothing need be said in explanation beyond simply noting them. The third is particularly important, inasmuch as the tendency of lithium chloride, first noted I believe by Mayer, to exchange chlorine for oxygen when ignited in presence of water, results in the formation of lithium hydrate or, in contact with products of combustion, lithium carbonate, both of which are insoluble in the mixture of ether and alcohol, and remain with the sodium and potassium chlorides. As to the effect of water in the mixture, an experiment of Mayer, in which it was found that 100 cm.^{3} of a mixture of alcohol of 96% and ether of 98% dissolved 0.1100 grm. of sodium chloride, is instructive. In regard to the solubility of the chlorides of sodium and potassium in the mixture of anhydrous ether and alcohol, Rammelsberg's statement, that from 0.9770 grm. of pure strongly heated sodium chloride with an undetermined amount of lithium chloride the mixture extracted 0.0130 grm., is unfortunately meaningless in the absence of information concerning the amount of solvent employed. J. Lawrence Smith * found, in making an exami-

* Am. Jour. Sci. [2], xvi. 56.

nation of this matter, that 10 cm.^{3} of the anhydrous ether-alcohol mixture extracted from 0.5 grm. of sodium chloride 0.0005 grm., and from 0.5 grm. of potassium chloride 0.0003 grm. Smith's mode of applying the method is better than the original; for, by taking care not to heat the mixed salts above 100° C., the danger of decomposing the lithium chloride is diminished, and by treating the dried salts with the ether-alcohol mixture in the capsule in which it is heated and weighed (protecting it by a small inverted bell-glass) the disadvantage of the transfer is avoided, but the danger is incurred that the mixed salts may not be thoroughly dried by heat so gentle. With this modification Smith obtained results which are rearranged in the following statement, and which do not throw a very favorable light upon the method.*

NaCl taken. grm.	KCl taken. grm.	LiCl taken. grm.	Weight dissolved. grm.	Error. grm.
0.2000	0.2000	0.0080	0.0101	0.0021+
0.2000	0.2000	0.0884	0.0862	0.0022—
0.2000	0.2000	0.8195	0.8341	0.0146+

It is obvious, therefore, that neither the method of Rammelsberg nor that of Mayer may justly claim to be what a good process should be, accurate and rapid; and in the dilemma many chemists have been inclined to accept, with Bunsen,† the inherent disadvantage of an indirect process, and in a mixture of sodium and lithium chlorides calculate the percentage of each from the known weight of the mixture and its contents in chlorine, and in a mixture of the three chlorides calculate the percentage of each from the known weight of the mixture and the determined contents in chlorine and potassium. Here again, however, as in Rammelsberg's process, the difficulty of bringing the chlorides to a definite condition for weighing without decomposing

* Dr. Smith's language in the description of these experiments is somewhat ambiguous, but it is believed that these figures represent the meaning intended. After the presentation of the data of the first experiment given here with the correction of an obvious typographical error, it is said of the second and third experiments that "a similar mixture containing 18.10 per cent of chloride of lithium furnished a residue of 17.65 per cent," and "a similar mixture containing 67.20 per cent of chloride of lithium gave a residue of 68.40." I have taken this to mean that in all three experiments 0.2 grm. of sodium chloride and 0.2 grm. of potassium chloride were employed with the different proportions of lithium chloride indicated for each experiment. At all events, if this is not the meaning of the language made use of, it is difficult to see a definite value in the experiments.

† Ann. d. Chem. u. Pharm., cxxii. 348.

the lithium chloride is an obstacle; and in case potassium is to be separated from large amounts of lithium by precipitation as potassio-platinic chloride, the concurrent precipitation of a similar salt of lithium, to which Jenzsch * has directed attention, may be the occasion of inexactness. So, the intrinsic unsatisfactoriness of indirect methods quite aside, it appears that in following Bunsen we have by no means all that is to be desired in an analytical method.

In looking about for better means for the separation of lithium from sodium and potassium, certain preliminary experiments on the behavior of the chlorides of these elements toward amyl alcohol gave very encouraging indications, and subsequent quantitative tests have borne out the hope that a successful method of separation might be based upon these relations.

In amyl alcohol the chlorides of sodium and potassium are highly insoluble, lithium chloride dissolves freely, and the attraction of amyl alcohol for water is so slight and its boiling point so far above 100° C. that the latter may be expelled without difficulty by the aid of gentle heating.

When amyl alcohol is poured into a solution of lithium chloride in water the liquid forms two layers, the aqueous solution of the salts at the bottom and the amyl alcohol now carrying a little water above. With the application of heat, the water evaporates slowly, then boils, and, passing through the alcohol, escapes, until toward the end of the operation the residual lithium chloride collects in a viscous globule, and finally dissolves with the exception of a slight incrustation. If now the alcohol is cooled and a drop of strong hydrochloric acid added and brought in contact with the deposit, and the boiling repeated, the solution is complete. This deposit I take to be lithium hydrate, resulting from the decomposition of the chloride by the protracted action of water at a temperature near its boiling point. The small amount of water which is added in and with the hydrochloric acid seems to exert no unfavorable influence, but rather to be beneficial in hastening the solution of the residue by securing immediate and sufficient contact.

In hot amyl alcohol, lithium chloride appears to be a little more soluble than in the same reagent at ordinary temperatures, but the solubility under the latter condition only was determined. By boiling the solution until turbidity began to show, cooling, filtering, and then evaporating a known volume of the concentrated solution to dryness

* Pogg. Ann., civ. 102.

and weighing the residue after converting it to the sulphate, it was found that one part of lithium chloride was held dissolved in the cold in about fifteen parts of amyl alcohol, 10 cm.³ of the solution containing in the mean 0.66 grm. of the chloride.

When aqueous solutions of sodium chloride or potassium chloride are treated with amyl alcohol and boiled, the water disappears, as before, leaving first a globule of the concentrated solution and finally the crystalline salts. On continuing the boiling until a thermometer dipped in the liquid indicates the temperature at which the alcohol boils by itself, a slight additional precipitation, doubtless due to the expulsion of the water retained by the alcohol up to this point, takes place upon the walls of the containing vessel. The results of quantitative tests of the solubility of sodium and potassium chlorides are given in the following tables. The strength of the solutions of sodium chloride and potassium chloride were determined by evaporating weighed portions in a platinum crucible and drying at a temperature considerably below the melting point of the salt, and weighing. The solution of lithium chloride was standardized by treating a weighed portion with sulphuric acid in excess, evaporating, igniting at red heat, and weighing. The standards were fixed by experiments (1) to (9).

	Weight of Solution of NaCl taken.	Weight of NaCl found.	Weight of NaCl in 10 grm. of Solution.	Mean.
	grm.	grm.	grm.	grm.
(1)	10.7110	0.1072	0.1001	
(2)	10.9419	0.1097	0.1003	0.1002
(3)	10.9325	0.1097	0.1003	

	Weight of Solution of KCl taken.	Weight of KCl found.	Weight of KCl in 10 grm. of Solution	Mean.
	grm.	grm.	grm.	grm.
(4)	9.3045	0.1744	0.1874	
(5)	10.7225	0.2006	0.1871	0.1872
(6)	11.1974	0.2096	0.1872	

	Weight of Solution of LiCl taken.	Weight of Li_2SO_4 found.	Weight of LiCl in 10 grm. of Solution.	Mean.
	grm.	grm.	grm.	grm.
(7)	10.9280	0.1635	0.1156	
(8)	11.1480	0.1665	0.1153	0.1154
(9)	10.8790	0.1626	0.1154	

To determine the solubility of sodium chloride and potassium chloride in amyl alcohol, portions of the test solutions were weighed out, evaporated to a convenient bulk in platinum crucibles of 100 cm.^{3} capacity, amyl alcohol was added, the water expelled by boiling, and the heating continued for some minutes after the thermometer in the liquid indicated 132° C., the boiling point of the alcohol employed. The liquid was then decanted with care and the residue dried at a temperature below its melting point and weighed. When the chlorides are precipitated in the manner described, the deposit generally adheres so closely, and such particles as do remain loose settle so well, that the supernatant liquid may be decanted to the end without appreciable transportation of the insoluble residue. For the sake of perfect security, however, in this part of the manipulation the decanted liquid was filtered under gentle pressure upon asbestos, with the aid of the device which I have previously described for such purposes,* and, after gentle heating, the increase in weight of the felt and the containing perforated crucible added to the weight of the residual salt. In no case did this increase exceed a few tenths of a milligram, and often could not be detected.

As a source of heat, a bath in which the sand of the sand-bath is replaced by smooth asbestos board is a convenience, or a piece of asbestos board simply, about 30 cm. square, supported by a broad tripod and heated under the middle by a Bunsen burner, answers equally well to secure every gradation of heat without danger of igniting the evaporated alcohol.

As a control upon the results obtained by weighing the residue as described, the filtrate was evaporated in a large platinum crucible, and the residue thus left gently heated and weighed. Though the evaporation be conducted with extreme care, the residue is almost sure to show some blackening, due to the carbonization of matter carried by the alcohol, which will not disappear entirely without the application of a degree of heat which the salts cannot bear without danger of volatilization. The weight of the residue from the amyl alcohol itself is small, — one portion of 50 cm.^{3} yielding 0.0003 grm. and its mate 0.0007 grm., — so that the data obtained by the evaporation of the filtered alcohol of the experiments, if not quite so trustworthy as the former testimony, may nevertheless serve the purpose of a very close control. Both sets of data are given in the following table.

* These Proceedings, Vol. XIII. p. 342.

	Weight of NaCl taken.	Total Weight of NaCl found.	Weight found in Residue.	Weight found in Solution.	Volume of residual Amyl Alcohol.
	grm.	grm.	grm.	grm.	cm.^{3}
(10)	0.1062	0.1067	0.1043	0.0024	52
(11)	0.1043	0.1047	0.1024	0.0023	46
(12)	0.1024	0.1030	0.1003	0.0027	51
(13)	0.1003	0.1008	0.0983	0.0025	45

Reducing these figures to a common level to show the action of the same amount of amyl alcohol in every case we have:—

	Loss of NaCl to 100 cm.^{3} of Amyl Alcohol.	Mean.	Weight of NaCl found in Solution in 100 cm.^{3} of Amyl Alcohol.	Mean.
	grm.	grm.	grm.	grm.
(10)	0.0037	0.0041	0.0046	0.0051
(11)	0.0041		0.0050	
(12)	0.0041		0.0053	
(13)	0.0044		0.0055	

	Weight of KCl taken.	Total Weight of KCl found.	Weight found in Residue.	Weight found in Solution.	Volume of residual Amyl Alcohol.
	grm.	grm.	grm.	grm.	cm.^{3}
(14)	0.2091	0.2093	0.2074	0.0019	35
(15)	0.2074	0.2078	0.2059	0.0019	36
(16)	0.2059	0.2059	0.2040	0.0019	32
(17)	0.2040	0.2041	0.2015	0.0026	45

Derived from these figures we have:—

	Loss of KCl to 100 cm.^{3} of Amyl Alcohol.	Mean.	Weight of KCl found in Solution in 100 cm.^{3} of Amyl Alcohol.	Mean.
	grm.	grm.	grm.	grm.
(14)	0.0049	0.0051	0.0054	0.0056
(15)	0.0041		0.0053	
(16)	0.0059		0.0059	
(17)	0.0056		0.0058	

From these figures it appears that the total weight of chloride found is always a little greater than that taken, the mean increase being 0.0005 grm. for sodium chloride, and 0.0002 grm. for potassium chloride. It appears also that the residue left by the evaporation of the decanted and filtered amyl alcohol is greater than the loss put upon the chloride by the treatment,— in the case of sodium chloride 0.0005 grm., in the mean, for every 50 cm.^{3} of amyl alcohol, which is about the quantity employed in the experiments; for potassic chloride 0.0002 grm., in the mean, for 40 $cm.^3$ of amyl alcohol, which is approximately the quantity used in that case. It will be seen, therefore, that there exists for both salts an exact coincidence between the mean total excess found and the difference between the figures which indicate the solubility of the salts for the two methods of determination; and, taking this fact in conjunction with the results of the evaporation of amyl alcohol in blank, — the mean residue being 0.0004 grm. for 40 $cm.^3$, and 0.0005 grm. for 50 $cm.^3$, — it seems to be brought out pretty clearly that the former set of figures represents more exactly the solubility of the salts, though the difference between the two series is not great. Resting, then, upon the former determinations, the solubility of sodium chloride may be taken as 0.0041 grm. in every 100 $cm.^3$ of anhydrous amyl alcohol, or one part in 30,000 parts by weight; and the solubility of potassium chloride, a little greater, is 0.0051 grm. to 100 $cm.^3$ of amyl alcohol, or one part in 24,000 by weight.

The conditions under which the salts are acted upon are such as should insure the complete saturation of the solvent, and in this connection it is interesting to note that for the quantities of material employed the discrepancy between comparable figures never exceeds 0.0005 grm.

In experiments (10), (11), and (14), (15), the alcohol was decanted and filtered at once while hot; in (12), (13), and (16), (17), it was cooled to 30° C. before decanting; so it appears that the solubility of the salts is not influenced by changes of temperature within the range from 30° C. to 132° C.

Used simply to wash the precipitate, amyl alcohol cannot, of course, exert an effect at all comparable with that manifested in the experiments which have been described, but to know just what this action may be is important. Experiments (18) to (22) were undertaken, therefore, to elucidate this point.

Weighed amounts of the test solutions were evaporated nearly to saturation in small glass beakers, amyl alcohol added, and, as in the previous experiments, the whole heated until the salt had deposited and the residual alcohol had boiled quietly for some minutes at its ordinary boiling point, the liquid decanted, filtered under gentle pressure by means of a weighed perforated crucible and felt of asbestos, the filtrate measured, the residue dislodged with the aid of a rubbing-rod and transferred to the crucible and washed with anhydrous amyl alcohol, the washings being collected and measured. The crucible and contents were dried over a free flame turned low so that the heat should not reach the melting point of the chlorides.

	Weight of NaCl taken.	Weight of NaCl found.	Weight of NaCl found, corrected for Solubility in residuol Amyl Alcohol.	Error of corrected Weight of NaCl found.	Volume of residual Amyl Alcohol.	Volume of Amyl Alcohol in Washings.
	grm.	grm.	grm.	grm.	$cm.^3$	$cm.^3$
(18)	0.0947	0.0937	0.0947	0.0000	24	44
(19)	0.1080	0.1074	0.1082	0.0002+	19	53

	Weight of KCl taken.	Weight of KCl found.	Weight of KCl found, corrected for Solubility in residual Amyl Alcohol.	Error of corrected Weight of KCl found.	Volume of residual Amyl Alcohol.	Volume of Amyl Alcohol in Washings.
	grm.	grm.	grm.	grm.	$cm.^3$	$cm.^3$
(20)	0.1846	0.1837	0.1847	0.0001+	20	60
(21)	0.1964	0.1946	0.1961	0.0003—	30	45
(22)	0.1857	0.1839	0.1854	0.0003—	30	60

These results show very plainly that the solvent effect of anhydrous amyl alcohol used for washing under the conditions described is trifling in the extreme, and may be neglected utterly providing the amount of the washing is not altogether disproportionate to the needs of the case.

We pass next to the consideration of the separation of the chlorides of sodium and potassium from lithium chloride. Weighed portions of the test solutions were concentrated and treated with amyl alcohol in the manner described until the precipitated salt was entirely free from water and the supernatant alcoholic solution of the lithium chloride boiled constantly at a point not far from that of the amyl alcohol employed. Then the liquid was cooled, a drop or two of strong hydrochloric acid added in accordance with the evident suggestion of the preliminary experiments previously mentioned, and heat again applied until the boiling had continued, as before, for some minutes at one point. The filtration, washing, drying, and weighing of the residue were effected as in experiments (18) to (22). In those of the experiments in which the lithium salt in solution was also determined, the end was accomplished by evaporating the filtrate and washings to dryness, treating the residue with sulphuric acid, and igniting and weighing as lithium sulphate. In the following table the weight of insoluble chloride actually found is given in one column, and this weight, corrected according to the data previously determined for the solubility of the chloride in the residual amyl alcohol appears in the column adjoining. So also the weight is given of the lithium sulphate actually found, and an adjacent column contains the result of correcting this weight for the accompanying sodium or potassium sulphate, or both, upon the hypothesis that these salts are neutral sulphates after the ignition. In the case of quantities so minute the error which is introduced by such an assumption cannot be considerable, and in relation to this point Dittmar * maintains that comparatively large amounts of acid sodium or potassium sulphate may be reduced to the neutral salt by ignition simply. The figures of the column showing the weights of lithium chloride found are derived by calculation from the weights of lithium sulphate actually found. The other headings of the table are sufficiently intelligible without further explanation.

	Weight of NaCl taken.	Weight of NaCl found.	Weight of NaCl found, corrected for Solubility in Amyl Alcohol.	Error in Weight of NaCl found	Error in corrected Weight of NaCl found.	Volume of Amyl Alcohol used. Residual.	Total.
	grm.	grm.	grm.	grm.	grm.	cm.^{3}	cm.^{3}
(23)	0.1089	0.1092	0.1095	0.0003+	0.0006+	7	70
(24)	0.1084	0.1085	0.1090	0.0001+	0.0006+	12	80
(25)	0.1074	0.1067	0.1074	0.0007—	0.0000	18	90

	Weight of LiCl taken.	Weight of Li_2SO_4 found.	Weight of LiCl found.	Corrected Weight of LiCl found.	Error in Weight of LiCl found.	Error in corrected Weight of LiCl found.
	grm.	grm.	grm.	grm.	grm.	grm.
(23)	0.1298	0.1682	0.1299	0.1296	0.0001+	0.0002—
(24)	0.1227	0.1592	0.1230	0.1225	0.0003+	0.0002—
(25)	0.0116	....	....	....	....	....

	Weight of KCl taken.	Weight of KCl found.	Weight of KCl found, corrected for Solubility in Amyl Alcohol.	Error in Weight of KCl found.	Error in corrected Weight of KCl found.	Volume of Amyl Alcohol used. Residual.	Total.
	grm.	grm.	grm.	grm.	grm.	cm.^{3}	cm.^{3}
(26)	0.2051	0.2036	0.2053	0.0015—	0.0002+	34	100
(27)	0.2022	0.2013	0.2032	0.0009—	0.0010+	37	100
(28)	0.2109	0.2096	0.2104	0.0013—	0.0005—	16	100
(29)	0.0984	0.0970	0.0980	0.0014—	0.0004—	20	90

	Weight of LiCl taken.	Weight of Li_2SO_4 found.	Weight of LiCl found.	Corrected Weight of LiCl found.	Error in Weight of LiCl found.	Error in corrected Weight of LiCl found.
	grm.	grm.	grm.	grm.	grm.	grm.
(26)	0.1256	0.1638	0.1265	0.1248	0.0009+	0.0008—
(27)	0.1287	0.1677	0.1296	0.1277	0.0009+	0.0010—
(28)	0.0113	....	....	....	....	....
(29)	0.0113	....	....	....	....	....

* Report on Researches into the Composition of Ocean Water, collected by H. M. S. Challenger during the Years 1873–1876, p. 18.

	Weight of NaCl taken.	Weight of KCl taken.	Weight of NaCl + KCl found.	Corrected Weight of NaCl + KCl found.	Volume of Amyl Alcohol used. Residual.	Total.
	grm.	grm.	grm.	grm.	cm.³	cm.³
(30)	0.1053	0.1031	0.2064	0.2084	22	100
(31)	0.1051	0.0945	0.1988	0.2003	16	80

	Weight of LiCl taken.	Error in Weight of NaCl + KCl found.	Error in corrected Weight of NaCl + KCl found.
	grm.	grm.	grm.
(30)	0.0113	0.0020—	0.0000
(31)	0.0113	0.0008—	0.0007+

It will be noticed that in experiments (23), (24), (26), and (27), the corrected error in the weight of the insoluble chloride has a positive value ranging from 0.0002+ grm. to 0.0010+ grm. with a mean of 0.0006+ grm.; and that in experiments (25), (28), (29), (30), and (31), the mean error is negative, amounting to less than 0.0001— grm., with a range from 0.0005— grm. to 0.0007+ grm.

The point of difference between these two series of experiments is the amount of lithium chloride introduced, only a tenth of that used in the former being employed in the latter. It is plain that, when we are dealing with the larger amount, a larger portion tends to remain behind with the insoluble chloride; and here again we meet, though to a degree comparatively harmless, the inclination of lithium chloride to yield chlorine and pass to the form of lithium hydrate. When the lithium chloride is present in small amount, as in the latter group of experiments, there can be little left undissolved; and the spectroscope confirms the evidence of the figures of analysis as to the perfectness of the separation, by showing in such cases either no lithium at all or merely fugitive traces. If a single precipitation is sufficient to effect a satisfactory separation of the insoluble chlorides from small amounts of lithium chloride, it is natural to suppo e that a repetition of the precipitation would be beneficial in treating larger quantities of lithium chloride. Experiments (32) to (37) illustrate the effect of a double precipitation. The chlorides were brought to filtration as before, the liquid was decanted as completely as possible, the precipitate washed slightly by decantation and redissolved in a little water, and the round of boiling, filtering, drying, and weighing carried to the end as before, care being taken to repeat the treatment with a drop of hydrochloric acid during the process of boiling. The two portions of residual amyl alcohol were measured apart, as well as the washings.

	Weight of NaCl token.	Weight of NaCl found.	Corrected Weight of NaCl found.	Error in Weight of NaCl found.	Error in corrected Weight of NaCl found.	Volume of Amyl Alcohol used. Residual. I.	II.	Total.
	grm.	grm.	grm.	grm.	grm.	cm.^{3}	cm.^{3}	cm.^{3}
(32)	0.1166	0.1163	0.1169	0.0003—	0.0003+	8	8	150
(33)	0.1139	0.1127	0.1132	0.0012—	0.0007—	5	7	150

	Weight of LiCl taken.	Weight of Li_2SO_4 found.	Weight of LiCl found.	Corrected Weight of LiCl found.	Error in Weight of LiCl found.	Error in corrected Weight of LiCl found.
	grm.	grm.	grm.	grm.	grm.	grm.
(32)	0.1287	0.1662	0.1284	0.1280	0.0003—	0.0007—
(33)	0.1347	0.1759	0.1359	0.1353	0.0012+	0.0006+

	Weight of KCl taken.	Weight of KCl found.	Corrected Weight of KCl found.	Error in Weight of KCl found.	Error in corrected Weight of KCl found.	Volume of Amyl Alcohol used. Residual. I.	II.	Total.
	grm.	grm.	grm.	grm.	grm.	cm.^{3}	cm.^{3}	cm.^{3}
(34)	0.1155	0.1142	0.1152	0.0013—	0.0003—	10	10	100
(35)	0.1034	0.1017	0.1028	0.0017—	0.0007—	10	12	200
(36)	0.1914	0.1905	0.1912	0.0009—	0.0002—	3	11	90
(37)	0.1953	0.1939	0.1950	0.0014—	0.0003—	4	18	110

	Weight of LiCl taken.	Weight of Li_2SO_4 found.	Weight of LiCl found.	Corrected Weight of LiCl found.	Error in Weight of LiCl found.	Error in corrected Weight of LiCl found.
	grm.	grm.	grm.	grm.	grm.	grm.
(34)	0.1125	0.1475	0.1139	0.1128	0.0014+	0.0003+
(35)	0.1251	0.1649	0.1274	0.1162	0.0023+	0.0011+
(36)	0.1263	....	....	....	....	....
(37)	0.1282	....	....	....	....	....

Thus it appears that, in the separation of the insoluble chlorides from the larger amounts of lithium chloride, the residue of two precipitations is substantially free from lithium.

For the sake of bringing the data in hand more directly into comparison, the corrected errors of the preceding determinations are tabulated again in the following statement.

No. Exp.	Chloride.	Corrected Error of Insoluble Chloride: precipitated *once* from about 0.13 grm. of LiCl.	precipitated *once* from about 0.013 grm. of LiCl.	precipitated *twice* from about 0.13 grm. of LiCl.	Error in corrected Weight of LiCl.	Approximate Mean Error of LiCl.
		grm.	grm.	grm.	grm.	grm.
(23)	NaCl	0.0006+	....	....	0.0002—	0.0005—
(24)	"	0.0006+	....	....	0.0002—	
(26)	KCl	0.0002+	....	....	0.0008—	
(27)	"	0.0010+	....	....	0.0010—	
(25)	NaCl	....	0.0000	....	....	
(28)	KCl	....	0.0005—	....	....	
(29)	"	....	0.0004—	....	....	
(30)	NaCl+KCl	....	0.0000	....	....	
(31)	" "	....	0.0007+	....	....	
(32)	NaCl	....	....	0.0003+	0.0007—	0.0003+
(33)	"	....	....	0.0007—	0.0006+	
(34)	KCl	....	....	0.0003—	0.0003+	
(35)	"	....	....	0.0007—	0.0011+	
(36)	"	....	....	0.0002—	....	
(37)	"	....	....	0.0003—	....	
	Approx. mean,	0.0006+	0.00004—	0.0003—		

Few processes in analytical chemistry are capable of yielding results more exact than these. The separation of from 0.1 grm. to 0.2 grm. of sodium or potassium chloride from a tenth of its own weight of lithium chloride is practically perfect in one operation, and from its own weight of lithium chloride the parting may be effected satisfactorily by two precipitations.

The points to be observed in executing the method may be recapitulated as follows:—

To the concentrated solution of the chlorides, amyl alcohol is added and heat is applied, gently at first to avoid danger of bumping, until, the water disappearing from solution and the point of ebullition rising and becoming constant for some minutes at a temperature which is approximately that at which the alcohol boils by itself, the chlorides of sodium and potassium are deposited and lithium chloride is dehydrated and taken into solution. At this stage in the operation the liquid is cooled and a drop or two of strong hydrochloric acid added to reconvert traces of lithium hydrate in the deposit, and the boiling continued until the alcohol is again free from water. If the amount of lithium chloride present is small it will now be found in solution, and the chlorides of sodium and potassium will be in the residue, excepting the traces, for which correction will be made subsequently. If, however, the weight of lithium chloride present exceeds ten or twenty milligrams, it is advisable at this point, though not absolutely essential to the attainment of fairly correct results, to decant the liquid from the residue, wash the latter a little with anhydrous amyl alcohol, dissolve in a few drops of water, and repeat the separation by boiling again in amyl alcohol. For washing, amyl alcohol previously dehydrated by boiling is to be used, and the filtrates are to be measured apart from the washings. In filtering it is best to make use of the perforated crucible and asbestos felt, and apply gentle pressure. The crucible and residue are ready for the balance after drying for a few minutes directly over a flame turned low. The weight of insoluble chlorides actually obtained in this manner is to be corrected by the addition of 0.00041 grm. for every 10 $cm.^3$ of amyl alcohol in the filtrate exclusive of washings if the insoluble salt is entirely sodium chloride, 0.00051 grm. for every 10 $cm.^3$ if potassium chloride constitutes the residue, and if both sodium and potassium chloride are present, 0.00092 grm.; but, as in the experiments described, the entire correction may in any case be kept within narrow limits, if due care be given to the reduction of the volume of residual alcohol before filtration. The filtrate and washings are evaporated to dryness, treated with sulphuric acid, the excess of the latter driven off, and the residue ignited to fusion and weighed. From the weight thus found the subtraction of 0.00050 grm. is to be made if sodium chloride constitutes the precipitate, 0.00059 grm. if potassium chloride alone is present in the residue, and 0.00109 if both of these chlorides are present, for every 10 $cm.^3$ of filtrate exclusive of washings.

Amyl alcohol is not costly, the manipulations of the process are easy, and the only objectionable feature — the development of the fumes of amyl alcohol — is one which is insignificant when good ventilation is available.

The process has been used for some months frequently and successfully, by others as well as myself, for the estimation of lithium in waters and minerals.

In this connection it seems best to include the record of certain experiments looking to the separation of the chlorides of sodium and potassium from the chlorides of magnesium and calcium. The behavior of magnesium chloride toward amyl alcohol is of interest, both with reference to the problem of separating sodium and potassium from lithium and magnesium when the latter are associated, and as concerns the parting of the alkalies from magnesium alone, — a matter which is by no means perfectly simple, — and experiments (38) to (41) touch upon this topic.

The chlorides of sodium and potassium were weighed, as before, in solution; the magnesium chloride was obtained by dissolving in hydrochloric acid the oxide specially prepared and weighed as such. The process of treatment was identical with that just described for the separation of the chlorides of potassium and sodium from lithium chloride.

	Weight of NaCl taken.	Weight of KCl taken.	Weight of NaCl + KCl found.	Corrected Weight of NaCl + KCl found.	Volume of Amyl Alcohol used. Residual. I.	II.	Total.
	grm.	grm.	grm.	grm.	cm.³	cm.³	cm.³
(38)	0.1030	0.1064	0.2079	0.2100	23	..	120
(39)	0.0967	0.1024	0.1976	0.2006	33	..	100
(40)	0.1030	0.1073	0.2071	0.2093	13	11	100
(41)	0.1053	0.1093	0.2114	0.2142	12	18	100

	Weight of MgO taken.	Error in Weight of NaCl + KCl found.	Error in corrected Weight of NaCl + KCl found.
	grm.	grm.	grm.
(38)	0.1000	0.0015—	0.0006+
(39)	0.1000	0.0015—	0.0015+
(40)	0.1000	0.0032—	0.0010—
(41)	0.1000	0.0032—	0.0004—

The residues of experiments (38) and (39), in which the separation was made by a single precipitation, carried traces of magnesia; those of (40) and (41), in which two precipitations were introduced, were found to contain in the one case no magnesia, and in the other an unweighable trace. These results point out a method by which the chlorides of sodium and potassium may be obtained free from magnesia, while the small amounts of the former which pass into solution with the magnesium chloride are capable of accurate estimation; and there seems to be no reason why the separation of these alkaline chlorides from magnesium chloride and lithium chloride occurring together should not be effected in one operation, and the parting of the latter salts brought about by the familiar method of precipitating the magnesia in the cold as ammonium-magnesium phosphate.

Experiments (42) to (48), upon the separation of sodium and potassium from calcium by the action of amyl alcohol on the chlorides, yielded the figures of the following table. The mode of treatment was identical with that of the experiments with magnesia, just described, excepting only the substitution of pure calcium oxide, specially prepared. for magnesium oxide.

	Weight of NaCl taken.	Weight of KCl taken.	Weight of NaCl + KCl found.	Corrected Weight of NaCl + KCl found.	Volume of Amyl Alcohol used. Residual. I.	II.	Total.
	grm.	grm.	grm.	grm.	cm.³	cm³	cm.³
(42)	0.0859	0.1126	0.2177	0.2195	20	. .	100
(43)	0.1018	0.1057	0.2217	0.2235	20	. .	100
(44)	0.1096	0.0962	0.2112	0.2130	20	. .	100
(45)	0.0985	0.1018	0.2113	0.2130	19	. .	100
(46)	0.0914	0.1104	0.1968	0.2000	20	15	100
(47)	0.0997	0.1100	0.2080	0.2089	3	7	90

	Weight of CaO taken.	Error in Weight of NaCl + KCl found.	Error in corrected Weight of NaCl + KCl found
	grm.	grm.	grm.
(42)	0.1000	0.0192+	0.0210+
(43)	0.1000	0.0142+	0.0160+
(44)	0.1000	0.0054+	0.0072+
(45)	0.1000	0.0110+	0.0127+
(46)	0.1000	0.0050—	0.0018—
(47)	0.1000	0.0017—	0.0008—

From these results it is plain that it is a far more difficult matter to dehydrate and dissolve calcium chloride than either magnesium chloride or lithium chloride. The separation of the chlorides of sodium and potassium from calcium chloride cannot be accomplished, for the quantities employed in these experiments, by a single precipitation; but the repetition of the treatment is effective. In the residues of experiments (46) and (47) calcium could not be found by the test with ammonium oxalate. In a case, therefore, in which the separation of sodium and potassium from lithium, magnesium, and calcium in one operation should be desirable, the end may probably be accomplished by means of the process here described.

Certain preliminary experiments with the nitrates of the bases under discussion indicate that these are susceptible of similar separation by the action of amyl alcohol; and the wide applicability in analytical operations of the general principle involved, — the dehydrating of salts by means of amyl alcohol or other liquid of high boiling-point and appropriate solvent action, — can scarcely be a matter of doubt.

VII.

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF THE MUSEUM OF HARVARD UNIVERSITY.*

V. — ON THE ANATOMY AND DEVELOPMENT OF AGARUM TURNERI, Post. & Rupr.

By James Ellis Humphrey.

Presented June 16, 1886.

The family of Laminariaceæ includes several genera of large, coarse marine algæ of an olive-brown color and leathery substance. In most of these, the thallus shows a distinct differentiation into stipe and lamina, and is attached to the substratum by branched, root-like processes, or rhizoids. This family contains forms which are the largest of Thallophytes, and indeed among the largest of plants.

Not to mention several contributions by earlier writers on the Algæ, three papers have recently been published which deal with the anatomy of Laminariaceæ, all by German writers and including observations on four genera. Reinke has described the anatomy of *Laminaria saccharina*, *L. digitata*, and *Alaria esculenta ;* † Will, that of *Macrocystis luxurians ;* ‡ and Grabendörfer, that of *Lessonia ovata.*§

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* The studies whose results are here recorded were carried on in the Cryptogamic Laboratory of Harvard University, under the direction of Dr. W. G. Farlow.

The following are the titles of the preceding papers of this series: —

1. Notes on some Species in the Third and Eleventh Centuries of Ellis's North American Fungi. Proc. Am. Acad., XVIII. 65–85.

2. The Cryptogamic Flora of the White Mountains. Appalachia, III. 232–251.

3. Notes on some Species of Gymnosporangium and Chrysomyxa of the United States. Proc. Am. Acad., XX. 311–323.

4. Notes on Arctic Algæ; based principally on Collections made at Ungava Bay by Mr. L. M. Turner. Proc. Am. Acad., XXI. 469–477.

† Beiträge zur Kentniss der Tange, — Pringsheim's Jahrbücher für wiss. Botanik, Bd. X. p. 371, 1876.

‡ Zur Anatomie von Macrocystis luxurians, — Botanische Zeitung, 42 Jahrgang, p. 801, 1884.

§ Beiträge zur Kentniss der Tange, — Bot. Zeit., 43 Jahrgang, p. 641, 1885.

These papers show that there is a great uniformity in the character and arrangement of the tissues composing the thallus in the different genera.

The adult stipe of the Laminariaceæ may be said, in general, to be composed of four forms of tissue. At the centre is a bundle of twisted and intertangled hypha-like filaments, among which are scattered long trumpet-shaped or funnel-formed cells, placed by twos with their large ends together. Will describes in detail a zone of tissue, composed of sieve-tubes with very abundant sieve-plates, which surrounds this core in the adult stipe of Macrocystis. Outside of the central filamentous tissue, or *medulla*, is a layer of elongated cylindrical cells, whose side walls are very much thickened and abundantly marked with pits, their intercellular spaces being filled by a slimy substance. In Macrocystis and Lessonia, this layer, which may be termed the *inner cortex*, is sharply defined against the medulla; but in Laminaria the medullary filaments penetrate its inner cell-rows, and cause a blending of the two tissues, so that no clear line of demarcation can be fixed between them. Next without the inner cortex are rows of thin-walled cells, more angular than the last in form. These compose a tissue called the *outer cortex*. They become smaller toward the surface of the stipe, and pass gradually into the single superficial layer of cells which forms the *epidermis*. This latter layer consists of small cells whose exposed outer walls are rounded and much thickened, and which contain the olive-brown pigment characteristic of this group of Algæ. The cells of both outer cortex and epidermis are traversed by very delicate partitions, both parallel and oblique to their walls. In Alaria, the cortical tissue seems not to be distinguishable into outer and inner layers.

The lamina is, anatomically as well as morphologically, a terminal expansion of the stipe, and shows the same tissues as the latter, but in quite different proportions. The medulla resembles that of the stipe, but the trumpet-shaped cells seen in the latter are not present. The cell-walls of the inner cortex are thinner than in the stipe, and contain no pits. The outer cortex forms but a small part of the thickness of the blade, and consists of small, thin-walled cells passing into an epidermal layer, as in the stipe. In Alaria, the stipe is prolonged into the lamina as a midrib, whose anatomy is that of the stipe itself.

The rhizoids consist of a mass of cells somewhat thick-walled at the centre, and decreasing in size and thickness of wall toward the surface, the outer layer forming an epidermis. No trace of medulla is present. At their points of contact with the substratum, the exposed cell-walls become very much, and often irregularly, thickened.

Each of the papers above quoted contributes something in regard to the growth or development of the species treated, and reference may be had to them for full details. It seems well established that the seat of growth in length is the point of union of stipe and lamina, where growth takes place either periodically or constantly. How the stipe grows in thickness seems as yet hardly clear. Reinke describes a "meristem cylinder" composed of the inner cells of the outer cortex in Laminaria, to which he ascribes a function similar to that of the cambium of Dicotyledons. And Will describes a peculiar layer immediately outside of the medullary tissue in the young stipe of Macrocystis, which serves as the source of increase of the medulla; this ring disappears in the adult stipe. The cells of the epidermis increase by the formation of walls at right angles to the surface, thus keeping pace with growth in thickness, as well as in length.

The differentiation of the frond into stipe and lamina is evident from a very early stage. When quite young, the stipe consists of a cortex and a few thick-walled axial cells, from which the medullary filaments develop later, as outgrowths. At a corresponding stage the lamina consists of two large-celled layers and epidermis, although an earlier condition is known in which it is but a single cell thick. The lamina is annually renewed from the region of growth, and Reinke considers it probable that not much change occurs in the structure of a given lamina, but that the successive steps in the development of the complex adult frond from the comparatively simple young condition are accomplished by an increase in complexity of structure in successively formed fronds, until the adult type is reached.

Agarum Turneri.

Agarum Turneri, the so-called Sea Colander, is one of the Laminariaceæ, having a cylindrical stipe 10 to 30 cm. in length, which becomes flat toward its upper end and finally expands into a broad lamina of an ovate or oblong shape, with a strongly cordate base and crisped margin. Through the middle of the lamina passes a broad, flat continuation of the stipe, the midrib. The lamina is abundantly perforated by holes of considerable size, which will be treated in detail later. The stipe splits up, at its base, into numerous branching rhizoids, by which the plant is attached to the substratum. The whole plant often reaches a meter in length. This alga is an inhabitant of the Arctic Ocean, and extends southward on the western shore of the Atlantic to Boston, and in the Pacific to California and Japan; being, like other Laminariaceæ, a lover of cold waters. At Eastport, Maine, it occurs at low-water mark, but south of that point it grows in deep water, from which it is frequently washed ashore.

At the suggestion of Dr. W. G. Farlow, these investigations have been undertaken with the purpose of learning the anatomy of the adult and of the young frond, and the mode of formation of the perforations of the lamina, in *Agarum Turneri*. The material used has been alcoholic, and has consisted of young fronds collected at Eastport in September, 1877, by Dr. Farlow, and of adult plants obtained at Marblehead, Mass., in November, 1885, by myself.

1. *Adult Anatomy.*

The stipe of the adult frond does not differ in its structure from the general type of the Laminariaceæ. The medulla and inner cortex together compose about one third of the whole diameter of the stipe at its base, but gradually enlarge so that, at the upper end, they form one half of its diameter. The component threads of the medulla are rather loosely matted together, and have many rounded cells scattered among them. These threads penetrate the innermost layers of the inner cortex quite freely, causing a gradual passage from one tissue to another, as in Laminaria. The cylindrical cells of the inner cortex average from three to four times as long as broad. Their side walls are much thickened and pitted, while their end walls are thin. The outer layers belonging to this tissue consist of smaller cells than the rest, and are clearly distinguishable from the inner rows of the outer cortex, which lie next to them. These latter form a darker and more refractive layer of cells, since they are very rich in protoplasm. The cells of the outer cortex become smaller and thinner-walled toward the surface, and their superficial layer is modified to form an epidermis. The epidermal cells have their exposed ends rounded and much thickened, and contain the characteristic olive-brown pigment. As in Laminaria, the cells of the whole outer cortex are crossed by very delicate parallel and oblique walls. The epidermis and cells immediately below present all the appearances of growing tissues.

The midrib continues the tissues of the stipe, but the ratios between the different tissues vary markedly from those in the stipe. The outer cortex, inner cortex, and medulla occupy about one, five, and two eighths, respectively, of the radius of the midrib. That is, the increase in proportion of the inner cortex, observed in passing upward from the base of the stipe, continues rapidly into the midrib, until the outer cortex is reduced to a very thin tissue. The outer cortex consists of a few layers of thin-walled cells arranged in rows perpendicular to the surface, the exposed outer layer being modified to form an epidermis. The inner cortex forms an abrupt change from the last, consisting of rounded cells with walls not so thick as in the corresponding cells of the stipe, and without pits, but much thicker than those of the outer cortex. The outer cells of this tissue are somewhat smaller than the rest. The medulla is identical in character with that of the stipe, and its filaments penetrate the inner cortex.

The passage from midrib to lamina is rather gradual, and the latter becomes thinner towards its edge. In the lamina, the distinction between outer and inner cortex is lost, and the whole cortical tissue consists of thin-walled cells. The inner layers are rather large-celled, but the outer cells are smaller, while those of the epidermal layer are quite small and have their outer walls thickened. (Fig. 7.) At the margin, where the frond is quite thin, the cortex is reduced to a very few cell-layers. The medulla becomes gradually thinner toward the margin of the lamina, where it consists of a few fine filaments fused into an indistinct mass. The rhizoids originate from the end and lower portion of the stipe, branching freely and irregularly, and often are considerably expanded at the ends which come in contact with and attach the plant to the substratum. Their tissue is a direct continuation of the outer cortex of the stipe, and is similar to it except in being rather smaller-celled. The outer cell-layer forms an epidermis, and the layer which comes into immediate contact with the substratum has its exposed walls thickened very strongly, and often irregularly, so that it not infrequently happens that the cavity of a cell is nearly or even wholly obliterated by the thickening of its wall.

2. *Growth.*

The cambium-like layer described by Reinke for Laminaria has also been mentioned as occurring in Agarum, but there appears to be another region of growth in the latter genus, which includes the epidermis and cell-layers immediately underlying it to the number of two or three. I believe that growth in thickness takes place in these two regions, each meristem adding, by its activity, to the tissue lying within it.

As in Laminaria, the epidermis follows growth in thickness by the increase of its cells through the formation of radially perpendicular walls.

The lamina of Agarum has never been observed to present any evidences of periodic renewal so plainly shown among the species of Laminaria, especially the digitate forms, during the spring months, although it has been collected in great quantities at all seasons on the coast of Massachusetts. This fact and the presence at all seasons of abundantly forming perforations, and only these in the basal part of the lamina, make it quite certain that the growth is continuous.

Even in very young fronds, the exact tip is not known. Many fronds, when very young, are markedly attenuated at the upper end, but none has been found with the actual tip still present. In any but a very early stage, the attenuate character of the upper end is lost and the lamina is ragged and water-worn at its apex.

3. *Anatomy of Young Frond.*

The specimens of the young frond of *Agarum Turneri* which have been at my disposal are as small as any known, but none is sufficiently young to show the one-layered condition of the blade known in Laminaria, if it exists in this species. A young frond of 3 cm. long has a stipe 4 or 5 mm. in length and not over .5 mm. in diameter, with several branched rhizoids at its base. The lamina is oblong in shape, about a centimeter broad and of the thickness of very thin writing-paper, with the margin slightly crisped or wholly flat. Through the middle of the lamina the midrib appears as a rather broad flat band, of about twice the thickness of the lamina and of a firmer texture. (Fig. 1.) Such a frond, while much simpler than in the adult condition, includes all the tissues of the latter except the medulla.

The stipe has an outer cortex composed of radial rows of rather thin-walled cells, the whole of which is deeply colored by the olive-brown pigment. This tissue is covered on its surface by a homogeneous cuticula, in consequence of which the exposed ends of the outer cells, while markedly rounded, are not thickened. The rest of the stipe, composing about two thirds of its diameter, consists of elongated cells closely resembling those of the inner cortex of the adult, but with somewhat less thickened walls. (Fig. 2.) No medullary threads are present at this stage, but a little later, when the perforations of the lamina begin to appear, they may be seen arising as outgrowths from the axial cells of the stipe. The structure of the midrib agrees completely with that of the stipe. A comparison of the two with the adult shows that the midrib undergoes the less change of structure, remaining always more primitive in condition. The lamina of such a frond as we are considering consists of two or three rows of large, squarish, thin-walled cells, covered by epidermal layers of much smaller cubical cells, containing the brown pigment. (Fig. 3.)

About simultaneously with the appearance of medullary threads in the stipe, they are seen between the large-celled layers at the base of the lamina, and gradually push out towards its edge as the plant grows older. The lamina does not further increase in complication of structure for a considerable time.

4. *Perforations of the Lamina.*

The very young lamina of *Agarum Turneri* is quite imperforate for a time, but when a length of 3 to 4 cm. is attained, the perforations, afterward so characteristic, begin to be formed in all parts of the frond. They continue to be developed during the life of the plant, especially at the base of the lamina and near its middle along the midrib, but also wherever growth has produced a considerable unperforated space. Any large frond will furnish an abundance of perforations in all stages of development. (Figs. 4 and 5.) The rarity of the occurrence of such holes among plants and the evident definiteness of their development give to their study much interest and importance.

The first indication of the formation of a hole is the appearance, on either of the faces of the lamina, of a small, conical, papilla-like elevation, with a corresponding depression on the opposite surface. (Fig. 5, *a*.) This papilla continues to push up until a rupture occurs at its tip (Fig. 5, *b*), and a small opening, like a pin-hole, is made through the lamina (Fig. 5, *c*). If a piece of a lamina with papillæ in various stages of development be held to the light, the tips of the papillæ will be seen to be translucent, and those most so which are nearest the rupturing point. This shows that there is a gradual decrease in the thickness of the tissue at the tip of a papilla, from the time of its beginning until the rupture takes place. The hole now increases in size with the growth of the frond (Fig. 5, *d*), and may reach 2 cm. in greatest diameter and become very irregular in shape, though usually of a broadly elliptical form. It retains for a long time the character of a perforation of the lamina with a raised margin when viewed from one surface, or a depressed one when viewed from the other face of the lamina.

The microscopic study of the details of the development of the perforations has required only sufficiently thin sections of their various stages. Free-hand cutting wholly failed to give these. A piece taken from the base of a lamina, and containing several early stages in the development of perforations, was then imbedded in paraffine and cut into very thin sections by means of the microtome. The sections were then mounted in balsam, according to the usual method for thin sections of animal tissues. Although this seems a hard treatment for an algal tissue, the tough, leathery character of the frond enabled it to withstand well, and very satisfactory results were obtained.

Sections prepared in this way show that a perforation originates as a depression of the epidermis of either of the surfaces of the lamina. (Fig. 6, *a*.) This depression is formed by a rapid multiplication of the cells of the epidermis in that region and the incurving of the layer in consequence of its increased length. (Fig. 7.) After the inward bending has begun, the continued growth of the epidermis causes it to press deeper and deeper into the underlying tissue, which is compressed and pushed aside, until the medulla is reached. (Fig. 6, *b*.) The depression has, at this stage, the form of a basin with sloping sides and a nearly flat bottom, lined by the unbroken epidermal layer. The bottom of this depression lies against the medullary tissue, while its sides are in contact with the compressed cortex and form angles with the medulla.

Further growth appears to take place only in that portion of the epidermis which forms the sides of the depression, and has two effects. Since the bottom of the depression remains passive while the sides are tending to push on into the medulla, the former is stretched with increasing force until a rupture occurs near its middle; this whole bottom layer of epidermis now dies and falls away, leaving the sides unrestrained. Under the influence of their rapid growth, the latter press into the medulla like a circular punch, cutting out that part of the medulla formerly in contact with the bottom of the epidermal depression. (Figs. 6, *c*, and 8.) Meanwhile, that part of the cortex of the other surface of the lamina which corresponds in position to these lost tissues has begun to show a changed appearance. Although not directly affected by the growth of the depression just described, it becomes dark and shrivelled in appearance (Fig. 8), and soon breaks away from the living cortical tissue surrounding it, escaping into the water as a small block of dead and collapsed cells. (Fig. 6, *d*.)

In this way the perforation of the lamina is completed, and we have a small hole, not usually exceeding .5 mm. in diameter, formed partly by the pushing aside, and partly by the death and breaking away of the tissues which formerly occupied its place.

Where the tissues have been pushed aside by the ingrowing epidermis, they remain covered by it, but where a part of the tissue has died and fallen away, as in case of the cortex of one surface, that part which becomes thus exposed is not at first protected. But very soon the exposed living cells of the cortex begin to thicken their outer walls and to acquire the characteristic brown color of epidermal cells. Finally they become completely indistinguishable from and continuous with the cells of the original epidermal layers of the two surfaces of the lamina. (Figs. 6, *e*, and 9.) In this we have distinct evidence that the epidermis consists simply of modified cortical cells, and that any cortical cells may become epidermal in character, if exposed to external influences.

Further changes in the perforations affect their size only, which increases with the growth of the lamina.

The results of the investigations detailed above may be summarized as follows: —

1. The structure of the adult frond of *Agarum Turneri* agrees closely with that of other Laminariaceæ, and especially with that of Laminaria.

2. The frond of Agarum grows in length at the union of stipe and lamina, as in other Laminariaceæ; growth in thickness probably takes place in two regions.

3. The structure of the young frond is much simpler than that of the adult, but its relations to the latter are clearly traceable.

4. The perforations of the lamina are formed by the simultaneous occurrence of an indentation of one surface and the death of the corresponding part of the opposite surface.

These results will serve at least to call up still unanswered questions, many of which require for their satisfactory solution access to abundant growing material in all stages. For a student who can command these desiderata, the work to be done on the Laminariaceæ is as interesting and important as the many unanswered questions connected with the study of other groups of marine algæ.

EXPLANATION OF PLATES.

Fig. 1. Young frond of *Agarum Turneri* about 3 cm. in length. × $\frac{5}{2}$.

Fig. 2. Transverse section of stipe of a frond like Figure 1. *cut.* Cuticula. *o. c.* Outer cortex. *i. c.* Inner cortex. × 175.

Fig. 3. Transverse section of lamina of a similar frond. *e.* Epidermis. *c.* Cortex. × 175.

Fig. 4. Part of adult lamina, showing perforations in various stages. × $\frac{1}{2}$.

Fig. 5. Section across basal part of lamina, showing various stages in formation of perforations. *a, b, c, d.* Successive stages. *f.* Plane of lamina. × 2.

Fig. 6. Diagrammatic view of five successive stages, *a, b, c, d, e,* in the development of a perforation. *c′.* Cortex. *m.* Medulla.

Fig. 7. Detailed figure of an early stage (Fig. 6, *a*) of a perforation. *e.* Epidermis. *c.* Cortex. *m.* Medulla. *x.* Apex of depression. × 175.

Fig. 8. Detailed figure of a later stage (Fig. 6, *c*). *e, c, m,* as in Figure 7. *x.* Medullary tissue cut out by growth of epidermis. *y.* Fragment of cortical tissue cut out. *z.* Cortex of upper surface beginning to shrivel. × 175.

Fig. 9. Detailed figure of section through a completed perforation (Fig. 6, *e*). *e, c, m,* as in Figure 7, the right-hand portion being represented in outline only. *v.* Remnants of dead cortical cells. × 175.

PL. I.

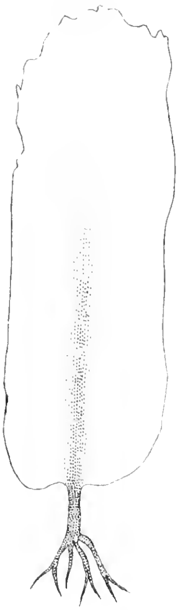


Fig. 1.

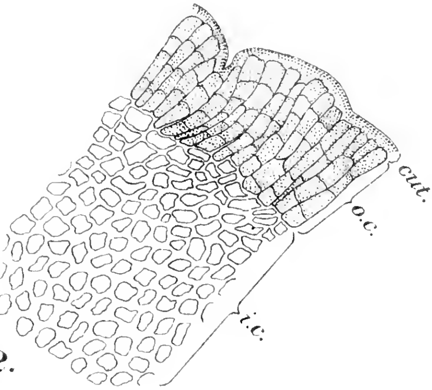
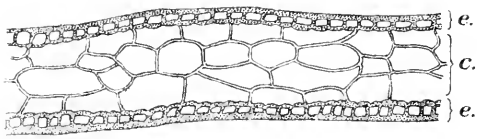


Fig. 2.



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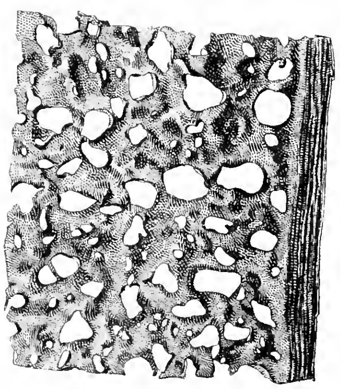

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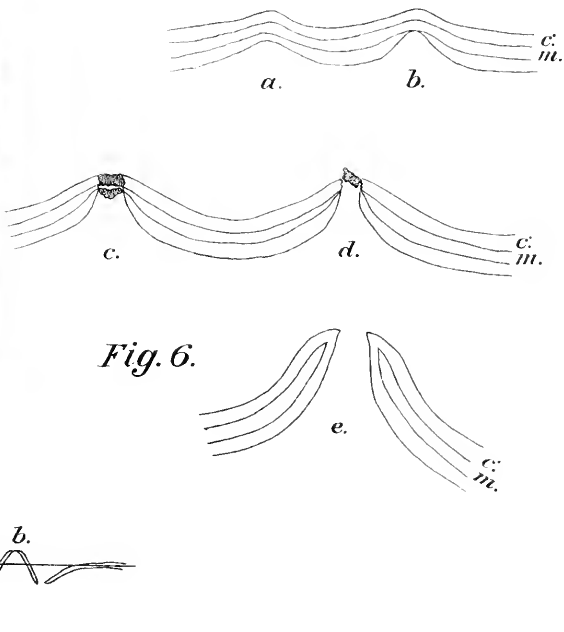

Fig. 6.

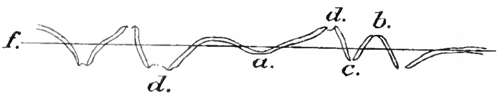

Fig. 5.

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DEVELOPMENT OF AGARUM.

PL. II.

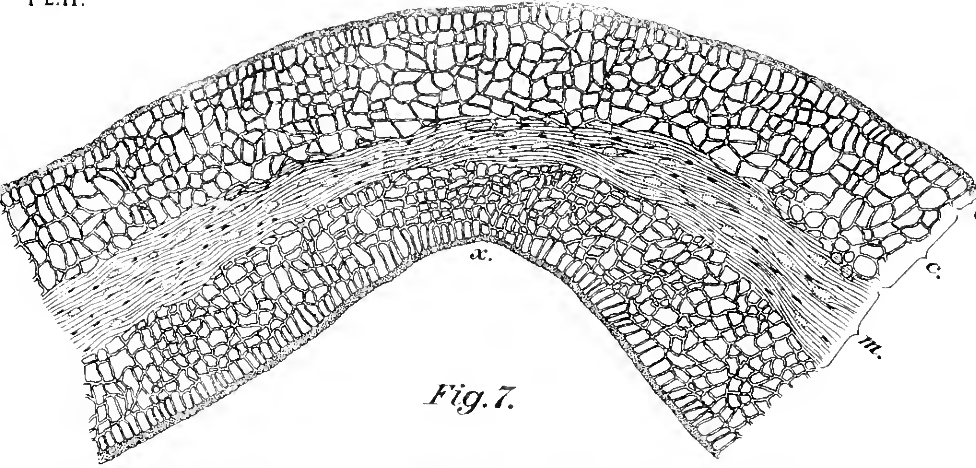


Fig. 7.

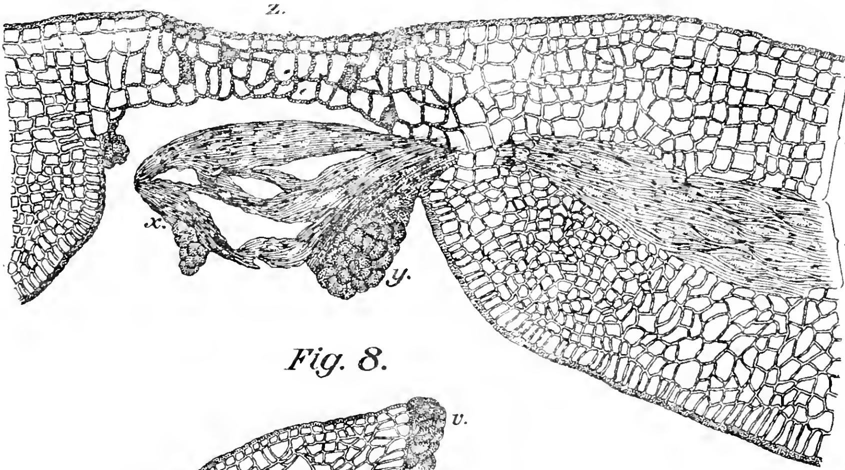
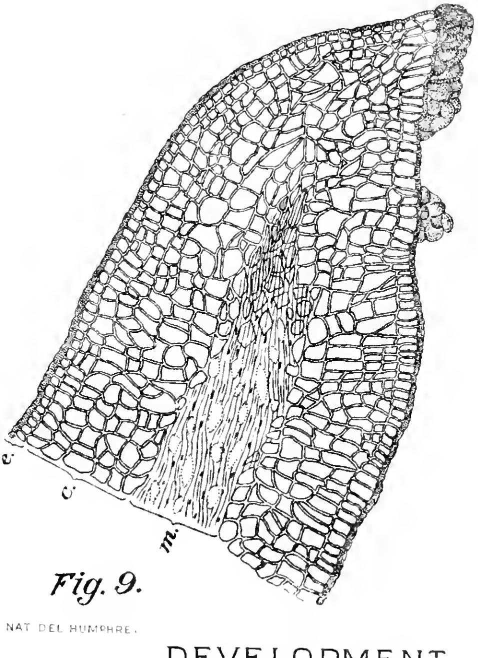


Fig. 8.



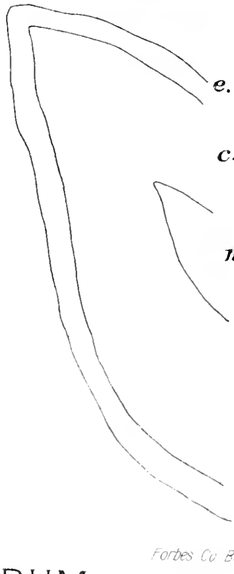


Fig. 9.

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DEVELOPMENT OF AGARUM.

VIII.

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF THE MUSEUM OF HARVARD UNIVERSITY.

VI. — ON THE MORPHOLOGY OF RAVENELIA GLANDULÆFORMIS.

By G. H. Parker.

Presented June 16, 1886.

At the suggestion of Dr. W. G. Farlow, in the fall of 1885, the writer commenced some investigations upon the leaf fungus known as *Ravenelia glandulæformis*, Berk. and Curt., and through the kindness of Mr. H. W. Ravenel an abundance of carefully selected material was placed at his disposal. This consisted of the dried leaves of the host plant, *Tephrosia virginiana*, Pers., which had been collected in 1879 at Aiken, S. C., by Mr. Ravenel, with the especial object of securing a series of the principal stages in the development of the fungus.

As may be seen from the literature of *Ravenelia*, our knowledge of this fungus is as yet incomplete, and questions of morphological interest concerning it are still unsettled. The object of this paper is to deal with one of these questions, namely, the morphology of the teleutosporic stage.

The young leaflets of *Tephrosia* show numerous dingy orange-colored spots scattered over both their upper and lower surfaces. These spots as a rule are more frequently met with below than above. On closer examination each spot is seen to consist of from one to several roundish or elongate swellings in the epidermis of the leaflet, the individual swellings often being ruptured above, and showing a cavity entering the tissue of the leaf. Usually, large clusters of such swellings on the lower surface of the leaflet are accompanied by several corresponding swellings on the upper surface, and almost invariably where swellings thus occur both above and below, the lower group is much the larger.

A transverse section of a leaflet in the region where the swellings occur shows a cavity in the leaf tissue below each swelling. This cavity arises from a separation of the epidermis and the leaf parenchyma at their plane of union. The epidermis bows up, producing the appearance of the swellings previously described, and the leaf parenchyma, instead of following the epidermis in its upward folding, tears away from it, and remains unaltered in position, or by shrivelling slightly sinks downward away from the epidermis, and thus increases the intervening space. The cavity, since it has considerable lateral extension compared with its depth, is quite shallow. The leaf parenchyma forming its floor is penetrated in all directions by the mycelium of the fungus; this mycelium on approaching the lower surface of the cavity gives rise to a great number of upward-growing filaments, which project into the cavity itself and form a sort of hymenium. On the free ends of many of these filaments the yellowish uredospores are born. These spores, after ripening, generally escape through the crater-like opening in the epidermis above; but often before they have completely disappeared the dark brown glistening heads of the teleutosporic stage may be seen emerging from the lower surface of the cavity, and, in the older leaves, filling completely the crater-like openings, which soon become much larger by the crumbling away of the surrounding dried epidermis. Several of these openings, by continued increase in size, may eventually run together, and thus comparatively large spaces on the leaflet may be covered with teleutosporic heads.

Although the heads usually occupy old depressions made by the uredospores, they occasionally form depressions of their own. Such a group may be seen in Figure 1. Here several individuals are still under the epidermis, while one has burst through and is projecting from the upper surface of the leaflet. The under surface presents a broad depression, from which, unfortunately, most of the heads were removed in the process of softening and cutting. This lower cluster presented all the appearances of one developed in a depression previously formed by the uredospores, and it is probable that the heads above are simply an outgrowth from the same stock of mycelium as that which gave rise to the larger cluster below. Thus far, all the heads found on the leaflets have been easily referable to their respective depressions, the instance shown in Figure 1 being the most anomalous yet observed. Should the explanation as applied in this instance prove generally true, it may be stated that the heads on the leaflets develop at a later period, but in the same depressions as the uredospores.

The uredospores have been observed only on the leaflets; the heads, on the other hand, have been seen not only in this position, but also on the leaf rhachis and the young portions of the stem proper, in both of which positions the clusters are denser than on the leaflets. Whether the heads on the stem and rhachis do or do not originate in cavities previously occupied by the uredospores cannot here be definitely stated.

For the more careful study of the individual heads the following methods have been found of advantage. For thin sections, portions of the leaflet bearing the fungus were embedded in paraffine, and sections were cut with a Jung microtome as employed in animal histology. Material to be softened or cleared either for hand sections or teasing should be boiled in a strong solution of potassic hydrate until the brown color of the heads noticeably tinges the reagent. Fair results in maceration were attained when this process of boiling was continued beyond the point above mentioned; but care must be exercised lest the boiling should go so far as to discharge completely the color from the heads. In this condition the parts are too transparent, and their separation not so easily accomplished as at that stage where some color remains.

In outline, the head (Fig. 2) appears as a swollen, umbrella-like mass, rounded or flattened above and connected with the host by a moderate stalk. Three regions may be defined in it: first, the spore-mass or brown cap-like cluster of cells at the top; second, the cyst region, composed of cells with thin transparent walls connecting the spore-mass with the third or stalk region, consisting of a series of compressed parallel cells passing from the cysts to the leaf tissue below.

The spore-mass is a low dome of cells whose outlines by mutual pressure have become irregularly polygonal. The number of cells as viewed from above varies from two or three in extreme cases (Fig. 5), to as many as fifty, the average being perhaps thirty (Figs. 3 and 4). Externally these cells may be divided into two groups, the marginal cells or those on the periphery of the dome (Fig. 3 *a*), and the central cells, including all those which do not come to the edge (Fig. 3 *b*).

A cross-section of the spore-mass is a low arch of cells (Fig. 6) in which the marginal cell *a* is seen to occupy a position which in the central region is taken up by two cells, one external, *b*, and the other internal, *c*. This arrangement, although generally constant for most heads, nevertheless has its exceptions; for, in some instances, the position of a marginal cell is occupied by two cells bearing the same relations to each other as the internal and external central cells, and again the place occupied by the internal and external central cells may be filled by a single cell. This latter case is comparatively rare, and where it has been observed the single cell was always next the marginal series.

By carefully treating the spore-mass with a hot solution of potassic hydrate, maceration was effected, and a pair of cells thus obtained is shown in Figure 7. The larger of these two is an external, the smaller an internal central cell; it is, however, as frequent an occurrence to find two internal or two external cells attached, as to find a group similar to that figured. The adhesion seems to be equally strong between all contiguous cells, and the grouping of incompletely macerated material is in consequence largely accidental.

The cells obtained by maceration lose their slightly angular outline, and become somewhat swollen. From the sections (Figs. 6 and 8), and from the isolated cells (Fig. 7), it will be seen that the outer walls of the external central cells, as well as the same walls of the marginal cells, are very much thickened, while those walls which are not exposed to the surface, but face contiguous cells, are thin. All the walls of the internal central cells are thin except those which are next the cyst region; these latter are of moderate thickness.

The line of separation between adjoining cells is usually discoverable without resort to reagents (Fig. 4); nevertheless difficulty may be experienced in separating two of the thin walls of adjacent cells. This difficulty can be overcome by checking the maceration process just before completion, when the lines of separation will have become well marked (Fig. 7). All the spore-cells contain a coarsely granular protoplasm, in the centre of which a nucleus may usually be discerned (Fig. 7).

The cyst region is composed of a number of rounded, transparent, thin-walled cells, forming a cluster somewhat smaller than the spore-mass itself, and connecting the latter with the stem region (Fig. 10). From the exterior it is difficult to make out the relationship existing between the cyst-cells and those of the spore-mass. In longitudinal sections, however, it may be seen (Fig. 8) that below each marginal cell and each pair of central cells there is a cyst-cell. This relationship seems to be almost invariable, — at least, in a long series of observations no exception has as yet occurred.

The individual cells in the centre of the cluster, from mutual pressure, are more or less angular. Those on the periphery have at least their outermost side convex, and often very decidedly so (Fig. 10).

The cell contents in the matured state seem to have disappeared completely, and all that remains is a delicate, thin-walled, almost transparent cyst, formed by the old cell wall. When the fungus has been allowed to ripen fully on the leaflet, the natural method for the detachment of the spore-mass seems to be by rupturing the cyst region. After the cysts have thus broken close to the stem, their jagged edges stand out as a sort of frill surrounding the spore-mass (Fig 9). It is probably this stalkless stage of the American *R. glandulæformis* which has been considered identical with the Indian *R. sessilis*, Berk. When many spore-masses become thus disconnected with their stalks, the irregular margins of their frills may mat together and form a continuous layer. In one instance, a mat composed of perhaps a hundred such spore-masses was lifted on the point of a knife from the surface of the leaflet. It held its form well, and could be turned on a slide, so as to expose, first its upper, then its lower surface, without tearing the heads apart.

The stalk presents more difficulties in the way of its study than either of the other two regions. In the dried specimens it was so much shrivelled that all attempts to get good sections showing its relation to the cyst-cells failed. Moreover, the density of the embedding material was such that it intensified the shrivelling (Fig. 8). By maceration and surface study of specimens swollen in a warm solution of potassic hydrate fair results were obtained.

The stalk is undoubtedly compound, since by pressure it may be split into a number of longitudinal filaments, the stalk-cells, extending its whole length. From the exterior each of these cells may be seen to abut against a cyst-cell (Fig. 10), and, since but one stalk-cell has been seen to adhere to a cyst-cell in all successfully macerated material (Fig. 11), it is highly probable that each cyst-cell rests upon a stalk-cell in much the same way that the cells of the spore-mass rest upon those of the cyst region.

The cells of the stalk are long, and by mutual pressure more or less angular; at their tops they expand slightly in order to clasp the cyst-cells, and below they unite with the mycelium in the leaf tissue. They have walls as thin as those of the cyst-cells, but, unlike these, they appear to possess slightly granular contents.

Since each stalk-cell supports a cyst-cell, and this in its turn supports a spore-cell, it becomes possible to consider the whole head as composed of a bundle of fused aerial hyphæ, bearing spores on their summits. The hyphæ consist of two parts, a simple stem portion and a cyst-cell. Each hypha carries on its cyst-cell a spore, which, if the hypha be marginal, is unilocular; if central, bilocular. If the morphology of the *Ravenelia* head be such as we have indicated, it is but natural to expect that confirmatory evidence should be found in its young stages.

The young heads first make their appearance amongst the paraphyses which line the cavities previously occupied by the uredospores. Portions of the leaflet on which these cavities were quite numerous were boiled in a weak solution of potassic hydrate, and picked to pieces with needles. Material thus teased contained the young heads, sometimes isolated, and sometimes attached to small fragments of leaf tissue.

The youngest head yet found (Fig. 12) consisted, in optical section, of four hyphæ, each of which is divided by cross partitions into three regions corresponding probably to the spore, the cyst-cell, and the stalk-cell of the matured head. Younger stages than this were difficult to distinguish from mere clusters of paraphyses, which are of not unfrequent occurrence. The individual paraphyses are generally smaller than a single hypha of such a specimen as that seen in Fig. 12, yet some of them attain a size much exceeding this, and intermediate clusters could probably be distinguished from very young heads only by the fact that their individual filaments would separate readily, whereas those of a true head are quite firmly bound together. It is probable that the hypha cluster destined to form a head rises from the mycelium at the base of the paraphyses, and from its first appearance is more or less consolidated. The stage seen in Fig. 12 is a slight advance on this condition. The head has begun to rise, and the hyphæ are elongating; the two primary sets of cross partitions have appeared, being the first intimations of the spore, cyst, and stalk regions. All the cells are filled with a granular protoplasm. A still more advanced stage is seen in Fig. 13. This head was almost completely isolated from the surrounding leaf tissue and mycelium, and consequently shows more of the stalk region than is seen in Fig. 12. The spore-mass has become proportionally larger than in the earlier stage, and a plane of separation dividing its central cells into an external and an internal series has been developed; the increasing thickness of the walls of the spore-cells is noticeable, but no brown color has as yet appeared. The cells destined to become the cyst-cells are still unmodified. The stalk-cells are slightly elongated. Below these last, and similar to them in appearance, is another set of cells, of which no trace has been found in the matured head. In the later stages these doubtless serve as a basement structure, usually hidden from view by the surrounding tissue. At this stage all the cells are filled with a finely granular protoplasm, and it is not until later that the cyst-cells lose their contents.

The further development of the head consists in an increase in the size of the spore-mass, accompanied with an enlargement of the cyst-cells and an elongation of the stem (Fig. 14). As the spore-mass develops, the outer walls of its cells continue to thicken, and at maturity assume a rich chestnut-brown color. The cyst-cells expand, and finally lose their contents. The stem, usually at quite a late period, becomes considerably lengthened, and the head, assuming the matured form, is lifted above the surface of the leaf.

In the course of the development of the head no feature has presented itself which cannot be easily harmonized with the proposition that the head is a bundle of fused hyphæ, bearing spores. In fact, since the earlier stages show the filamentous nature of the head more plainly than the more advanced conditions, and since a study of these stages explains how that arrangement is disguised in the mature head, it is evident that the course of development not only does not oppose our former hypothesis, but doubles the argument in favor of it. As a final statement concerning the morphological nature of the head, we may therefore assert, that, from the anatomy of both the matured and developing head, the structure is essentially that of a cluster of fused teleutosporic stalks, individually equivalent to a stalk and teleutospore of such a form as *Puccinia*, and collectively equal to a cluster of the same.

Having reached the above conclusion concerning the morphology of the teleutosporic stage of *Ravenelia glandulæformis*, it remains only for us to conclude with some notes upon a few of the other species of this genus. As preliminary to these, a short historical review of what is already known of these species may not be inappropriate.

With the exception of a recent paper by Mr. M. C. Cooke, the contributions to the literature of *Ravenelia* have been rather of a systematic nature than otherwise, and, although more or less anatomical detail is necessary in such work, still it must be remembered that anatomy was not the end sought for, but rather a necessary accompaniment.

The Rev. M. J. Berkeley first called attention to the genus *Ravenelia*, and in a short paper* gave descriptions of two species, *R. Indica*, Berk., and *R. glandulosa*, Berk. and Curt. The following

* The Gardeners' Chronicle, p. 132, 1853.

is a summary of the author's remarks on the anatomy of these species. *R. Indica* occurs on the pods of an Indian species of *Acacia;* the clusters of heads upon one side of the pod are represented by corresponding clusters on the opposite side. Upon careful examination, the head of *R. Indica* is seen to "consist of a large, umbrella-shaped dark cap," the spore-mass, "often $\frac{1}{250}$ of an inch across, composed of a number of closely packed cells, supported by a long, hyaline, delicate, and apparently compound stem, round the top of which is suspended a circle of elongate hyaline bodies," the cyst-cells. In *R. glandulosa*, the South Carolinian species, the stem is shorter than in *R. Indica*, and the hyaline bodies at the top of the stem are fused firmly together into a single mass, the cyst region. Two figures of each species accompany the text, and serve to illustrate the remarks already noted.

In his "Introduction to Cryptogamic Botany," p. 323, 1857, the Rev. Mr. Berkeley places *Ravenelia* in the *Cœomacei*, and states that "the spore," i. e. spore-mass, "is in this case of considerable size, and evidently reticulate, and below it, either free or in contact with the stem, is a circle of colorless bags, foreshadowing a more complicated system of articulation than even in the following group," *Pucciniæi.* On page 305 are two figures, one of *R. Indica* and the other of *R. glandulæformis*, Berk. and Curt. (= the former *R. glandulosa*, Berk. and Curt.), both essentially like those of the previous paper.

In 1873, Messrs. Berkeley and Broome presented to the Linnean Society for publication the second part of their "Enumeration of the Fungi of Ceylon," * and on page 93 of their paper five species of *Ravenelia* are described. The term pseudospore is here made to replace that of spore, as applied to the spore-mass. *R. Indica* is redescribed, and its cyst-cells are figured as having filiform processes extending from their centres back into the depths of the head. These are called "glandular stipitate bodies." *R. sessilis*, Berk., and *R. aculeifera*, Berk., are described as new. *R. macrocystis*, Berk. and Br., and *R. stictica*, Berk. and Br., also new species, are figured with a frill of mycelium-like threads, replacing in position the irregular line of the ruptured cyst-cells at the base of *R. sessilis.* The outer surface of the spore-mass of *R. stictica* is figured and described as slightly echinate.

The latest paper touching upon *Ravenelia* is that by Mr. M. C. Cooke.† In it all the species of the genus are described, with this

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* Journ. Linn. Soc. (Bot.), XIV. pp. 29–140. 1875.

† The Genus Ravenelia. Journ. Roy. Micr. Soc., Ser. 1, Vol. III. Part 1, pp. 384 to 389. 1880.

change in the nomenclature, that the term capitule is substituted for pseudospore as employed by the Rev. Mr. Berkeley, and that this latter term is now used to designate the single spores of the spore-mass. *R. glandulæformis*, Berk. and Curt., and *R. Indica*, Berk., are redescribed. The remaining species are all sessile, and the author remarks, that, although they are "described as sessile, this must rather be interpreted to intimate that the stem is reduced to such a minimum as to be little more than a mere point of attachment." *R. glabra*, K. and Cke., is added. This last species, from the material at hand, seemed to have no stem- or cyst-cells, but Mr. Cooke is of the opinion that in fresh material the cyst-cells would probably be found. *R. aculeifera*, Berk., is spoken of as having hyaline processes at the base of its spore-mass, and shows no trace of either stem- or cyst-cells. *R. Hobsoni*, Cke. (= *R. stictica*, Berk. and Br., Grevillea, V. p. 15), has hyaline spines on its marginal spore-cells. *R. stictica*, Berk. and Br., is described as possessing small cysts and a spore-mass, with a warty outer surface. *R. macrocystis* has not been seen by the author.

The material available for anatomical work seems to have been largely *R. aculeifera*, Berk. By gentle pressure a spore-mass of this species can be broken up into its individual spore-cells, which are club-shaped, with their thick outer ends deep brown, and their narrower inner ends colorless. In all cases the single spores extend from the under to the upper surface of the spore-mass, and there is nothing in the central region corresponding to what we have described in *R. glandulæformis* as an internal and an external set of spore-cells; in other words, all the hyphæ of *R. aculeifera*, if there be such, bear unilocular spores. Other species were examined, and the author became convinced that the structure of the spore-mass was essentially the same in all, — a cluster of spores temporarily held together, but destined to separate at maturity. "The barren cysts which surround the capitules in some species yet require to be investigated. The stalk, in both *R. Indica* and *R. glandulæformis*, under pressure separates into parallel tubes. Probably, but this is only speculation, the number of threads may equal that of the pseudospores in the capitule."

The type of structure which we have suggested for *R. glandulæformis* is partially anticipated in Mr. Cooke's closing remark. To what extent this type explains the structure of the remaining species of *Ravenelia* is a question only to be answered after a careful comparative study. Through the kindness of Dr. Farlow, the writer was given access to the specimens of *Ravenelia* contained in the Curtis collection, Dr. Farlow's private collection, and the exsiccati of various authors. The specimens from these three sources form the basis for the following notes.

The Curtis collection contained one specimen of *R. Indica*, Berk. In this specimen the fungus occurred as a large patch of heads on one side of an acacia pod. The single heads, when removed from the host and softened in a solution of potassic hydrate, appeared as in Figure 17. They consisted of a dark brown spore-mass subtended by cyst-cells, which, after being treated with potash, swelled, and hung from the lower edge of the spore-mass like a series of inflated bags. The stalk, although treated in the same manner as that of *R. glandulæformis*, showed nothing indicative of a compound nature. It appeared, moreover, to be attached at a central point on the lower face of the spore-mass, and was apparently not connected with the cyst-cells. Of all the species which we have examined, *R. Indica* has the longest stem, its length often being two or three times the breadth of the head.

The specimen referred to above was the only authenticated one representing this species in the collection. Besides this, however, there was some material from Mexico, which in its general habit was similar to that of *R. Indica* except that it occurred on the leaflets, and not the pods, of *Acacia*. Upon microscopic examination, the heads of the Indian (Fig. 17) and the Mexican form (Fig. 19) proved so like each other that they were practically indistinguishable. Since the only difference between these two forms was in their position on the host, we feel confident that the *Ravenelia* before us is no other than *R. Indica*. This species, we believe, has never before been found in America, and we take pleasure in announcing its discovery by Mr. C. G. Pringle, who collected it on *Acacia anisophylla*, Watson, and *A. crassifolia*, Gray, at Jimulco, Mexico.

In the Mexican specimens the heads occurred in dense dark brown patches on the upper surface of the leaflets of the two species of *Acacia* before mentioned. The patches are so large that they at times cover the leaflets on which they are situated. Single heads or small groups of heads may be found on both surfaces of the leaflet, but especially on the under side, directly below each large patch. The heads occur also here and there on the leaf rhachis.

A transverse section of a leaflet in the region of one of these patches shows the leaf tissue permeated in all directions by a firm-walled mycelium, which, under the patch, passes outward between the epidermal cells of the leaflet, and gives rise to a hymenium on the outer surface of the leaflet, whence arise the teleutosporic heads.

The epidermal layer is not ruptured and curled back as in *R. glandulæformis* (Fig. 1), but the individual cells retain their original positions, and the mycelium makes its way outward between them, curling up and reflecting only the heavy cuticula.

The hymenium consists of short paraphyses, which are closely packed together, each paraphysis having two or three transverse partitions. The young heads appear on a level with the summits of the paraphyses, and seem to be connected with the deeper mycelium by several stalk-cells. The older heads rise far above the paraphyses, and are supported by what appears to be one of the stalk-cells very greatly elongated. What has happened to the other stalk-cells, or whether the head was ever connected with more than one of these cells, is uncertain.

The matured head in cross-section (Fig. 18) shows a structure quite different from that of *R. glandulæformis.* The spores are throughout unilocular, and, although in the centre of the head each one is subtended by a cyst-cell, on the sides one large cyst-cell underlies two or even three of the spore-cells. The stalk is attached to one or two of these small central cyst-cells, and upon the application of a solution of potassic hydrate the larger lateral cysts swell into the balloon-like form seen in Figs. 17 and 19, and so hide the stalk that it appears to attach itself to the spore-mass independently of any cysts. The stalk, which becomes greatly elongated as the head matures, seems to be simple, and not compound as in *R. glandulæformis.*

Of all the species which we have examined, *R. Indica* is the only one in which the spore-cells are persistently unilocular, the stalk simple, and two or three spores often subtended by one cyst-cell. Unfortunately, *R. aculeifera* has not been examined; but, according to Mr. Cooke, this species also has unilocular spores, and it is therefore probable that *R. aculeifera* is of the same type of structure as *R. Indica.* These two species may then be placed in a group contrasted in the three characters already mentioned with *R. glandulæformis* and its allies.

Amongst the species closely related to *R. glandulæformis* is *R. glabra*, K. and Cke. This species was distributed in the Rabenhorst-Winter, Fungi Europæi, Nos. 2624 and 2624 b, upon the leaflets and leaf rhachis of *Calpurnia silvatica*, E. Mey. The teleutosporic heads occur in clusters scattered over the leaflets. These clusters are individually quite small compared with those of *R. glandulæformis*, and, unlike the latter, they are never placed so closely together as to give the appearance of covering the general surface of the leaflet. Each cluster protrudes from a crater-like opening, which was formed by rupturing and reflecting the epidermis in much the same manner as in *R. glandulæformis.* The individual heads agree with those of the latter species in having practically the same structure; the spore-mass in longitudinal section (Fig. 20) shows the lateral and internal and external central cells arranged upon the same plan as in *R. glandulæformis;* one cyst-cell underlies each spore-cell in the base of the spore-mass; the stalk is compound, and the relation of its cells to the cysts is the same as in *R. glandulæformis.* What has already been said of the morphology of the American species will doubtless apply with equal force to *R. glabra.*

A third form which will come under the present group is a species which was described by the Rev. Mr. Berkeley as *R. sessilis*, and which was found upon *Acacia Lebbek* in Ceylon. The Curtis collection contained one specimen of this species, from which the head (Fig. 15) was taken. This specimen, together with others, was carefully studied, and, aside from the difference in the host and locality, no distinguishing mark could be found between it and *R. glandulæformis.* The spore-mass, cysts, and compound stalk agreed in detail with those of the American species, and we were unable by any structural peculiarity to distinguish them.

In addition to the Ceylon material, Ravenel's "Fungi Americani Exsiccati" contained a specimen labelled, "*Ravenelia sessilis*, Berk., *in foliis Tephrosiæ*, Aiken, S. C.," and it was through this specimen that *R. sessilis* had been attributed to America. Figure 16 represents a head from the Ravenel Exsiccati, and here, as in the previous case, a diligent search failed to bring to light any character distinguishing this from *R. glandulæformis.* Neither the host nor the locality in this case could serve to separate them, and consequently we can see no reason for considering them distinct.

It is then hardly open to doubt, that *R. sessilis* as distributed by Mr. Ravenel is *R. glandulæformis*, in which perhaps a majority of the ripened heads have broken from the stalks, as has already been explained, and appear on the leaflet in this stalkless condition. As we have before remarked, the Ceylon *R. sessilis* can only be distinguished from *R. glandulæformis* by the difference of its host and habitat, and not by any structural peculiarity. What the specific value of these characters is we leave to those better able to judge; for ourselves, we must candidly admit that, even in the case of the Ceylon *R. sessilis*, we do not see reasons enough for considering it distinct from *R. glandulæformis.*

The remaining two species differ from all those which we have mentioned in the finely tuberculate outer surface of their spore-masses. No. 10 of Vize's "Micro Fungi Exotici" is an East Indian *Ravenelia*, which, unlike all others, occurs not in clusters, but superficially scattered over the leaf of an unknown host. It is named *R. stictica*, Berk. and Br., and has a small head composed of half a dozen spore-cells, with cysts and a compound stem. Its stem and cyst-cells are arranged after the type of *R. glandulæformis*, but the spore-cells are all unilocular (Fig. 21), and in this respect it approaches *R. Indica*. However, since the spores appear to be subtended each by a cyst-cell, and these in turn supported by stalk-cells, its affinities as a whole are closer to *R. glandulæformis* than to *R. Indica*. The ornamentation of its spores is very characteristic; their whole outer surface is covered with small, wart-like protuberances, while on the periphery of the spore-mass these are so much elongated and enlarged that they appear as so many spines.

The second species agrees with the one just described in having the whole outer surface of its spore-mass covered with small prominences, but the heads are much larger and heavier than those of the former, and consist of about thirty closely compacted small spores, the lateral ones devoid of spines. This species was from Winter's Herbarium, and was labelled "*Ravenelia Tephrosiæ*, Kalchbr. On *Tephrosia* (*macropoda?*), Natal." The stalk is compound, and the cyst-cells, as far as can be seen externally, are arranged in accordance with the type of *R. glandulæformis*. The general habit of the fungus when seen on its host is strikingly like that of the last-named species.

With this we conclude the list of species which have come under our observation, and as a result of these notes we may present in closing two generalizations: first, that the species examined seem to fall under two distinct types of structure, one represented by *R. Indica*, and including that species and probably *R. aculeifera*, and the other represented by *R. glandulæformis*, and including *R. sessilis*, *R. glabra*, *R. Tephrosiæ*, and probably *R. stictica* (Vize); second, that all the species thus far examined have had well-developed stalks and cyst-cells, and that consequently the so-called sessile species are in all probability species in which the specimens studied were so ripe as to have ruptured their cyst-cells, and thus appeared stemless. Such species as are related to *R. glandulæformis* will probably be found to have much the same development as that form; those of the type of *R. Indica* require yet to be investigated, and we feel that it is in this direction that a profitable field for research awaits the future student of *Ravenelia*.

EXPLANATION OF FIGURES.

[All magnified 330 diameters.]

PLATE I.

Ravenelia glandulæformis, Berk. and Curt.

Fig. 1. A transverse section of the leaflet of *Tephrosia virginiana*, Pers. The normal condition of the leaf tissue is seen at the left. The section was cut with a hand razor after the leaflet had been softened in a warm solution of potassic hydrate.

Fig. 2. A head cut from the leaflet and mounted in alcohol to show the general habit.

Fig. 3. A spore-mass mounted in glycerine jelly, seen from above; *a*, marginal cells; *b*, central cells.

Fig. 4. A spore-mass mounted in alcohol, seen from above.

Fig. 5. An abnormal head mounted in alcohol, seen from the side. The cells *a*, *b*, and *c* have thick brown walls. The stalk is broken off.

Fig. 6. The cross-section of a spore-mass which has been treated with potassic hydrate and mounted in balsam. Lateral cell, *a*; external central cell, *b*; internal central cell, *c*.

Fig. 7. An internal and an external central cell from a head macerated in a solution of potassic hydrate.

Fig. 8. A transverse section of a head treated with alcohol, and mounted in balsam.

Fig. 9. A very ripe head mounted in alcohol and viewed from above. The spore-mass has broken from the stalk, and the ruptured cysts project beyond its periphery.

PLATE II.

Ravenelia glandulæformis, B. and C.

Fig. 10. A side view of a head treated with a warm solution of potassic hydrate.

Fig. 11. A head partially macerated in a warm solution of potassic hydrate, seen from the side.

Fig. 12. An optical section of a very young head, isolated by teasing a piece of leaf-tissue previously boiled in a solution of potassic hydrate.

Fig. 13. A head in a more advanced stage than the last, obtained by teasing.

Fig. 14. A side view of a still older head.

Ravenelia sessilis, Berk.

Fig. 15. A head treated with potassic hydrate. (Curtis Coll.)

Fig. 16. A head similarly treated. (Ravenel's Exsiccati.)

Ravenelia Indica, Berk.

Fig. 17. Side view of a head softened in potassic hydrate. (Curtis Coll.)

Fig. 18. A cross-section of a spore-mass mounted in balsam. (Mexico.)

Fig. 19. Side view of a head softened in a solution of potassic hydrate. (Mexico.)

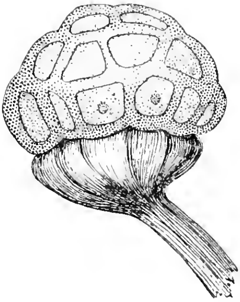

FIG 2

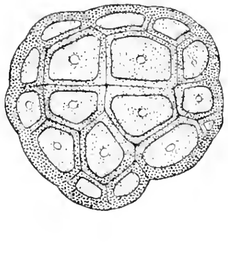

FIG 4

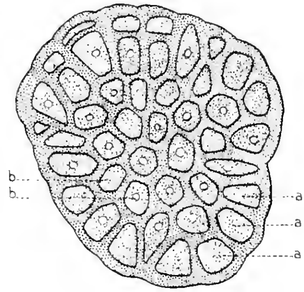

FIG 3

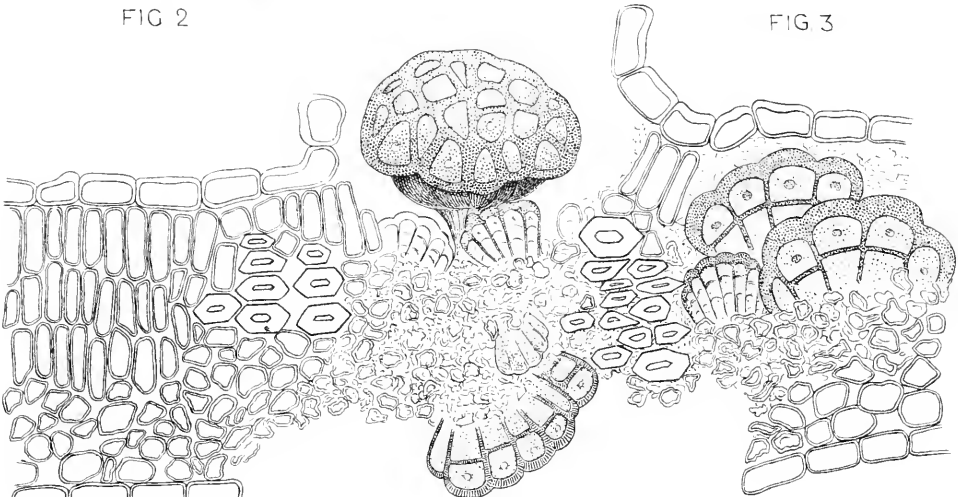

FIG 1

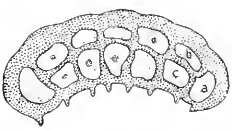

FIG. 6

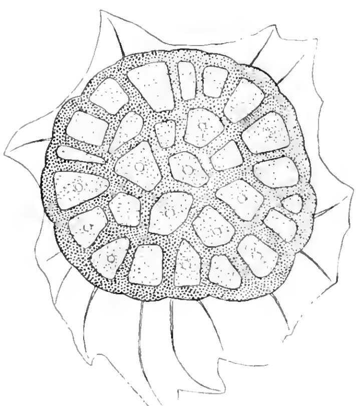

FIG. 9

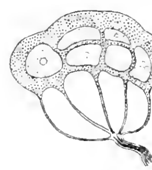

FIG. 8

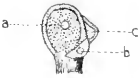

FIG 5

FIG 7

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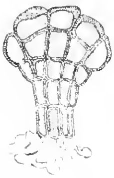
FIG 13

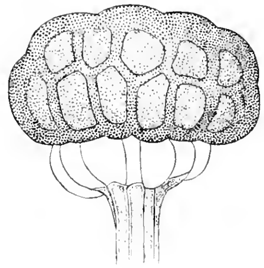
FIG. 10

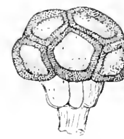
FIG 14

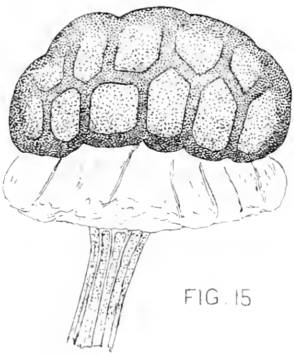
FIG. 15


FIG 12

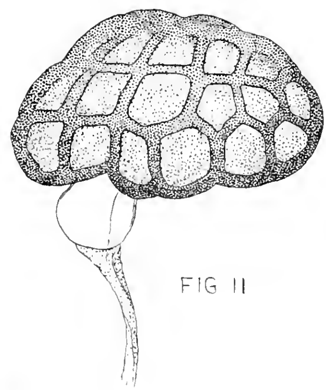
FIG 11

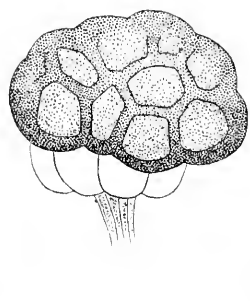
FIG. 16

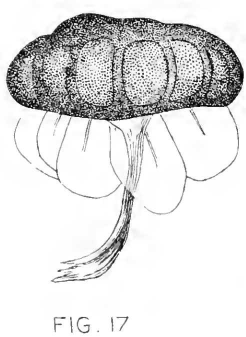
FIG. 17

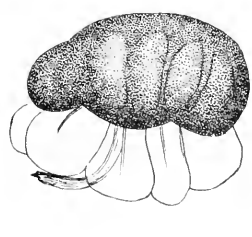
FIG. 19

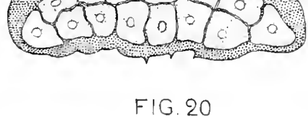
FIG. 20


FIG. 21

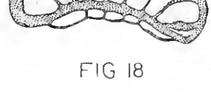
FIG 18

G.H.P. Del

Forbes Co Boston

Ravenelia glabra, C. and K.

Fig. 20. A cross-section of a spore-mass treated with potassic hydrate and mounted in balsam.

Ravenelia stictica, Bk. and Br.

Fig. 21. A cross-section of a spore-mass treated with potassic hydrate and mounted in balsam.

INVESTIGATIONS ON LIGHT AND HEAT, MADE AND PUBLISHED WHOLLY OR IN PART WITH APPROPRIATION FROM THE RUMFORD FUND.

IX.

CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

XXVI. — EXPERIMENTS ON THE MELTING PLATINUM STANDARD OF LIGHT.

BY CHARLES R. CROSS.

Presented June 16, 1886.

NOTWITHSTANDING the fact that the amount of light emitted normally by a square centimeter of platinum at its point of solidification has been adopted as a standard both by the International Electrical Conference and by the United States National Conference of Electricians, but very few experiments have been made to determine whether it can be made reliable and capable of practical use. An approach toward giving the method a practical form was made by W. Siemens,* who proposed to substitute the light emitted by a given area of platinum at its melting point instead of at its point of solidification, and suggested a means by which with this modification the standard could readily be utilized.

The following experiments resulted from a conference of a portion of the Committee on Standards of Light appointed at the Electrical Conference at Philadelphia in 1884.† They had for their object the ascertaining of a single fact, viz. the amount of the average deviation which would arise in a series of measurements of the light emitted by a strip or wire of platinum of given surface when at the melting point.

A few preliminary experiments were made by the writer, in which a measured length of fine platinum wire, four one-thousandths of an inch in diameter, was placed at one end of the bar of a Bunsen photometer, with a gas-jet shining through a limited aperture at the other end. A current from a small hand Gramme machine was carried through the wire, which was made to glow more and more brilliantly

* Wied. Ann., 1884, vol. xxii. p. 304.

† Messrs. J. Trowbridge, E. C. Pickering, and C. R. Cross.

by increasing the speed of the machine. Following the method of Siemens, the greased disk of the photometer was moved farther and farther from the incandescent platinum, so as to keep the disk uniformly illuminated, until finally melting occurred. The last reading of the position of the disk gave the illuminating power of the wire at melting. An unexpected constancy in the results was found, so that it seemed worth while to make a longer series of such observations, which was done in the following manner. At one end of the bar of a greased-disk photometer 200 centimeters (78.74 inches) long was placed a circular aperture, through which shone the light of an Argand gas-burner. A platinum-wire lamp was constructed, in which a given length of wire was stretched between two fixed knife-edges, and held by clips, thus allowing of speedy adjustment of the wire. The disk used was furnished with two mirrors inclined at 45° in the usual manner, and it was always placed so that the two sides as seen by reflection appeared alike, — a method of measuring much more satisfactory than the one commonly employed with the Bunsen photometer. The length of wire used was measured between the edges when cold, and allowed to expand freely. An attempt was made to use a slit of given length in front of a longer wire, which was abandoned owing to errors arising from inequality in the length of that portion of the wire whose light passed through the slit when the wire expanded. The use of a small weight stretching the wire tight, as suggested by Professor Pickering and employed by him in a small lamp, presents some advantages, but was discarded from fear of elongating the wire and so causing it to break before complete fusion was reached. Melting was brought about by the use of a slide-resistance of German-silver wire in circuit with the platinum wire and a dynamo machine. The variable resistance of the slide was lessened until the platinum wire melted, the photometer-disk being meanwhile moved repeatedly, its final reading giving the light emitted by the platinum in terms of the light emitted by the aperture opposite.

No attempt has been made in these experiments to determine the absolute illuminating power of the wire, but only to ascertain whether ordinary commercial platinum wire has any practical value for use as a primary or a secondary standard.

Two different sizes of wire were used, whose diameters were .004 in. and .006 in. respectively. Wire from two different makers was also used, ordinary wire drawn without special care being taken because of its availability. The length used was always the same when cold, viz. two inches. A very large number of measurements were made, chiefly by Messrs. F. H. Crane and H. E. H. Clifford, students in the laboratory, and careful and accurate observers.

Five sets of observations on successive fusions of wire were made by each observer, and the mean taken. The mean and the average deviation from the mean of a long series of such sets were then found. The tables give the results of the measurements. In all cases the distance between the opposite lights is 78.74 in. (200 cm.), and the diameter of the aperture in front of the gas flame $\frac{3}{8}$ in. The recorded distances are measured from the aperture.

In order to give an idea of the degree of concordance of the separate individual readings, the following sets (Table I.) are taken at random. The numbers given are the final positions of the disk, in each experiment, in inches.

TABLE I.

Diameter of wire = .004 in.

	Observer *M.*	Observer *N.*
	43.7	43.6
	43.6	43.7
	43.7	43.7
	43.6	43.5
	43.5	43.8
Mean	43.62	43.66

A change of 0.1 in. corresponds to an absolute change of 0.007 in illuminating power of opposite light = 1.1 per cent.

Diameter of wire = .006 in.

	Observer *N.*	Observer *N.*
	37.7	37.4
	37.8	37.2
	37.4	37.4
	37.2	36.8
	37.2	37.2
Mean	37.46	37.20

A change of 0.1 in. corresponds to an absolute change of 0.01 in illuminating power of opposite light = 1.0 per cent.

Table II. is given at length as indicating more clearly the variations among consecutive sets of measurements. I. P. denotes the illuminating power of the platinum wire in terms of that of the opposite light. The average deviation of I. P. is the change in this quantity produced by an increase in the scale-reading equal to the average deviation in inches.

TABLE II.

Diameter of wire = .004 in. Sample A.

Averages of 5 Experiments. Observer *M*.	Averages of 5 Experiments. Observer *N*.
43.6	43.7
43.7	43.5
43.6	43.5
43.7	43.4
43.5	43.4
43.6	43.6
43.5	43.3
43.6	43.6
43.6	43.2
43.5	43.7
Mean 43.59	Mean 43.49
Average deviation .06 in.	Average deviation .13 in.
I. P. = .650.	I. P. = .657.
Average deviation I. P. = .004.	Average deviation I. P = .009.

Tables III. and IV. give the means of the various sets of experiments. Column 1 shows the sample used; 2, the mean of the series taken; 3, the number of observations from which the mean is derived; 4, the observer; 5, the illuminating power; 6, the average deviation in inches; and 7, the average deviation in terms of the illuminating power. It will be seen that the maximum average deviation in I. P. for the finer wire is 1.7 per cent, and for the coarser wire 1.6 per cent of the total value.

TABLE III.

Diameter of wire = .004 in.

Sample.	Mean.	Number of Obs.	Observer.	I. P.	Av. Dev. Inches.	Av. Dev. I. P.
A	43.59	50	*M*	.650	.06	.004
A	43.49	50	*N*	.657	.13	.009
B	43.77	50	*N*	.638	.11	.007
B	43.70	50	*M*	.643	.16	.011
B	44.86	50	*N*	.570	.18	.010
A	45.16	50	*N*	.553	.12	.007
A	43.72	50	*N*	.641	.12	.007

TABLE IV.

Diameter of wire = .006 in.

Sample.	Mean.	Number of Obs.	Observer.	I. P.	Av. Dev. Inches.	Av. Dev. I. P.
A	35.37	20	*N*	1.504	0.15	.024
A	37.19	30	*N*	1.249	0.14	.019

In order to determine the possible accuracy of setting the photometer disk, several series of readings (Table V.) were taken, in which two apertures through which a gas-flame shone were balanced against each other. These readings were taken with apertures of different sizes, in order to test the accuracy of setting in different parts of the scale; that is, for different relative brilliancies of the lights. Series 3 and 4 were taken so as to bring the disk in the same position as that which it occupied with the .004 in. and .006 in. platinum wire.

TABLE V.

Series.	Number of Observations.	Mean.	I. P.	Av. Dev. Inches.	Av. Dev. I. P.
1	50	31.35	2.286	.076	.019
2	50	31.40	2.273	.054	.012
3	50	43.92	0.628	.042	.003
4	50	36.48	1.342	.044	.005

It appears that the average deviation of the different readings when the opposite illuminated apertures were balanced against each other is in general considerably less than that of the readings with the melting wire. The maximum average deviation of I. P. is 0.8 per cent of its total value; the minimum value is about half as great.

Marked differences in the illuminating power of the platinum wire of the same diameter on different days were observed, contrasting strongly with the uniformity of the results of successive measurements. This undoubtedly arose from changes in the quality, and hence in the illuminating power, of the gas, as the height of the flame was kept constant. In future experiments I hope to obtain a more constant standard by using a moderator lamp with aperture, or else by employing the pentane burner.

A consideration of the results given in Tables III. and IV. shows that the light emitted by a filament of commercial platinum at the melting point is quite constant in successive measurements, and it appears to present greater uniformity than many of our commercial standards. There is little doubt, moreover, that by the use of a wire longer, and perhaps of larger diameter, the results would be improved, as there would be less liability to error from the cooling of the ends of the wire by contact with the metal supports (an action, however, which can easily be removed altogether), and from accidental minute inequalities in the length of the wire used. It would also be desirable to use platinum of better quality than is usually found in commercial wire, and to have special care exercised in drawing to insure accurate cylindricity.

It is also evident that such a wire as I have used cannot at best be employed except as a secondary standard, since the ratio of the luminosities of the two gauges of wire employed is not at all in the ratio of the projection of their surfaces.

Still further, a difficulty may arise in the use of a melting platinum wire or strip even as a secondary standard from variations in the physical condition of the metal due to cracking, occluded gases, or other causes. No certain evidence of this was observed with the samples of wire employed, but I am not at all sure that it may not occur with different specimens of commercial wire. From a few preliminary experiments of a series still in progress it appears probable that successive heating and cooling, or continued heating of the wire even under ordinary atmospheric pressure, tend slightly to raise its point of fusion, an action which Edison has shown* to be carried to an extreme degree when continued heating in vacuo is employed. Thus, in one experiment the wire was heated by the current and cooled from one to ten times, and then carried up to its melting point, photometric readings being taken as in previous experiments, with the following results. The wire was .006 inches in diameter. Each value given is the mean of five measurements.

	Mean Reading.
Without reheating	37.65
Reheated once	37.42
" twice	37.42
" 3 times	37.62
" 4 "	37.26
" 5 "	37.06
" 10 "	37.26

* Proceedings of American Association, 1879, vol. xxviii. p. 173.

The lesser readings indicate greater luminosity of the melting wire.

In another experiment, the wire in its ordinary condition melted when the reading (mean of 5 measurements) was 37.8 in. After annealing in a Bunsen flame, the mean reading at melting (for five experiments) was 37.2 in. After heating to a yellow heat by passing a current of electricity through it for half an hour, the reading at melting (mean of 23 measurements) was 36.9 in.

If further experiment should show conclusively that the light emitted by melting platinum is variable beyond narrow limits, it is clear that any photometric standard based on the luminosity of *melting* platinum will present no advantage over those standards now in ordinary use, unless specially prepared platinum freed from gases and consolidated by Edison's process of heating in vacuo is found to be available. Probably solidifying platinum, provided its point of solidification is sufficiently definite, would be free from this objection, although this can hardly be accepted without experimental proof.

Rogers Laboratory of Physics,
June, 1886.

INVESTIGATIONS ON LIGHT AND HEAT, MADE AND PUBLISHED WHOLLY OR IN PART WITH APPROPRIATION FROM THE RUMFORD FUND.

X.

CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

XXVII. — THE INVERSE ELECTROMOTIVE FORCE OF THE VOLTAIC ARC.

BY CHARLES R. CROSS AND WM. E. SHEPARD.

Presented June 16, 1886.

THE fact that the total or equivalent resistance of a voltaic arc consists of two parts, the one constant for the same current, the other variable in proportion to the length of the arc, was first made known by Edlund in 1867 and 1868.* This total resistance, r, is evidently represented by the equation $r = a + bl$, and if the constant a be multiplied by the current, C, employed, the inverse electromotive force is found.

Later researches have shown conclusively, with the silent arc, throughout a great range of length and of current strength, that this product, aC, is approximately constant.

The most recent results on this subject are those of Fröhlich,† whose results give a value of 39 volts for the quantity aC; of Peukert,‡ who finds a mean value of 35 volts for currents of 10 ampères and over; and Von Lang,§ who assigns a value of 39 volts.

It has long been known that on the passage of the arc from the whistling to the silent stage, as the carbons are separated, there is a sudden rise in the difference of potential between them. At the same time, the arc becomes much brighter and hotter, from which we should naturally infer that the conductive resistance would diminish. The current, however, is at the same time diminished.

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* Poggendorff's Annalen, 1867, vol. cxxxi. p. 586; 1868, vol. cxxxiv. p. 250.

† Elektrotechnische Zeitschrift, 1883, vol. iv. p. 150.

‡ Zeitschrift für Elektrotechnik, 1885, vol. iii. p. 111.

§ Centralblatt für Elektrotechnik, 1885, vol. vii. pp. 315, 446.

These facts might lead one to infer the probability of there being a sudden rise in the inverse electromotive force of the arc at the point when whistling ceases. So far as we are aware, this matter had not been studied previous to the observations which we have to present.

The quantity $a C$ was originally supposed by Edlund to be of the nature of an opposing electromotive force. It is true that this view has not been accepted without question, and that the real cause of the phenomena under consideration is still somewhat uncertain; but we shall, nevertheless, in this paper, for convenience of description, refer to this quantity $a C$ as the inverse electromotive force of the arc.

The object of the experiments described in the present paper was to review the results of earlier observers on the quiet arc, to extend the observations to the whistling arc, and to observe the effect on the inverse electromotive force of the arc caused by variations in the position and temperature of the electrodes, by the presence of volatilized substances in the arc, and by variations in the density of the air in which the arc is formed.

A lamp was constructed for the purpose whose upper carbon was movable in a vertical direction by a micrometer screw, having a pitch of $\frac{1}{32}$ of an inch. Wires ran from brass collars surrounding the carbons, and as near as possible to their extremities, to a voltmeter, which gave the difference of potential between the carbons. The current of electricity was usually furnished by a Brush dynamo machine. It was measured in some cases by means of a carefully and frequently calibrated Ayrton and Perry permanent magnet ammeter, and in others by a Paterson and Cooper electromagnet ammeter, also calibrated by comparison with standard instruments. A similarly calibrated Ayrton and Perry permanent magnet voltmeter was employed for the potential measurements. Reversals of readings were obtained by a mercury commutator so arranged as to reverse both the current and potential instruments simultaneously. The quotient of the difference of potential between the carbons divided by the current gave the equivalent resistance of the arc. Care was taken that the arc should be formed so as to pass between those points of the carbons which were closest together, which was secured by filing them flat. The separation between the points as measured by the micrometer, therefore, gave the length of the arc. It was of course necessary to make the measurements with a sufficient degree of quickness, so that no sensible burning away should occur before they were finished. No difficulty was found in doing this, as it took a number of seconds for the filed carbons to shorten by any material amount. Before each set of measurements the carbons after filing were screwed into contact, the reading of the micrometer taken, and the carbons were then separated by the desired amount. It was found, however, that the expansion of the carbons by heat was a noticeable quantity, and hence, except with very long arcs, the arc was allowed to form, and then the carbons were quickly screwed into contact and again separated by the desired amount. For arcs so long that this was not practicable, the expansion was estimated and allowed for. The change of reading from this cause appeared to vary from $\frac{1}{20}$ to $\frac{1}{4}$ of a revolution of the micrometer screw; that is, from $\frac{1}{640}$ to $\frac{1}{128}$ of an inch. In order to avoid undue disturbance of the dynamo during the measurements, the dynamo circuit was never broken, but by means of a suitable key the current was thrown into a wire resistance approximately equivalent to the arc resistance before the arc was broken. The current forming the arc was regulated by means of suitable resistance coils interposed in the circuit.

In most of the measurements Boulton carbons were used. Ten successive measurements with reversals were usually made in each series, keeping the current and electromotive force as nearly constant as possible, and taking the mean value as the result of one set of measurements for the length of arc used. The two following tables, taken at random, are given in full to indicate the degree of variation observed. One of the tables shows results with a silent arc, one with a whistling arc. The column headed A contains the scale readings of the ammeter; that headed V, those of the voltmeter. The mean of each of these is taken, and the current and electromotive force desired are then found by multiplication of the mean by the proper instrumental constants, which, with the tables given, are 1.00 for the ammeter and 2.12 for the voltmeter.

TABLE I. — SILENT ARC.

Length of Arc = $\frac{3}{32}$ in.

A.	V.
5.3	21.2
5.3	21.5
4.9	22.2
5.1	21.0
5.1	21.7
5.1	21.2
4.8	22.7
5.0	21.2
4.9	22.0
4.8	22.2
5.1	22.2
5.2	21.8
5.1	22.2
5.1	22.2
5.1	23.0
5.2	22.8
4.8	23.8
4.9	23.7
4.8	24.2
4.5	24.5
Mean, 5.0	22.37

C = 5.00 ampères.
E = 47.42 volts.
R = 9.48 ohms.

TABLE II. — WHISTLING ARC.

Length of Arc = $\frac{2}{32}$ in.

A.	V.
5.2	19.0
5.3	18.2
5.1	18.2
5.1	18.2
5.2	18.2
5.2	18.2
5.3	18.0
5.1	19.0
4.9	19.0
4.8	19.8
4.8	19.0
4.8	19.0
5.1	18.8
5.2	18.2
5.1	18.5
4.9	19.2
4.9	18.8
5.0	18.2
5.0	19.0
5.0	19.0
Mean, 5.05	18.67

C = 5.05 ampères.
E = 39.59 volts.
R = 7.84 ohms.

Owing to the great variability of the arc, it is of course impossible to avoid having a considerable average deviation with a series of successive measurements of current and electromotive force; but, as will be seen, in spite of the necessarily large limits of variation, consistent results are nevertheless obtainable.

About 1200 measurements were taken, embracing 60 series of 10 readings with reversals, using lengths of arc of from $\frac{1}{128}$ in. to $\frac{1}{2}$ in., and currents varying from 3 to 10 ampères. Ordinarily we made a series of measurements with increasing lengths of arc, keeping the current as nearly constant as possible by means of resistance coils. The variations in the current were rarely more than a few hundredths of an ampère, and as the current was measured simultaneously with the electromotive force, these small changes did no harm. The equivalent resistance for each length of arc, with the various strengths of current, was obtained from the data given by the measurements. The following tables show the results reached. The first column gives the separation of the carbons, which is the length of the arc, the unit being $\frac{1}{32}$ of an inch; the second column gives the equivalent resistance in ohms, which is the electromotive force between the carbons divided by the corresponding value of the current; the third column states whether the arc was a silent (S.) or whistling (W.) one. The value of the current given over each table is the mean of the values found in the various separate measurements.

Upright Arc.

TABLE III.

Current = 3.27 ampères.

Length of Arc.	Resistance.	Character.
0.25	5.51–5.93	W.
0.50	7.41	"
0.50	6.96*	"
1.00	9.50	"
1.00	9.86*	W. (slightly.)

TABLE IV.

Current = 5.04 ampères.

Length of Arc.	Resistance.	Character.
1	5.67	W. (slightly.)
2	8.14	S.
3	9.51	"
4	10 02	"
5	10 57	"
6	11.10	"
7	11.60	"

TABLE V.

Current = 7 ampères.

Length of Arc.	Resistance.	Character.
0.25	2.49	W.
0.50	2.89	"
1.00	3.60	"
1.00	3.55	"
2.00	5.28	"
2.00	5.17	" (low.)
3.00	6.28	S.
3.00	6.41	"
4.00	6.77	"
4.00	6.72	"
5.00	6.97	"
6.00	7.25	"
7.00	7.51	"
8.00	7.80	"
9.00	8.06	"
12.00	8.97	"
12.00	8.90	"
14.00	9.31	S. (flaming.)

TABLE VI.

Current = 7.94 ampères.

Length of Arc.	Resistance.	Character.
0.50	2.42	W.
1.00	3.09	"
2.00	4.58	W. (slightly.)
3.00	5.60	S.
4.00	6.04	"
5.00	6.32	"
6.00	6.49	"
7.00	6.73	"
8.00	7.14	"
10.00	7.51	"
12.00	8.09	"
14.00	8.57	"
16.00	8.89	"

* These results were given by Carré carbons.

TABLE VII.

Current = 10.04 ampères.

Length of Arc.	Resistance.	Character.
0.50	1.86	W.
1.00	2.30	"
1.00	2.19	"
1.00	2.34	"
2.00	2.95	S.
3.00	3.94	"
3.00	3.74	W. (low.)
4.00	4.45	S.
5.00	4.67	"
6.00	4.91	"
7.00	5.08	"
8.00	5.32	"
8.00	5 22	"
10.00	5.66	S. (flaming.)

From the measurements as given in the tables, curves were next plotted on a large scale for each mean strength of current, with the separations of the carbons as abscissæ and the corresponding resistances as ordinates.

These curves were in all cases found to be composed of two straight lines, the intersection of which corresponds approximately to the point at which the arc, as it is gradually lengthened, passes from a whistling to a silent one. The curve for the whistling arc is the steepest. Hence, for the curve corresponding to each strength of current there are two different intercepts and two different angles made with the axis of abscissæ, according as the arc is whistling or silent. Since the intercept gives the quantity a in the general equation $r = a + bl$, which quantity being multiplied by the current gives the corresponding value of the inverse electromotive force of the arc, it follows that for any particular current there is a definite opposing electromotive force for the whistling arc as for the silent arc, whatever its length, but that the former is different from and less than the latter. Also, there is for the whistling arc, as well as for the silent arc with any definite current, a definite value of b, and hence a simple proportionality between the variable portion of the equivalent resistance and the length. The values of b are greater with the whistling than with the silent arc for the same current strength.

From the curves plotted as described, the linear equations of the two branches corresponding to the silent and whistling arcs were obtained. These are given in Tables VIII. and IX., and are numbered for convenience of reference. The length, l, is expressed in terms of the pitch of the micrometer screw, i. e. in thirty-seconds of an inch. The current is expressed in ampères. Lengths of arc up to $\frac{16}{32}$ in. were observed.

TABLE VIII. — SILENT ARC.

Current.	Number.	Equation.	E. M. F. $= a \times C$.
5.04	1	$r = 7.97 + .515\,l$	40.16
7.00	2	$r = 5.73 + .261\,l$	40.11
7.92	3	$r = 5.00 + .256\,l$	39.60
10.04	4	$r = 3.73 + .198\,l$	37.45
			Mean, 39.33

TABLE IX. — WHISTLING ARC.

Current.	Number.	Equation.	E. M. F. $= a \times C$.
3.27	5	$r = 4.70 + 4.90\,l$	15.37
5.03	6	$r = 3.14 + 2.53\,l$	15.79
7.00	7	$r = 2.10 + 1.55\,l$	14.70
7.95	8	$r = 1.81 + 1.26\,l$	14.39
10.03	9	$r = 1.46 + 0.787\,l$	14.64
			Mean, 14.98

The fourth column of the table gives the inverse electromotive force corresponding to each current, as found by multiplying the intercept given in the equation by that current. It appears from the results, that for the silent arc the mean value of the inverse electromotive force is approximately 39 volts. There is, however, an evident diminution in this value as the current rises, and by reference to the equations given in Peukert's paper, already cited, it will be seen that they also indicate the probability of such a change.

When the arc becomes very long there is an apparent tendency to an abnormally small value of the equivalent resistance. This was observed in the values of the resistance when the arc was $\frac{14}{32}$ in. long, with a current of 7 ampères, and when the arc was $\frac{16}{32}$ in. long with a current of 8 ampères. It was also noticed with very long arcs in which metallic salts were volatilized.

Table IX. also shows us an additional fact. Not only is the inverse electromotive force of the silent arc the same for any given current, irrespective of the length of the arc (within the limits of whistling), but it also has, like that of the silent arc, an approximately definite value for all currents. The mean of the results with the silent arc given in the table is about 15 volts. There is, also, notwithstanding some anomalous results, the same manifest diminution with increase of current that we observe with the silent arc. It will further be noticed, that the constant, b, diminishes as the current increases, but that its value is several times as great for the whistling as for the silent arc.

For both the silent and whistling arcs, the conductive resistance, bl, diminishes as the current is increased, at first rapidly, afterwards more slowly.

The equations verify previous observations, in that the passage from higher to lower inverse electromotive force is a sudden one. It takes place with a greater separation of the carbons, and less equivalent resistance, as the current is stronger, a result agreeing with that reached by White from direct measurements.* The following figures (Table X.), taken from the curves as plotted, illustrate this. The first column gives the approximate current, the second the equivalent resistance, the third the separation of the carbons at which the change would take place, which last is, of course, the abscissa of the point of intersection of the two straight lines representing the two varieties of arc.

TABLE X.

Current.	Equivalent Resistance.	Distance between Carbons.
5.0	9.22	$\frac{2.4}{32}$ = .075 in.
7.0	6.46	$\frac{2.8}{32}$ = .087 in.
7.9	5.83	$\frac{3.2}{32}$ = .100 in.
10.0	4.46	$\frac{3.8}{32}$ = .119 in.

These values would doubtlessly vary considerably with the nature of the carbons used for the electrodes.

It was also noticed with the stronger currents, that, on lengthening the arc, the whistle ceased slightly before the higher inverse electromotive force was reached. This appeared to be somewhat influenced by the quality of the carbons. In all cases, however, the line of demarcation between the silent and the whistling arc was very defi-

* Electrician, 1884, vol. xiv. p. 56.

nite. With the whistling arc, there was always great unsteadiness, which was very much diminished at the moment when the arc became quiet. At the same time the positive carbon suddenly brightened, indicating a great rise of temperature.

A quite interesting peculiarity was noticed in the curves for the whistling arcs. As will also be seen from the equations, the lines all converge approximately towards a point situated behind the axis of ordinates, and corresponding algebraically to a negative separation of about $9 \times \frac{1}{32}$ inches, the corresponding algebraic value of the resistance being about $\frac{7}{10}$ ohms. This property of the curves furnishes a means of finding approximately the equivalent resistance of any whistling arc, as follows. Divide the average value of the inverse electromotive force, 15.13 volts, by the strength of the current, which gives the intercept, a, corresponding to the current in question. Draw a line from the point of convergence as given above, through the upper point of the intercept, and it will be the curve for this current. The ordinate corresponding to any abscissa gives the equivalent resistance for that length of arc. The curve for the smallest current used, 3.27 ampères, alone shows much deviation from the rule. The curves for the silent arcs do not show any such definite point of convergence.

It is interesting to examine Edlund's early values for the inverse electromotive force in the light of the preceding results. His first values are expressed in units which are purely arbitrary. They show approximately, however, the same figure for $a\,C$ through a considerable range of variation in the strength of the current. His later results give 9.7 as the value of the inverse electromotive force with a current of 30 Bunsen elements, the electromotive force of a Bunsen cell being taken as a unit. With 50 elements its value rose to 15. It seems probable that the former result was reached with a whistling arc, and the latter with a silent one. It is difficult to explain the existence of certain intermediate values, but the method by which they were obtained is liable to great errors.

If we consider Peukert's paper, we find that the results from which he derives his value of 35 do not include any with a less current than 10 ampères, and but one in which the length of the arc is less than 2 mm., so that the arcs were probably all silent. The observations from which Fröhlich constructs the curve giving the value of 39 are too irregular to show any difference that might exist between the values of the constant for the silent and for the whistling arcs. Von Lang states that the arcs measured by him were carefully kept from hissing by manual adjustment.

A large number of measurements were made with an inverted arc, in which the positive carbon was below and the negative one above.

Currents of approximately 5, 7, and 10 ampères were used, with lengths of arc up to $\frac{7}{32}$ inch. There was much unsteadiness in the voltmeter for arcs more than $\frac{3}{32}$ inch long, there being a slow and irregular fluctuation of the needle between definite limits. Very probably this was due to irregularities in the air currents rising from the lower and hotter positive carbon. In some sets of the measurements (Series II. of tables) the extreme readings were taken and separate curves drawn for each. The following tables (XI. to XVIII.) give the results of the measurements.

Inverted Arc. — Series I.

TABLE XI.

Current = 5.1 ampères.

Length.	Resistance.
0.50	3.88
1.00	4.91
2.00	7.50
3.00	9.00
4.00	9.50
5.00	9.90
6.00	10.60

TABLE XII.

Current = 7.3 ampères.

Length.	Resistance.
1	3.22
2	4.64
3	5.85
4	6.49
5	6.76
6	6.91
7	7.14
8	7.38

Inverted Arc. — Series II.

TABLE XIII.

Current = 5.1 ampères.

Separation.	Resistance.	
	Minimum.	Maximum.
0.50	3.86	....
1.00	5.05	5.48
2.00	6.98	8.23
3.00	8.81	9.52
4.00	9.33	10.38
4.00	9.14	9.97
5.00	9.52	10.60
6.00	9.81	11.01
7.00	10.40	11.43
8.00	10.40	12.00
9.00	10.80	12.50

TABLE XIV.

Current = 10.2 ampères.

Separation.	Resistance.	
	Minimum.	Maximum.
3	3.06	3.83
4	3.60	4.70

TABLE XV.

Current = 9.6 ampères.

Separation.	Minimum.	Maximum.
5	4.10	5.17
6	4.18	5.27
7	4.18	5.60

The curves for the inverted arc were constructed, as already explained for the upright arc. These were found, as with the latter, to consist of two distinct straight lines, corresponding to the silent and the whistling arcs respectively. The following equations (Tables XVI., XVII.) represent the results obtained. Equations 10 and 12 were found by taking the extreme readings as described, the current being steady at 5.1 ampères. Equation 11 was obtained from another series of experiments, using the same strength of current, but taking the mean reading of the voltmeter at each observation. Equations 14 and 15 were constructed from the extreme readings. The current varied slightly with these last, the average value being 9.6 ampères for the silent arc and 10.2 ampères for the whistling arc. The inverse electromotive force is given in the last column of the table.

TABLE XVI. — Silent Arc.

Current.	Number.	Equation.	E. M. F. $= a \times C$.
5.1 (max.)	10	$r = 7.70 + .540\, l$	39.27 }
5.1	11	$r = 7.70 + .450\, l$	39.27 } 39.27
5.1 (min.)	12	$r = 7.70 + .367\, l$	39.27 }
7.3	13	$r = 5.60 + .214\, l$	40.88 – 40.88
9.6 (max.)	14	$r = 4.01 + .230\, l$	38.50 } 38.07
9.6 (min.)	15	$r = 3.92 + .052\, l$	37.63 }
			Mean, 39.41

TABLE XVII. — Whistling Arc.

Current.	Number.	Equation.	E. M. F. $= a \times C$.
5.1 (max.)	16	$r = 2.95 + 2.67\, l$	15.04 }
5.1	17	$r = 2.85 + 2.07\, l$	14.54 } 14.71
5.1 (min.)	18	$r = 2.85 + 2.03\, l$	14.54 }
7.3	19	$r = 1.95 + 1.32\, l$	14.23 – 14.23
10.2 (max.)	20	$r = 1.30 + 0.846\, l$	13.26 } 13.26
10.2 (min.)	21	$r = 1.30 + 0.583\, l$	13.26 }
			Mean, 14.07

It will be seen from the figures in the last column that the fluctuations of the voltmeter to which we have referred were, for the most part, due to variations in the conductive resistance of the arc, the inverse electromotive force being almost constant for the same current, notwithstanding the variations occurring in the total resistance. With the whistling arc the inverse electromotive force is decidedly less for the same current in the inverted than in the upright arc, and the same is probably true to a less degree with the silent arc, though this is not so clearly shown in our observations, partly on account of an exceptionally high value for the inverse electromotive force with the current of 7.3 ampères and inverted arc.

It will also be observed that the corresponding values of the conductive resistance (bl) and the total equivalent resistance are both somewhat less for the inverted arc. This differs from a result somewhat doubtfully recorded by Niaudet.*

The points of intersection of the lines corresponding to the two varieties of the inverted arc are given in the following table, as read from the curves. They may also, of course, be obtained by solution of the equations.

TABLE XVIII.

Current.	Equivalent Resistance.	Distance between Carbons.
5.1 (max.)	8.92	$\frac{2.2}{32}$ = .069 in.
5.1	9.05	$\frac{3.0}{32}$ = .094 in.
5.1 (min.)	8.74	$\frac{2.9}{32}$ = .091 in.
7.3	6.32	$\frac{3.3}{32}$ = .103 in.
9.6–10.2 (max.)	5.02	$\frac{4.4}{32}$ = .137 in.
9.6–10.2 (min.)	4.16	$\frac{4.9}{32}$ = .153 in.

Comparing this with the table already given for the upright arc, it appears that with the inverted arc the length at which the higher inverse electromotive force sets in is somewhat greater. The corresponding equivalent resistance is not greatly different in the two cases.

Measurements were also made of the resistance of arcs into which certain metallic salts had been introduced. The salt, in powder, was placed on the lower (negative) carbon while this was quite hot, care being taken entirely to cover the carbon point, and to keep the powder from being jarred off on forming the arc. The reading of the voltmeter for a given length of arc remained quite constant for a short time after the arc was established, so that readings could readily be obtained.

Observations were made with arcs containing biborate of soda, sulphate of soda, and sulphate of potash. The arcs employed were from $\frac{1}{32}$ to $\frac{4}{32}$ in. in length with the biborate of soda, from $\frac{1}{32}$ to $\frac{5}{32}$ with the sulphate of soda, and from $\frac{1}{32}$ to $\frac{16}{32}$ with the sulphate of

* Machines Electriques à Courants Continus, p. 133.

potash. The current was approximately 5 ampères. The equation $r = a + bl$ still expressed the results as follows: —

TABLE XIX.

Current.	Salt.	Number.	Equation.
5.10	Biborate of Soda	22	$r = 1.25 + .290\ l$
4.94	Sulphate of Soda	23	$r = 2.20 + .418\ l$
5.10	Sulphate of Potash	24	$r = 1.77 + .223\ l$

The values of the inverse electromotive force were for biborate of soda 6.38 volts, for sulphate of soda 10.86 volts, and for sulphate of potash 9.03 volts. The conductive resistance, as well as the inverse electromotive force, is diminished by the presence of the salts in the arc.

The data from which the curves giving the preceding equations were constructed, are given in the following tables.

TABLE XX.

Biborate of Soda.

Current = 5.10 ampères.

Length.	Resistance.
1	1.53
2	1.82
3	2 12
4	2.41

TABLE XXI.

Sulphate of Soda.

Cnrrent = 4.94 ampères.

Length.	Resistance.
1	2.64
2	2.98
3	3.43
4	3.85
5	4.00

TABLE XXII. — Sulphate of Potash.

Current = 5.10 ampères.

Length.	Resistance.
1	2.00
2	2.21
3	2.49
4	2.71
5	2.96
6	3.08
7	3.29
9	3.82
11	4.21
13	4.58
15	4.91

Whatever may prove to be the real cause of the inverse electromotive force of the arc, it is clear that it is intimately connected with variations in the temperature of the carbons. Thus both the actual temperature and the difference of temperature between the carbons is greater with the silent than with the whistling arc, and at the same time the inverse electromotive force of the former is the higher. Again, the temperature of the carbons is apparently lowered when metallic salts are introduced into the arc, and the inverse electromotive force falls at the same time. Edlund * found that by heating the negative carbon by a blast-lamp, the inverse electromotive force was raised; but this was not the case when the flame of the lamp was directed against the positive carbon, and in fact there then seemed to be a fall. It seems very probable that this last result came from the fact that the positive carbon was so much hotter than the flame that the effect of the latter was on the whole to cool the arc. We endeavored to increase the temperature of the positive carbon in a different manner, by surrounding it with a deep cup-shaped shield of fire-clay, which projected over the end of the carbon so as to envelop the arc, thus preventing radiation. At the same time a broad, flat, horizontal plate of brass was attached to the lower and negative carbon. This obstructed the access of air to the arc, and thus tended to keep up its temperature.

A current of 7 ampères was employed, with arcs varying from $\frac{1}{32}$ to $\frac{12}{32}$ in. in length. As the carbons could not be filed in these experiments, the length of the arc was obtained by screwing the points into contact while the current was passing, and then separating them to the required distance. A moderately high wire resistance was placed in the circuit with the arc, so that there was no material change in the strength of the current and condition of the dynamo machine caused by this adjustment of the carbons, and the needed measurements could be made rapidly. There was considerable periodic fluctuation of the reading of the voltmeter, as had been noticed previously with the inverted arc, and two curves were drawn corresponding to the extreme readings. The current was sensibly constant. The highest set of values for the equivalent resistances corresponding to different lengths of arc are satisfied for the silent arc by the equation (25) $r = 6.70 + .16\ l$, and for the whistling arc by the equation (26) $r = 3.02 + 1.10\ l$. The corresponding values of the inverse electromotive force are 46.9 volts and 21.1 volts. The lowest set

* Pogg. Ann., vol. cxxxiv. p. 250.

of values are satisfied by the equations (27) $r = 6.70 + .09\, l$ for the silent arc, and (28) $r = 3.02 + .97\, l$ for the whistling arc. The corresponding values of the inverse electromotive force are the same as before, viz. 46.9 and 21.1, respectively, showing that the changes observed in the difference of potential between the carbons were due to variations in the conductive resistance, and not to variations in the inverse electromotive force of the arc. These resistance variations, while amply large to affect the readings of the voltmeter, were too small to produce any sensible change in the strength of the main current. It also appears by a comparison of the equations just given for the shielded arc with equations (2) and (7) that the coefficient of l is decidedly less with the shielded arc, showing that the conductive resistance of the arc is diminished by the increased temperature, as would be anticipated. The increased inverse electromotive force is much greater than we had expected to find it, and at first might lead one to surmise why, with the ordinary arc, the inverse electromotive force does not rise with increased strength of current. This is probably to be explained by the fact that the chief effect of an increase in current is to heat a larger area of the carbons to the same temperature, rather than to raise them to a considerably higher temperature.

Observing the position of the point of intersection of the lines representing the silent and whistling arcs, we find that the passage from low to high inverse electromotive force occurs with a length of arc of $\frac{3.92}{32} = .123$ in. for the line represented by equation (26), and of $\frac{4.20}{32} = .131$ in. for that of equation (28), which values are greater than those occurring with the normal arc and the same strength of current. The corresponding equivalent resistances are 7.34 ohms and 7.07 ohms.

We next tried the reverse experiment of cooling the upper positive carbon. This was done by surrounding the lower end of the carbon with a brass tube through which a current of cold water flowed. The negative electrode was left in its usual condition. The arc under these conditions was extremely unstable; the slightest breath would extinguish it, and even with a current of 10 ampères it could not be elongated to a greater length than $\frac{3}{32}$ in. It was quite blue, whistled, and gave but very little light. The extreme length of arc used was $\frac{3}{32}$ in. with the weaker, and $\frac{2}{32}$ in. with the stronger current. Plotted curves gave the following equations, satisfying the observations with tolerable exactness.

Current.	Number.	Equation.
7	29	$r = 1.67 + 1.11\, l$
8	30	$r = 0.70 + 1.82\, l$

The corresponding inverse electromotive forces are 11.7 volts and 5.6 volts respectively. Both of these are much below the value already found for the whistling arc under normal conditions. But we also find here, for the first time, a great difference between the inverse electromotive force with different currents. As with the normal arc, the higher value occurs with the lesser current. With the current of 7 ampères the conductive resistance is lower than with the normal arc, but with 8 ampères it is higher. Owing to the low inverse electromotive force, the total resistance is considerably less with both strengths of current.

It was our intention to observe also the effect of cooling the negative carbon, but this was prevented by an accident to the apparatus. There is no reason to suppose, in the light of Edlund's experiments already cited, that this would have made any change in the nature of the results.

This fall of inverse electromotive force with lowered temperature of the arc may be the explanation of the fall which occurs with the inverted arc, as the increased convection when the hot positive crater is turned upward may be sufficient to lower the temperature by a slight amount.

The following tables give the data from which our equations were determined.

TABLE XXIII.

Positive Carbon Heated.

Current = 7 ampères.

Length.	Resistance.	
	Minimum.	Maximum.
1	3 86	4.24
2	4 91	5.15
3	5.90	6.36
4	6 97	7.42
5	7.42	7.42
6	7.27	7.66
7	7.31	7.88
8	7.21	7.97
9	7.57	8 10
10	....	8.48
11	....	8.64
12	....	9.10

TABLE XXIV.

Positive Carbon Cooled.

Current = 7 ampères.

Length.	Resistance.
1	2.72
2	3.96
3	4.99
Current = 8 ampères.	
1	2.52
2	4.35

For observations on the arc formed under diminished pressure and in different gases, a metallic receiver was constructed in which the rod carrying the upper carbon passed through the closed top of the receiver, and was movable by means of a micrometer screw. A window set in the side of the receiver allowed observation of the arc. The exhaustion could be read by an attached gauge. The rubber screw plug, through which the rod passed, was covered with oil or glycerine to diminish the leakage. The construction of the apparatus was greatly delayed by unforeseen circumstances, so that up to the present date we have been able to make only a very few experiments. Some difficulty has also been met with from the heating and vaporization of portions of liquid which have leaked into the receiver. This was partially avoided by immersing the receiver in water. In the experiments thus far made with this apparatus, the pressure was 4 inches of mercury. Currents were employed of 5, 7.95, and 9.86 ampères respectively, with lengths of arc from $\frac{1}{64}$ to $\frac{6}{32}$ inch. In all the experiments the positive carbon was uppermost. The arc was found to be a whistling one up to the extreme limits obtained. The results of the experiments are given in Table XXV.

TABLE XXV.

Current = 5.00 ampères.

Length.	Resistance.
0.50	3.70
1.00	4.42
1.00	4.33
2.00	5.38
2.00	5.38
3.00	7.12*
3.00	7.12*
4.00	7.68

Current = 7.95 ampères.

Length.	Resistance.
0.50	1.69*
1.00	2.45
1.00	2.57
2.00	3.06
2.00	3.21
3.00	3.70
3.00	3.66
4.00	4.28
4.00	4.17
5.00	4.93
5.00	4.80
6.00	5.51
6.00	5.37

Current = 9.86 ampères.

Length.	Resistance.
0.50	1.75
1.00	1.97
1.00	2.09
2.00	2.42
2.00	2.42
3.00	2.74
3.00	2.92
4.00	3.32
4.00	3.14
5.00	3.86

These results, when plotted as before, give straight lines, represented by the following equations.

TABLE XXVI.

Current.	Number.	Equation.	E. M. F. $= a \times C$.
5.00	31	$r = 3.30 + 1.09\,l$	16.50
7.95	32	$r = 2.00 + 0.57\,l$	15.90
9.86	33	$r = 1.70 + 0.38\,l$	16.76
			Mean, 16.39

* These values deviate greatly from the curves.

These lines are all less inclined than those for the same current with whistling arc under normal pressure; showing that as the arc is lengthened the resistance proper increases less rapidly when the pressure is reduced. The total equivalent resistance is, of course, greatly diminished by reduction of pressure, but this reduction seems to be wholly due to diminished conductive resistance, the inverse electromotive force for the arcs used, all of which were whistling ones, being even slightly greater than at normal pressure, so far as can be judged from the data at present obtained.

The scanty data at hand would not justify us, however, in concluding this apparent increase to be real. If such proves to be the case, the action is probably of the same nature as that supposed by Edlund to exist in the discharge of electricity in ordinary vacuum tubes; that is, an increase in the opposition offered to the passage of electricity from the solid electrodes, as the pressure of the intervening gaseous medium is diminished. Further experiment, extending to higher vacua, and also with increased density, is necessary before any definite conclusions can be drawn as to this point.

In addition to those facts which are commonly recognized, the following conclusions seem to be justified by our experiments.

1. There is a definite inverse electromotive force for the whistling arc, whose value is approximately 15 volts.

2. The inverse electromotive force for both the silent and whistling arcs diminishes slowly as the current increases.

3. The inverse electromotive force, at least for the whistling arc, is less for the inverted than for the upright arc.

4. The great change in equivalent resistance which occurs when volatile salts are introduced into the arc is chiefly due to a large fall in the inverse electromotive force, although there is at the same time a marked diminution in the conductive resistance.

5. The diminished total resistance of the arc in rarefied air is due solely to a diminution in the conductive resistance.

6. There is some evidence to show that, with considerable reduction of pressure, there is a slight increase in the inverse electromotive force.

Rogers Laboratory of Physics,
June, 1886.

XI.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE

ON THE DIRECT CONVERSION OF AROMATIC SULPHONATES INTO THE CORRESPONDING AMIDO COMPOUNDS.

By C. Loring Jackson and John F. Wing.

The action of sodium or potassium amide on organic substances has been studied but little; in fact, when we took up the subject, there were no papers more recent than those of Beilstein and Geuther * on sodium amide in 1858, and of Baumert and Landolt † on potassium amide in 1859. The reason for this neglect may be found probably in the curious observation made in both of these papers, that the alkaline amides are not acted on in the way which we should expect by most haloid organic compounds, neither ethylchloride, or iodide, nor chlorbenzol, nor acetylchloride giving the corresponding amido compounds; ‡ in fact, benzoylchloride is the only haloid organic compound tried which acted as would be expected, giving benzamide and dibenzamide. Accordingly, in taking up the subject, we have turned our attention to the effect of sodium amide on sulphonates, in the hope of obtaining an action similar to the well-known replacements of the sulpho-group by hydroxyl, cyanogen, or carboxyl, when fused with potassic hydrate, cyanide, or formiate respectively. This expectation

* Ann. Chem., cviii. 88.

† Ibid., cxi. 1.

‡ These results so far as the ethyl compounds are concerned have been confirmed recently by J. Walter, who, in a paper (Journ. pr. Chem., xxxiv. 132) drawn out by the preliminary notice of our work, states that at low temperatures no ethylamine is formed from ethylbromide; but by heating the sodium amide until it begins to melt, and passing over it a stream of hydrogen impregnated with ethylbromide, ethylamine was formed, recognized by the carbylamine reaction. Under similar conditions brombenzol gave small quantities of aniline. He however does not consider it proved, that the amine was formed from the sodium amide, rather than from the ammonia set free during the reaction.

has been fulfilled, as by heating potassic benzolmonosulphonate with sodium amide we have obtained aniline, and in the same way metaphenylenediamine from potassic benzolmetadisulphonate; but unfortunately the yield, especially in the latter case, is so small, that the method could hardly be used with profit for the preparation of new amido compounds, so that its usefulness must be confined to determinations of constitution.

The sodium amide was prepared according to the method of Beilstein and Geuther, that is, passing dry ammonia gas over sodium heated in a series of small flasks, except that after the first experiment we dispensed with the use of hydrogen for expelling the air from the flasks before the sodium was heated, using the ammonia gas itself for that purpose.

Action with Potassic Benzolmonosulphonate. — One of the flasks containing the sodium amide was broken, its contents pulverized as rapidly as possible, and mixed (without separating the powdered glass from the flask) with anhydrous potassic benzolmonosulphonate in about the proportion of one molecule of each, calculated from the amount of sodium used in making the amide. The mixture was then heated gently over the lamp in a test-tube until the brown fused spots, which appear at first, had spread throughout the entire mass; but the process should be stopped before these spots show signs of decomposition, as, if the heat is carried too high, the yield is not so large. During the heating some aniline vapor escapes, but the amount of this is so insignificant, that it is not worth while to carry on the process in a retort. The product was then carefully treated with water, and distilled with steam as long as anything passed over. The presence of aniline in the turbid distillate was determined by its smell, by the strong purple color which the distillate gave with a solution of bleaching-powder, and by the analysis of the chloride made by adding dilute hydrochloric acid to the distillate, filtering, and evaporating to dryness.

0.4966 gr. of the salt gave 0.554 gr. of argentic chloride.

	Calculated for $C_6H_5NH_3Cl$.	Found.
Chlorine	27.41	27.60

The yield varied a great deal, but was in the neighborhood of 10 per cent, rising once as high as 15 per cent of the theory. The portion of the distillate insoluble in dilute hydrochloric acid consisted of white scales, which, after repeated recrystallization from ligroine, melted between 53° and 54°, and gave an intense blue color with strong nitric acid. We therefore inferred that they consisted of diphenylamine, an inference confirmed by the analysis of the chloride prepared by the action of strong hydrochloric acid and alcohol on the substance, which gave the following result.

0.1334 gr. of the salt gave 0.0916 gr. of argentic chloride.

	Calculated for $(C_6H_5)_2NH_2Cl$.	Found.
Chlorine	17.27	16.97

The formation of diphenylamine by this reaction would seem to show that the sodium amide used by us was a mixture of $NaNH_2$ with Na_2NH, whereas Beilstein and Geuther proved that the formula of their sodium amide was $NaNH_2$. The explanation of this difference probably can be found in the fact that our amide still contained an excess of sodium, the flasks used by us not being made of a sufficiently resistant glass to allow us to carry the reaction to an end, while in their experiments all the sodium was converted into the amide. It is also possible, but not probable, that the diphenylamine was formed by a secondary reaction from the aniline.

Some experiments to determine the temperature at which the reaction takes place showed that some amine was obtained at 280°, and the yield was not improved at 300–350°; but that a much better result was reached by heating over the free lamp than with an oil- or air-bath, the products at the temperatures given above amounting respectively to 6.8 and 5.4 per cent of the theoretical, or about one half of the amount obtained by the more rapid direct heating over the lamp.

Action with Potassic Benzolmetadisulphonate. — The salt mixed with about the equivalent amount of sodium amide was heated in a test-tube as before; but it was found necessary in this case to continue the heating until the brown spots which formed at first had turned black, and showed signs of decomposition, since, if the action was stopped while they were still brown, as in the case of the monosulphonate, the yield was exceedingly small. At best, the yield was not satisfactory, reaching at the outside five per cent of the theory, so that we did not attempt to collect enough of the tolerably unstable chloride of the metaphenylenediamine for analysis, but contented ourselves with proving its presence by qualitative tests. For this purpose, the product of the reaction was cautiously treated with water, and the aqueous solution extracted with ether; one portion of the ether extract was shaken with dilute sulphuric acid, and to the acid solution thus obtained a very minute amount of sodic nitrite was added, which turned it yellow; another portion of the ether extract was shaken with dilute hydrochloric acid, the acid solution evaporated to dryness, and the residue redissolved in water, filtered from brown decomposition products, and treated with a solution of sodic nitrite, when a heavy reddish brown precipitate of phenylene brown was formed; finally, another portion of the ethereal solution of the base was treated with a solution of the nitrate of diazobenzol, when a red crystalline precipitate was formed, which turned yellow upon the addition of ammonic hydrate, and was therefore the nitrate of chrysoidine. All these tests indicate the presence of metaphenylenediamine in the product of the action of sodium amide upon the potassic benzolmetadisulphonate. The small yield is undoubtedly due to decomposition of a portion of the diamine at the comparatively high temperature necessary for the reaction, as there was a large amount of tarry matter always associated with the product.

XII.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

ON BENZYLDIMETHYLAMINE.

BY C. LORING JACKSON AND JOHN F. WING.

AT the beginning of the last academic year we prepared the benzyldimethylamine with the intention of making an extended research on this substance; but as the carrying out of this research has been indefinitely postponed on account of the pressure of other more interesting work, we have thought it proper to publish the results already obtained, consisting of the preparation and properties of the base and some of its salts, for the benefit of any one who may follow us in this line of research, rather than on account of any especial interest in the results themselves.

The benzyldimethylamine has been already obtained by Schotten,* as one of the products of the distillation of the free base derived from the addition product of methylbenzylpiperidine and methyliodide; but he contented himself with the determination of its presence by the analysis of its chlorplatinate.

Benzyldimethylamine. — To prepare the substance an alcoholic solution of dimethylamine was made by the decomposition of nitrosodimethylaniline, according to the method of Baeyer and Caro,† the gas being passed into absolute alcohol, and this was allowed to stand for some hours with benzylchloride. At the end of this time, the reaction, which was accompanied with evolution of heat, was finished; and after distilling off the alcohol on the water-bath, the product was treated with water, and then with hydrochloric acid, after which it was extracted with ether to remove a slight non-basic impurity. The base was then set free with sodic hydrate, extracted with ether, washed in the ethereal solution, dried with potassic hydrate, and purified by distillation after driving off the ether. The aqueous liquid, from which

* Ber. d. ch. G., 1882, p. 424.

† Ibid., 1874, p. 963.

the base was extracted with ether, contains the excess of dimethylamine, and the chloride of dibenzyldimethylammonium, the extraction of which will be described later in this paper.

Properties of the Benzyldimethylamine. — It forms a colorless liquid with a peculiar smell, boiling at 183–184° * with the column entirely in the vapor and the barometer at 76.53 cm. It is insoluble in water, but mixes freely with alcohol or ether. Two attempts to convert it into a nitroso-compound gave negative results.

The *Chloride* is deliquescent, and forms white radiating crystals.

The *Nitrate* is also deliquescent, so that crystals can be obtained only with difficulty; it forms slender white needles, with many shorter ones crossing them at right angles.

The composition of the base was determined by the analysis of its chlorplatinate and acid ferrocyanide.

Chlorplatinate, $[C_7H_7(CH_3)_2N]_2H_2PtCl_6$. — The salt was prepared by adding chlorplatinic acid to the free base, purified by crystallization from water, dried at 100°, and analyzed.

I. 0.2288 gr. of the salt left on ignition 0.0656 gr. of platinum.
II. 0.3320 gr. left 0.0944 gr. of platinum.
III. 0.3994 gr. left 0.1148 gr. of platinum.
IV. 0.4244 gr. left 0.1216 gr. of platinum.

	Calculated for $[C_7H_7(CH_3)_2N]_2H_2PtCl_6$.	Found. I.	II.	III.	IV.
Platinum	28.63	28.67	28.43	28.74	28.65

Properties. — The appearance of the substance varied a great deal, according to the conditions under which the crystals were obtained; thus we have observed it in thick orange prisms, in long yellow needles, or in pointed crystals shaped like a spear-head. † It is slightly soluble in water, and in alcohol. Water is the best solvent for it, good crystals being easily obtained from the aqueous solution.

Ferrocyanide, $(C_7H_7(CH_3)_2N)_2H_4Fe(CN)_6$. — This substance was obtained as a white precipitate, when a solution of potassic ferrocyanide was added to a slightly acid solution of the chloride. It contains no water of crystallization, and its composition was determined by the following analyses.

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* This determination of the boiling point was made with too small a quantity of the substance, and must be considered as merely approximate. If we had continued the research, we should have repeated it on a more satisfactory scale.

† The identity of the substance in all these forms was proved by analyses.

I. 0.5224 gr. of the salt dried in vacuo gave on ignition 0.0852 gr. of ferric oxide.

II. 0.3714 gr. gave 0.0612 gr. of ferric oxide.

	Calculated for $[C_7H_7(CH_3)_2N]_2H_4FeCN$.	Found. I.	II.
Iron	11.53	11.41	11.53

Properties. — It forms white pearly scales, which are very sparingly soluble in water, and on exposure to the air turn slightly green, but the amount of the decomposition thus indicated is so small as to be inappreciable by analysis.

With mercuric chloride the base gave an uninviting viscous product, while with zincic chloride it formed a characteristic double salt, which separated from concentrated solutions as an oil, but soon solidified in good-sized rhombic crystals; an analysis of a not perfectly pure sample of this salt led to the following results.

0.3492 gr. of the salt gave 0.4090 gr. of argentic chloride.

	Calculated for $[C_7H_7(CH_3)_2NHCl]_2ZnCl_2$.	Found.
Chlorine	29.65	28.95

Dibenzyldimethylammonic Chloride, $(C_7H_7)_2(CH_3)_2NCl$. — This substance was left in the aqueous solution after the benzyldimethylamine had been shaken out with ether, and, when this solution was evaporated to one half its original volume, separated as a yellow oil, which solidified as it cooled. It can be freed partially from the inorganic salts present mechanically, or by solution in chloroform, although chloroform does not remove it from its aqueous solution, and purified by washing with a saturated solution of sodic carbonate, and finally dissolving it out of the inorganic impurities with alcohol or chloroform.

Properties. — It forms white rhombic crystals often in spear-head forms and a centimeter broad, or masses of radiating prisms or needles, but usually separates from its solutions as an oil, which solidifies after standing for some time, more rapidly if touched with a crystal of the substance. It is freely soluble in water, but nearly insoluble in a saturated solution of sodic carbonate, soluble with some difficulty in alcohol, but freely in chloroform, which is the best solvent for it; it is also soluble in ether, benzol, carbonic disulphide, and glacial acetic acid, insoluble in ligroine. When heated, it gives benzylchloride, recognized by its smell and action on the eyes, and a base, which however seems to boil at a higher temperature than the benzyldimethylamine; but the experiment should be repeated on a larger scale. If the aqueous solution of the chloride is boiled with argentic oxide, it becomes strongly alkaline, but it is necessary to boil for some days in order to convert it completely into the free base.

Dibenzyldimethylammonic Chlorplatinate, $[(C_7H_7)_2(CH_3)_2N]_2PtCl_6$. — This substance was prepared by adding an alcoholic solution of the chloride to chlorplatinic acid, and purified by recrystallizing from water. Its composition was determined by the following analysis.

0.2012 gr. of the salt gave 0.0454 gr. of platinum.

	Calculated for $[(C_7H_7)_2(CH_3)_2N]_2PtCl_6$.	Found.
Platinum	22.64	22.56

It is nearly insoluble in cold water, but crystallizes from a hot aqueous solution in large shining yellow plates, often a centimeter in length, or in feather-like forms.

XIII.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

A NEW METHOD FOR THE QUANTITATIVE DETERMINATION OF HYDROXYL.

By C. Loring Jackson and G. W. Rolfe.

The methods now in use for determining the number of hydroxyl radicals in a molecule can be divided into two classes, — those which consist in the analysis of the acetyl or benzoyl compound, and those which depend on the saponification of the acetyl compound and the quantitative determination of one or other of the products of the decomposition. Methods of the first class cannot be applied to substances having large molecular weights, as then the differences in percentage composition approach the limit of error of the analysis; and even methods of the second sort have led to false conclusions in many cases, (for instance, with æsculine and æsculetine, which give soluble compounds with magnesic hydrate,) or are inapplicable, owing to the instability of the compound with saponifying agents. We have worked out, therefore, a new method for determining hydroxyl quantitatively, which is applicable in cases where the methods now in use can be applied only with difficulty or give uncertain results, and, we hope, will commend itself also in other cases on account of its simplicity, as it does away with the additional operation of saponification — often a tedious one — necessary in methods of the second class.

Our process consists in converting the substance into its parabrombenzoyl compound, and determining the amount of bromine introduced by an analysis according to the method of Carius. It therefore belongs with methods of the first class, but has the advantage that the differences in percentage composition are larger than when carbon and hydrogen are determined in the benzoyl or acetyl compounds, as is shown by the following comparison of the differences caused by the presence of one more hydroxyl in the molecule between the percentages of carbon in the benzoyl and of bromine in the brombenzoyl derivatives of æsculetine, æsculine, and fisetine,* substances which we have selected for calculation on account of the differences in their molecular weights.

Name and Formulas of Substance.	Benzoyl Compound. Difference in % of C.	Brombenzoyl Compound. Difference in % of Br.
Æsculetine, $C_9H_3O(OH)_3$ $C_9H_4O_2(OH)_2$	1.97	3.60
Æsculine, $C_{15}H_{10}O_3(OH)_6$ $C_{15}H_{11}O_4(OH)_5$	0.90	1.50
Fisetine, $C_{23}H_{10}O_3(OH)_6$ $C_{23}H_{11}O_4(OH)_5$	0.78	1.66

The numbers given in the third column of the above table are far enough removed from the maximum analytical error to leave no doubt in regard to the composition of the substance; and we may add, that, as far as our experiments go, the parabrombenzoates show a much greater tendency to crystallization than the corresponding benzoates, so that in most cases the error from incomplete purification can be reduced to a minimum.

In deciding which acid containing bromine was the best adapted to our purpose, we rejected the fat acids, although, other things being equal, they were to be preferred on account of the greater differences in the percentages of bromine, because we feared the removal of a portion of the bromine in the preparation or purification of the ester, and accordingly selected from the aromatic acids that one which we found could be prepared most easily, that is, the parabrombenzoic acid.

In the remainder of the paper we give the details of the methods which we found most convenient for the preparation of the parabrombenzoic acid, and its chloride and anhydride, as well as a few experiments on the formation of parabrombenzoyl esters, undertaken to determine whether these bodies could be formed as easily as the corresponding benzoyl compounds, but we have not considered it necessary to extend these experiments to the less accessible substances, or to multiply them for the commoner bodies, as those which we have tried are sufficient to prove the general application of the method; showing that the parabrombenzoylchloride is as reactive as benzoylchloride, and

* Schmid, Ber. d. ch. G., 1886, p. 1351.

that the anhydride, although on account of its high melting-point somewhat less manageable than the non-substituted one, acts excellently on all substnnces which can stand a high temperature, and can usually be made to act on those which cannot by heating with anhydrous benzol in a sealed tube. As all the derivatives of parabrombenzoic acid described in this paper, with the exception of the chloride, are new, we give a full account of their properties, as a contribution to our knowledge of this hitherto neglected acid.

Preparation of Parabrombenzoic Acid.

Although this method offers no new features, we think it best to describe it as a matter of convenience for those who may wish to obtain the acid in quantity. The first step is the preparation of crude monobromtoluol by mixing toluol with ten per cent of its weight of iodine and the calculated amount of bromine. After the mixture has stood at the ordinary temperature for twelve hours, the product is washed with sodic hydrate and water, the bromtoluol fractioned, and the portion boiling from 180° to 190° oxidized by boiling 150 gr. of it in a flask with a return-condenser for twelve hours with 400 gr. of potassic dichromate and 550 gr. of sulphuric acid diluted with twice its bulk of water. The unoxidized oil, consisting of orthobromtoluol with a little para, is distilled off with steam, and the acid purified by washing with water and conversion into the sodic salt. The product is free from the isomeric brombenzoic acids, as shown by its melting point, 248–250° (uncorr.). The yield varied from 40 to 70 per cent of the weight of crude bromtoluol used, and a preparation can be carried through from toluol to the pure acid in less than one week.

Parabrombenzoylchloride, $C_6H_4BrCOCl$. — This substance has been prepared by J. W. Raveill,* under the direction of Hübner; but he gives only the most meagre description of it, stating that it forms colorless, easily fusible, volatile needles. It is prepared without difficulty by heating a mixture of phosphoric pentachloride and the dry acid in a flask to 100° until the reaction has ceased, when the temperature is to be raised to 150°, and kept at this point until the greater part of the phosphoric oxychloride formed has passed off. The chloride is then extracted with ligroine and purified by distillation. The yield is about 80 per cent. Its composition was determined by the following analyses: —

* Ann. Chem., ccxxii. 178, note.

I. 0.4010 gr. of the substance gave on combustion 0.5575 gr. of carbonic dioxide and 0.0745 gr. of water.

II. 0.2273 gr. gave by the method of Carius 0.3448 gr. of the mixture of argentic chloride and bromide.

III. 0.4160 gr. gave by the same method 0.6278 gr. of the mixture of argentic chloride and bromide.

IV. 0.3014 gr. gave, when boiled with a solution of pure potassic hydrate, after acidification with nitric acid and precipitation with argentic nitrate, 0.1962 gr. of argentic chloride.

V. 0.4284 gr. gave by the same method 0.2773 gr. of argentic chloride.

	Calculated for $C_6H_4BrCOCl$.	Found. I.	II.	III.	IV.	V.
Carbon	38.26	37.92				
Hydrogen	1.82	2.06				
Chlorine and bromine	52.62	. . .	52.61	52.86		
Chlorine	16.17	. . .	. . .	. . .	16.08	16.01

Properties. — White needles with an odor similar to that of benzoylchloride, but much less marked, owing to its higher boiling point; melting point, 30°. It boils at 245–247° * (uncorr.) with slight decomposition; water does not dissolve it, and acts upon it very slowly, if at all, in the cold, more rapidly when boiling; it is easily soluble in ligroine or benzol, while alcohol dissolves it with conversion into the ethylester, a viscous liquid with an odor similar to that of oil of anise.

Parabrombenzoic Anhydride, $(C_6H_4BrCO)_2O$. — This substance was prepared by heating the sodic parabrombenzoate with parabrombenzoylchloride not in excess; convenient proportions are 3 gr. of the sodic salt to 2 gr. of the chloride. The mixture was heated in a flask with an air-condenser for an hour to 200° by means of a paraffine bath, and the product purified by washing, first with ligroine, then with a strong solution of sodic carbonate, and finally with benzol to remove the tarry impurities. The yield was about 50 per cent. Owing to its very slight solubility in all the common solvents, we did not attempt to purify it by crystallization, but this was fortunately unnecessary as the following analyses show that the substance purified as above by washing is essentially pure.

* It was not thought worth while to try to determine this temperature with greater accuracy, because of the decomposition with which the boiling is accompanied.

I. 0.2310 gr. of the substance gave by the method of Carius 0.2260 gr. of argentic bromide.

II. 0.2167 gr. gave 0.2138 gr. of argentic bromide.

	Calculated for $(C_6H_4BrCO)_2O$.	Found. I.	II.
Bromine	41.67	41.64	41.99

Properties. — As obtained by the method described above, it forms an odorless, bulky, white powder; crystallized from chloroform, it forms minute oblong rectangular plates; from benzol, small pointed needles; melting point, 212–213°. It is insoluble in water, and apparently not decomposed by it even when boiling; almost insoluble in ether, glacial acetic acid, or carbonic disulphide; slightly soluble in benzol, somewhat more so in chloroform, which is the best solvent for it; hot alcohol dissolves it freely, converting it into the ethylester, as shown by the characteristic odor of that substance. Cold sodic hydrate is essentially without action on it, but decomposes and dissolves it slowly when warmed with it.

Phenylparabrombenzoate, $C_6H_4BrCOOC_6H_5$. — This substance was made by heating phenol and parabrombenzoylchloride in a flask with a return-condenser to about 200°. It was also prepared from phenol and parabrombenzoic anhydride at the same temperature. The product, a waxy solid, was purified by crystallization from alcohol, dried at 100°, and analyzed.

I. 0.1927 gr. of the substance gave by the method of Carius 0.1295 gr. of argentic bromide.

II. 0.1051 gr. gave 0.0710 gr. of argentic bromide.

	Calculated for $C_6H_4BrCO_2C_6H_5$.	Found. I.	II.
Bromine	28.88	28.61	28.76

Properties. — White scales with a pearly lustre somewhat resembling naphthaline; it has a slight agreeable odor, and melts at 117°. It is insoluble in water, readily soluble in alcohol, methyl alcohol, ether, benzol, chloroform, or carbonic disulphide, less so in ligroine, and not freely soluble in glacial acetic acid. Alcohol is the best solvent for it.

Phenylbenzoate is a well-crystallized substance melting at 68–69°.

Pyrogallol Triparabrombenzoate, $(C_6H_4BrCOO)_3C_6H_3$. — This substance was made by the action of parabrombenzoylchloride on pyrogallol at 100° for six hours. After removing the excess of the chloride with ligroine, the residue was washed with a boiling solution of sodic carbonate, and the slightly yellowish waxy solid purified by crystallization from hot benzol. Its composition was determined by the following analyses: —

I. 0.1569 gr. of the substance gave by the method of Carius 0.1322 gr. of argentic bromide.

II. 0.1153 gr. gave 0.0963 gr. of argentic bromide.

	Calculated for $(C_7H_4BrO_2)_3C_6H_3$.	Found. I.	Found. II.
Bromine	35.56	35.85	35.55

Properties. — It forms a white crystalline powder made up of microscopic diamond-shaped plates, which belong to the monoclinic system, to judge from their behavior toward polarized light; melting-point, 140°. Freely soluble in benzol, ether, or chloroform, very slightly soluble in alcohol, glacial acetic acid, or carbonic disulphide, and essentially insoluble in water or ligroine. Hot benzol is the best solvent for it.

It is an important point in favor of our method, that this is a crystalline substance, whereas the product of the action of benzoylchloride on pyrogallol was, according to Nachbaur,* resinous, and the difficulties in the way of its purification were so great that its formula could not be determined with certainty.

Parabrombenzamide, $C_6H_4BrCONH_2$. — This substance was prepared, as a contribution to our knowledge of the derivatives of parabrombenzoic acid, by the action of strong ammonic hydrate on the parabrombenzoylchloride. The white curdy precipitate thus obtained was purified by three recrystallizations from boiling water. Its composition was determined by the following analyses: —

I. 0.3012 gr. of the substance gave 18.6 c.c. of nitrogen gas under a pressure of 767 mm. and a temperature of 18°.

II. 0.1326 gr. of substance gave by the method of Carius 0.1260 gr. of argentic bromide.

	Calculated for $C_6H_4BrCONH_2$.	Found. I.	Found. II.
Nitrogen	7.00	7.20	
Bromine	40.00	. . .	40.44

Properties. — It forms small white rectangular plates with a pearly lustre; melting point, 186°. It is insoluble, or nearly so, in cold water, soluble in hot, and in alcohol, ether, or glacial acetic acid, very slightly soluble in chloroform, and essentially insoluble in ligroine, benzol, or carbonic disulphide.

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* Wien. Acad. Ber., xxiv. 270.

XIV.

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF THE MUSEUM OF HARVARD UNIVERSITY.

VII. — ON CERTAIN CULTURES OF GYMNOSPORANGIUM, WITH NOTES ON THEIR RŒSTELIÆ.

By Roland Thaxter.

Presented December 8, 1886.

In a paper entitled "Notes on some Species of Gymnosporangium and Chrysomyxa of the United States," communicated to the Academy in February, 1885, Prof. Farlow gave an account of certain cultures conducted by him with a view to determine the relation of the species of *Gymnosporangium* found in this vicinity to the different *Rœsteliæ* growing in the same locality; and it is the object of the present paper to supplement these observations by an account of further experiments on the subject undertaken by the writer while studying in Prof. Farlow's laboratory during the past spring.

The more important results obtained have already been published in an article read by Prof. Farlow before the American Association for the Advancement of Science, at Buffalo, and contained in the September number of the Botanical Gazette; yet a somewhat more detailed account may be of interest, together with some further observations on the species of *Rœstelia* which may serve to explain several doubtful points in this connection. As a guide also to those unacquainted with the cycle of development of these fungi, it may not be amiss, before considering the cultures, briefly to summarize it.

The species of *Gymnosporangia*, or cedar apples as they are popularly known, are fungi parasitic upon certain cedars, — in this vicinity *Juniperus communis* and *Virginiana* together with *Cupressus thyoides* being the species attacked, — upon which they produce distortions more or less characteristic in appearance. At maturity, towards the close of spring, the fungus consists of certain sporiferous masses emerging from the distortions produced by the growth of its mycelium in the stem or leaves of the host plant. When moistened, these masses expand to many times their former size, becoming soft and gelatinous, while the spores upon their surface germinate with great rapidity. This germination consists in the growth of certain hyphæ (*promycelia*), which in turn bear laterally one or more, usually four, secondary spores, known as *sporidia;* or simply break up by the formation of transverse partitions into spore-like bodies having a similar function. These sporidia are then carried by the wind, often very considerable distances, until they come in contact with certain *Pomeæ* which furnish conditions for the further development of the fungus. In case these conditions are not supplied, the production of secondary sporidia serves as a further means of dissemination.

Having fallen upon a proper host, the sporidia produce the next phase of development by germinating, and entering the tissues of its leaves, fresh shoots, or fruit. A slight discoloration of the part affected ensues, followed by the production of flask-shaped cavities opening upon its surface known as *spermogonia*, within which are formed minute bodies, the *spermatia*, of doubtful function. These spermogonia are usually accompanied by bright orange discolorations, and by the secretion of a viscous saccharine substance attractive to insects.

The next step in development consists in the formation of *æcidia*, which appear upon the under surface of the leaves directly opposite the spermogonia, or in the same position with them if the part affected is a young shoot or fruit. The æcidia are cup-shaped bodies, within which numerous spores are produced successively, being pushed out in a mass surrounded by a membranous envelope, the *peridium*. By the rupture of this membrane the spores escape, and, carried by the wind to a proper host, produce upon it the *Gymnosporangia* from which they were originally derived. This completes the round of development, which may be summarized as follows: the *Gymnosporangia* on cedars produce spores (*teleutospores*), and these in turn produce sporidia, which, falling upon various *Pomeæ*, result in the formation of a *Rœstelia*, producing æcidial spores, which serve to reinfect the cedars with *Gymnosporangia*.

To trace this connection directly by actual experiment under test conditions was the object of the present cultures, and for this purpose seedlings and older plants of the following species were employed, viz.: *Cratægus tomentosa* and *coccinea*, *Pyrus malus*, *arbutifolia*, and *Americana*, with *Amelanchier Canadensis*. The plants were potted in most cases before the leaves were developed, towards the end of April, and kept in my rooms in Boston until the middle of July, at which time the more important results of the experiments had been reached. The locality was especially favorable for the purpose, being some miles from the nearest cedars, and this, together with the fact that only such leaves and shoots were infected as had developed after the plants were brought to Boston, went far to diminish the chance of accidental infection from outside sources.

Four rooms were at my disposal, and it was thus possible to guard against any mixture of the *Gymnosporangia* employed. A number of control plants were also used, and, by making the intervals between successive sowings sufficiently great, plants subsequently infected were made to serve a similar purpose. The *Gymnosporangia* used included all the species found in this vicinity; namely, *macropus*, *clavariæforme*, *globosum*, *biseptatum*, *Ellisii*, *clavipes*, and *conicum*. All of these, with the exception of *Ellisii*, mature at about the same time, generally during the first week in May; and a supply of branches bearing the distortions peculiar to the various species was gathered in April, before the sporiferous masses had been protruded by rains, and kept apart in water for the subsequent sowings.

The method of infection was as follows. Unexpanded sporiferous masses were put in watch-glasses with a little water, and these placed in a moist chamber, a common jelly tumbler filled with wet *sphagnum* being found convenient for this purpose. In from twelve to eighteen hours the teleutospores had as a rule produced an abundance of sporidia in the water and on the surface of the expanded masses. The latter were then torn apart, and placed directly upon the plants to be infected, which were first thoroughly sprinkled, and after infection kept, when practicable, under bell jars or cones of wet paper for about twenty-four hours; after which they were uncovered and repeatedly sprinkled. The results obtained seemed better where portions of the jelly were applied, than when water with sporidia in suspension was employed; but in the former case it is necessary to remove the dried membrane that remains, which otherwise injures the tender leaves.

In view of the theory that the spermatia are sexual in function, and fertilize a female organ, the *trichogyne*, which subsequently gives rise to the æcidium, a "fertilization" was attempted by collecting the exudations from the spermogonia in a drop of water, and painting them upon the under side of different leaves in plants infected by the same species. This was carefully followed up with *G. globosum*, without resulting in the production of any æcidia, and in two instances where æcidia were obtained (*G. biseptatum* and *macropus*) no such fertilization was attempted, thus giving no definite result for or against the sexual theory. It should be mentioned that small flies were repeatedly observed feeding on the secretions of the spermogonia; yet as these are usually confined to the upper surface of the leaves, it is difficult to understand the agency of such insects in fertilizing a female organ borne supposedly on the under side.

Turning now to the individual cultures my results with the different species were as follows.

G. MACROPUS.

April 30. Sporidia sown on
3 *Pyrus Americana.*
4 *Pyrus malus.*
3 *Cratægus coccinea.*

May 11. No result. All the plants reinfected, and in addition
2 *Amelanchier Canadensis.*
1 *Pyrus arbutifolia.*

May 13. Spots with spermogonia appeared on single leaves of two apples; but being questionable, the leaves were cut off.

May 22. Spermogonia appeared abundantly on two apples.

May 28. Two additional plants of *Pyrus malus* infected, on which spermogonia appeared.

June 5. Sporidia sown on immature fruit of *Amelanchier*, which was kept under a bell glass.

June 12. Signs of æcidia forming on the under side of the apple leaves first infected, while the leaves of those infected May 28 withered and ultimately fell off from no apparent cause. The remaining plants yielded no result whatever.

July 10. Peridia began to show on the two apples first mentioned as affected. These developed slowly, and towards the end of July were recognizable as belonging to the *Æcidium pyratum* of Schweinitz. It did not however assume the penicillate form peculiar to this *Ræstelia* until exposed to the weather; when the peridia, formerly long and barely lacerate, were turned back in the characteristic fashion.

G. CLAVARIÆFORME.

April 30. Sporidia sown on
3 *Pyrus Americana.*
3 *Pyrus malus.*

May 11. No result, and the same plants reinfected with the addition of
3 *Cratægus tomentosa.*

May 18. Spermogonia appeared on each *Cratægus*.

May 30. Signs of æcidia on all the leaves affected, localized on the midribs and veins.

June 2. Peridia began to show, which in about a week developed a *Ræstelia*, having the microscopic characters of *lacerata* (the form subsequently spoken of as *lacerata*, *x*), while the peridia were but slightly lacerate and resembled those obtained from the *macropus* culture before exposure to the weather. With the remaining plants no result was obtained.

G. GLOBOSUM.

April 30. Sporidia sown on
- 3 *Cratægus coccinea.*
- 3 *Pyrus Americana.*
- 3 *Pyrus malus.*

May 9. Spermogonia appeared abundantly on all the *Cratægus* plants, on a single leaf of *Pyrus Americana*, and on one apple.

May 16. All plants that had not produced spermogonia were reinfected without result.

June 2. Sporidia sown on
- 1 *Amelanchier Canadensis.*

June 12. Spermogonia on *Amelanchier*, not in great abundance. This plant was accidentally destroyed late in June, at which time it showed no signs of æcidia, while the remaining plants affected continued to produce spermogonia until late in July, when the leaves withered and fell off.

G. BISEPTATUM.

May 30. Sporidia sown on
- 2 *Amelanchier Canadensis.*
- 1 *Pyrus arbutifolia.*

June 12. Spermogonia on both Amelanchiers, the *Pyrus* not affected. Towards the end of June there were slight indications of æcidia in most of the affected leaves. The development of the *Ræstelia* was very slow; and though the bulbous base of *R. botryapites* was recognizable in August, it was not until early in October that peridia were developed having the appearance and microscopic characters of *botryapites*.

G. Ellisii.

June 12. Sporidia sown on detached leaves of
Pyrus arbutifolia,
Cratægus tomentosa,
and kept in a moist chamber.

June 14. Sporidia sown on
2 *Amelanchier Canadensis.*
2 *Cratægus tomentosa.*

June 20. A manifest effect on the *Pyrus* leaves which, however, moulded without actually producing spermogonia.

June 23. Yellow discolorations appeared where sporidia were sown on the *Amelanchier* plants; otherwise no further result.

G. clavipes.

May 11. Sporidia sown on
3 *Cratægus tomentosa.*
3 *Pyrus malus.*
2 *Amelanchier Canadensis.*
1 *Pyrus arbutifolia.*

May 22. Spermogonia appeared on both Amelanchiers, on two fresh shoots, as well as numerous leaves, and also upon a single apple leaf. No result with the remaining plants.

June 3. Signs of æcidia appeared on the young shoots of *Amelanchier*, one of which died, while the other,

June 12, produced *Ræstelia aurantiaca* in abundance. The leaves affected continued for some time to produce spermogonia, which showed a tendency to run along the veins and midrib.

G. conicum.

May 4. Sporidia sown on
1 *Amelanchier Canadensis.*
1 *Pyrus arbutifolia.*
3 *Pyrus Americana.*
4 *Pyrus malus.*

May 10–11. Spermogonia appeared on the *Amelanchier* and on one apple.

May 22. Signs of æcidia on most of the *Amelanchier* leaves, and,

May 31, a *Ræstelia*, apparently *R. cornuta*, was fairly well developed. No results with the remaining plants.

Such, in brief, were the results reached, and at first sight it would seem an easy matter, having obtained æcidia from five of the seven species of *Gymnosporangium*, to refer these, at least, to their respective *Rœsteliæ*. The task is, however, not so simple, for the reason that considerable confusion exists as to the identity and distinctions of the species of *Rœstelia* as they occur in nature.

Of the forms resulting from the present cultures *R. aurantiaca* and *botryapites* are unmistakable, and cannot be confounded with any other New England form, as may be said also of *R. transformans*. With the others, unfortunately, the case is different. Even with material collected out of doors it is difficult satisfactorily to separate them, either by gross appearance or microscopic characters; while a detailed examination of each species, as at present defined, is very confusing, and leads to the conclusion that the usual characterization of these species is erroneous in several respects.

The form, for instance, generally known in this country as *R. penicillata*, occurring on *Pyrus coronaria* and *P. malus*, as well as upon *Cydonia vulgaris* and perhaps *Cratægus*, described by Schweinitz as *Æcidium pyratum*, appears to have been incorrectly referred to the first-mentioned species. The European form distributed as *R. penicillata* on *Pyrus malus* and *Cratægus*, and considered by some authorities as a form of *R. lacerata*, seems to be very properly retained by Winter as distinct, under the name *Æcidium penicillatum*, and an examination of four exsiccati, (Karst. Fung. Fenniæ 295, Rabh. Herb. Myc. 788, Rabh. Fung. Eur. 1390, Erickson Fung. Scand. 75,) together with specimens from the Tyrol in Prof. Farlow's herbarium, indicates a well-marked species quite distinct from any American form known to me. The spores are as large as those of *aurantiaca*, averaging about 40 μ in diameter, while the peridial cells are very characteristic. Not only are they very large (about $120 \times 65\,\mu$), but the markings are peculiar, and consist of fine, clearly marked branching and anastomosing striæ running transversely without prominent ridges. In our form, on the other hand, the spores are smaller, about 25 μ in diameter, while the peridial cells are smaller and narrower, their average measurement being about $22 \times 80\,\mu$, and are marked by striæ running obliquely and anastomosing obscurely, the outline of the cell being broken by coarse ridges. In both species, the cells when isolated tend to become curved outwards, most conspicuously so in the American form; a fact to which is due the outward curling of the peridial lacerations resulting in the habit peculiar to both.

Turning next to *R. lacerata*, there seems to have been a confusion of forms in this instance also. The material thus named occurring in America includes at least two, and perhaps three forms; one, which for convenience we will call *lacerata*, *x*, is found abundantly in this vicinity and further to the eastward on the fruit, stems, and less frequently on the leaves, of *Amelanchier* and *Cratægus*, during June and July, wholly disappearing by the end of the latter month. A second form, *lacerata*, *y*, infests the leaves of *Cratægus*, and does not appear until early in August; while a third and smaller form, *lacerata*, *z*, is found abundantly on *Pyrus malus* simultaneously with it.

The first of these (*lacerata*, *x*) is very similar to Oersted's figure of *lacerata*, and is identical with the European *carpophila* of Bagnis, distributed in Herb. Critt. Ital. II. 732, and in Myc. Univ. 1326, while it occurs under *lacerata* in various other exsiccati on *Cratægus*, and seems undoubtedly distinct from the forms *y* and *z*, of which the first is usually considered the more typical form of *lacerata*, while the second is referred with some doubt to the same species. In general appearance it bears a superficial resemblance to *penicillata* and *pyrata;* but although the peridium tends to become finely shredded, the shreds are straight, diverging only slightly, without any tendency to curl outwards as in these species; nor is this tendency observable in single cells. The spores are large, having a diameter of about 27 μ, while the peridial cells are long and narrow, about $90 \times 16\ \mu$, the outline broken by fine, not very distinct ridges, the striæ somewhat obscure and *horizontal*.

In the forms *y* and *z*, the spores are smaller, about 20 μ in diameter, while the peridial cells are smaller and broader in proportion to their length, about $20 \times 65\ \mu$, with a tendency to a rhomboidal shape; the ridges are deep and sharply cut as a rule, with the striæ clearly marked and running obliquely in two directions; those above the median line, where the striæ are horizontal, running in a plane nearly at right angles to those below it. The two forms seem nearly identical microscopically; the spores and peridial cells of *z* are perhaps slightly smaller, but otherwise it differs from *y* only by its smaller size and faded yellow color.

It should be remarked, that, from a microscopic point of view, the *Rœstelia* obtained on *Cratægus* after sowing *G. clavariæforme* was identical with the form *x;* while in habit it resembled *y* very closely, the peridia being but slightly lacerate. It must be remembered, however, that the cultures were not exposed to the weather, being kept indoors during their whole development, and that, had they been exposed to rain and wind, a different habit might have supervened, as was the case with the *Rœstelia* obtained from *macropus*, where the penicillate habit was preceded by one very similar to that obtained in the present instance, the *Rœstelia* producing slender unbroken peridia, which became lacerate and curled backwards only after exposure for a short time to rain and wind. The same absence of any laceration was marked in the case of the *aurantiaca* culture, where the usually lacerate peridia were unbroken.

Of these three forms, the first, *x*, seems to me to be the true *lacerata*, as understood by Oersted and distributed as above mentioned. As regards the other two, no definite statement can be made. It should be noted, however, that, with the exception of a slight variation in the size of the spores, neither of these forms can be satisfactorily separated microscopically from *R. cornuta*, as it occurs in this country on *Pyrus Americana* and *Amelanchier*, or from a form with the *cornuta* habit, collected at Kittery, Maine, on *Pyrus arbutifolia*, apparently a new host for this species. Moreover, the form *y* often assumes a habit identical with the most typical *cornuta*, if somewhat more slender. This I have frequently observed at Kittery, and it is well shown by specimens collected in Massachusetts by Mr. Seymore, who has kindly allowed me to examine the *Rœsteliæ* in his herbarium. The possibility that these forms *y* and *z* are one or both *cornuta*, is a natural inference from the above facts. Yet, as already remarked, it is impossible from our present knowledge of them to consider it more than a conjecture.

Turning for a moment to my culture of *G. conicum*, it should be observed that the *Rœstelia* obtained had the typical *cornuta* habit, yet was not separable microscopically from the form *y*, while the date of development corresponds with neither, being earlier by about two months or more. This rapid development is therefore not easily explained, as the *Rœstelia* is not referable to any other form. That it was accidental is rendered more probable from the fact that I was unable to find any such *Rœstelia* during June in localities where *G. conicum* was abundant.

No microscopic examination of the spermogonia obtained was attempted, and in general they presented much the same appearance. Those from *clavipes*, however, were the least conspicuous and those from *macropus* were tinged with greenish and preceded in every case by yellowish discolorations. *G. globosum* produced the brightest and most luxuriant spermogonia of all, yet, as already stated, though appearing on four distinct hosts, they produced no æcidia, and it is impossible even to guess with what *Rœstelia* it is connected.

As regards the different species of *Gymnosporangium*, little need be said, since they are all readily separable. As stated by Prof. Farlow, *G. conicum,* previously referred to *clavipes*, must be added to our list of species. It is very common in this vicinity, forming the familiar bird's-nest distortions on *Juniperus Virginiana* appearing on the leaves and stem, and apparently identical with the European form on *J. communis,* though as yet it has not been observed upon this host in America.

G. clavipes, although a very common species in this vicinity on *J. Virginiana,* and further eastward on *J. communis,* is more likely to escape notice than other *Gymnosporangia,* from the fact that the distortion produced is inconspicuous; while the sporiferous masses, although more brightly colored than in the other species, are small and only slightly protruded when moist. The spores are characteristic, from their rounded outline and inflated pedicels, the latter as broad as the spores themselves, together with their peculiar method of germination, which takes place invariably from either extremity, as was shown by a large number of cultures in which no exception was noticed.

G. clavariæforme I have found common in this vicinity where *J. communis* occurs, and further to the eastward in great abundance; as at Kittery, where it is often difficult to find a juniper that is free from its attack. It precedes the other species in its date of maturity.

If my conclusions regarding its *Ræstelia* are correct, *G. macropus* must be regarded as autonomous, thus disposing of Schroeter's theory of its identity with *clavariæforme,* which seems, however, scarcely tenable on other grounds.

G. biseptatum appears to be common wherever *C. thyoides* occurs, and I found its distortions abundant at Greenland, N. H., near Portsmouth.

G. Ellisii, besides its well-known peculiarities of structure, differs from the other species in its date of maturity, which is later than any of the others. At Greenland, where it occurred together with the last-mentioned species, it was in the best condition for cultures about June 10, and in the vicinity of Boston perhaps a week earlier.

A comparison of the geographical range of the *Gymnosporangia* and *Ræsteliæ* in those localities where I have had an opportunity of observing them is not as instructive in indicating their relations as one might suppose, and often the reverse is true.

At Kittery, for instance, a locality on the sea-shore at the southernmost point of Maine, there is a certain correspondence, the form *lacerata, α,* with *clavariæforme,* and *aurantiaca* with *clavipes,* being the most abundant. *R. cornuta,* if I rightly refer to this species the form found on *Pyrus arbutifolia* and *Cratægus*, is somewhat more common than the comparative rarity of *conicum* in the same region would lead one to expect. *R. pyrata* was not observed at all, and *macropus* only in a single instance. *R. botryapites*, however, is exceedingly common, although no *Cupressus* is known to me within eight miles. *R. transformans* was not observed, but was collected at Greenland about a half-mile from the nearest *Cupressus*.

While collecting at Mt. Washington, N. H., during the last week in August of the present year, I observed spermogonia with æcidia just forming on leaves of *Pyrus Americana* along the path from the Mt. Washington carriage road to a point about half a mile below the snow arch in Tuckerman's Ravine. These developed in a moist chamber sufficiently to show the species to be *cornuta*. Later in the season Prof. Farlow found the same species of *Ræstelia* well developed upon the same host at an altitude of 2,500 feet on Mt. Moriah, both these localities being miles from any *Juniperus*. Prof. Farlow has also collected the most typical form of *cornuta* at Eastport, Maine, on the same host.

In the vicinity of Boston, the various *Gymnosporangia* are about equally common, with the exception of the *Cupressus* forms, and here also *botryapites* is far more abundant and widely distributed than the comparative infrequency of *Cupressus* localities would lead one to expect.

Despite these discrepancies, the species of *Gymnosporangia* with their *Ræsteliæ*, assuming my determination of *lacerata* and *cornuta* to be correct, may be with tolerable safety summarized as follows: —

G. conicum	=	*R. cornuta.*
G. clavipes	=	*R. aurantiaca.*
G. clavariæforme	=	*R. lacerata.*
G. macropus	=	*R. pyrata.*
G. biseptatum	=	*R. botryapites.*
G. Ellisii	=	*R. transformans* probably.
G. globosum	=	?.

In closing, I must express my great obligation to Prof. Farlow for advice and assistance, as well as for the privilege of examining a large number of exsiccati without which any satisfactory results as regards the more obscure *Ræsteliæ* would have been impossible.

XV.

CONTRIBUTIONS TO AMERICAN BOTANY.

By Asa Gray.

Communicated December 8, 1886.

1. *Revision of some Polypetalous Genera and Orders precursory to the Flora of North America.*

Papaveraceæ.

The following is thought to be a somewhat improved arrangement of the North American genera.

Tribe I. Platystemoneæ. Leaves mainly opposite or whorled and entire. Flowers usually trimerous, with a lobed or angled ovary, and a distinct stigma terminating each carpel and so alternate with the placentæ. *Platystemon*, *Platystigma*.

Tribe II. Papavereæ. Leaves mainly alternate. Flowers rarely trimerous. Carpels completely combined, even the stigmas confluent or radiate from a common centre, never more numerous than the placentæ. — I. Petals (4 or 6) usually scarious-marcescent and persistent till the fruit matures: capsule of 3 to 6 valves alternating with as many nerviform placentæ. *Canbya;* trimerous, and stigmas opposite placentæ. *Arctomecon;* dimerous, and stigmas alternate with the placentæ. II. Petals 8–12, not crumpled in bud, which is never drooping; deciduous stigmas (2) alternate with the placentæ. *Sanguinaria.* III. Petals 4 or 6, usually crumpled in the bud, deciduous. 1. Shrubby, and with stigmas over the two valves, i. e. alternate with the nerviform placentæ. *Dendromecon.* 2. Shrubby-based, pluricarpellary, and stigmas over the septiform placentæ. *Romneya.* 3. Herbaceous, and stigmas over the placentæ. *Argemone*, *Papaver*, *Meconopsis*, *Stylophorum*, *Chelidonium*, *Glaucium.*

Tribe III. Hunnemanniæ. Leaves alternate. Flowers dimerous, erect in the bud, as if perigynous from dilatation and excavation of the torus. Stigmas twice or thrice as many as the placentæ. Capsule siliquiform, pluricostate, elastically two-valved from base to apex. *Hunnemannia*, *Eschscholtzia.*

ESCHSCHOLTZIA, Cham. From the mass of diverse forms which, in the lack of a better understanding, we have been in the habit of accumulating under the name of *E. Californica*, Mr. Watson first separated a very small-flowered one as *E. minutiflora;* and recently Prof. Greene, in a monographic revision of the genus, has described several species. Unfortunately he had not the types of the older annual species. The recognition of *E. Californica* as a perennial, which, though long known, had been generally overlooked (because it promptly blossoms the first year and is cultivated as an annual), has been helpful. It was not quite clear what *E. cæspitosa*, *E. tenuifolia*, and *E. hypecoides* were founded on; and a further uncertainty was introduced by Mr. Bentham's reference, in Plantæ Hartwegianæ, of an obvious *E. Californica* to *E. tenuifolia*, although with misgiving. An inspection of the originals now makes it clear that these three annual species are all one. *E. cæspitosa* and *E. tenuifolia*, which are quite alike, represent the form with leaves mainly subradical, and *E. hypecoides*, a leafy-stemmed and shorter-peduncled form. It should be mentioned, however, that, in the Kew herbarium, the only original of *E. cæspitosa* is that of the Hookerian herbarium. If there was one in that of Bentham (as is probable), it is not in place. Of these three specific names that of *E. cæspitosa* should be preferred for the species, that of *E. hypecoides* relating to a less usual form, probably growing in shade. Then the name of *E. tenuifolia*, Hook. (not of Benth.), may be retained for the very distinct species figured in Bot. Mag. t. 4812, and taken up under this name by Greene, who detected the unique character of its seeds.

I cannot yet well define the species, but the subjoined arrangement may be offered.†

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† ESCHSCHOLTZIA, Cham.

1. Dilated torus funnelform, bearing an expanded rim outside of the insertion of the calyptrate calyx (but variable in width): mature seeds with a coarse and salient superficial reticulation of the episperm: anthesis of 3 or 4 days.

* Perennial, large-flowered.

E. Californica, Cham., of which *E. Douglasii*, Torr. & Gray, and *E. tenuifolia?* Benth. Pl. Hartweg. 296, are forms with narrower border to the torus.

* * Winter annual, low, small-flowered: petals 5 to 8 lines long.

E. peninsularis, Greene, Bull. Calif. Acad. i. 68. Southern and Lower California, where it is the common species.

2. Dilated torus destitute of expanded rim or border, although the margin sometimes becomes sphacelate in age, a hyaline internal edge (within the inser-

Portulacaceæ.

In this as in most other very natural orders, the genera are difficult of limitation. But the forms appear not to run together in the way they do in such an order as the *Polemoniaceæ*, perhaps because the species are fewer, yet they give the systematist much trouble. I propose to arrange the North American genera as follows.

Perigynous; i. e. calyx partly connate with the ovary and capsule, both circumscissile. 1. PORTULACA.
Hypogynous: i. e. calyx, corolla, &c. free.
Shrubby: seeds and embryo merely uncinate-curved. 2. TALINOPSIS.
Herbaceous: embryo coiled round central albumen.
Calyx 2-sepalous, herbaceous, deciduous, sometimes tardily so. Stamens 5 to 30. 3. TALINUM.
Calyx 4–8-sepalous, herbaceous, persistent: petals 5 to 16: stamens 10 to 40: capsule circumscissile at very base. 4. LEWISIA.

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tion of the calyx) commonly a little projecting: annuals, mostly either low or slender.

* Petals 4 to 8 or 12 lines long, broadly cuneiform, lasting more than one day.

+ Seeds superficially reticulated or else smoothish.

++ Stems equably and very leafy to the top, branching above: leaves mostly surpassing the peduncles, finely decomposed into very narrow linear divaricate divisions and lobes: petals seldom half-inch long: herbage wholly glabrous and glaucous.

E. RAMOSA, Greene, Bull Torr. Club, 1886. *E. elegans*, Greene, Bull. Calif. Acad. i. 182. *E. Californica*, var. *hypecoides*, Watson, Proc. Am. Acad. xi. 112, the small-flowered plants. Islands off the coast of Lower California, *Streets*, *Palmer*, *Greene*, and Santa Cruz Island off Santa Barbara, *Greene*.

++ ++ Stems scapiform or sparsely leafy: divisions of leaves fewer and less divergent.

E. CÆSPITOSA, Benth. Herbage often hispidulous when young, at least the petioles, sometimes quite glabrous: leaves thinnish; the lobes and divisions from filiform-linear to linear-cuneate: petals pure yellow, half-inch to inch long. *E. cæspitosa* and *E. tenuifolia*, Benth. l. c.; both subscapose and slender-leaved. *E. Austinæ*, Greene, Bull. Calif. Acad. i. 69. A common species in California; passing doubtless into

Var. HYPECOIDES, *E. hypecoides*, Benth. l. c., a form more leafy-stemmed, with less finely dissected leaves, and smaller flowers.

E. MEXICANA, Greene, l. c. Stouter and dwarf, wholly glabrous and glaucous, with leaves of much thicker texture and coarser dissection, the lobes crowded: peduncles 2 to 10 inches long, mostly scapiform: petals orange-yellow, broad, half-inch to almost an inch long. *E. Douglasii*, var. *parvula*, Gray, Pl. Wright. ii. 10. The most eastern species, extending from the Rio Grande in New Mexico to S. Utah and probably the borders of S. California. At Paso del Norte and below, Wright collected it within the Mexican lines, thus barely justifying the

Calyx 2-sepalous, wholly persistent.
  Herbaceous sepals concave, not scarious: gynœcium 3-merous.
    Petals 5 to 10, rarely only 3, mostly ephemeral: stamens 5 (rarely 3) to 25, seldom of same number as the petals: ovules and seeds several or numerous: capsule either circumscissile or 3-valved from summit. 5. CALANDRINIA.
    Petals 5, seldom ephemeral: stamens 5 (or 3 in two Montioid species): ovules and seeds few. 6. CLAYTONIA.
    Petals 5, unequal and united below into a short cleft tube: stamens 3: seeds 2 or 3. 7. MONTIA.
  Scarious or partly scarious rounded sepals plane: gynœcium 2-merous: capsule 2-valved. 8. CALYPTRIDIUM.

I make no account of the character of seeds strophiolate or estrophiolate, introduced, I believe, by Fenzl and kept up by Bentham and Hooker, to distinguish *Talinum* from the genera that follow it. For, indeed, the strophiole is obscure or wholly wanting to the seeds of the typical species of *Talinum* (as Rohrbach in Fl. Brasil. notices); and,

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specific name. To this may doubtfully be referred *E. elegans*, Greene, l. c. (excl. var. *ramosa*), coll. on Guadalupe Island by Palmer and Greene.

+ + Seeds with a thick very coarsely and deeply pitted coat: divisions of the leaves filiform-linear.

E. GLYPTOSPERMA, Greene, l. c. A low scapose species, with finely dissected leaves, from the Mohave Desert, to which probably belongs *E. Parishii*, Greene, l. c. 183, from farther south.

+ + + Seed-coat strongly muricate-squamose in about 12 longitudinal rows: stems low and slender, somewhat hispidulous-pubescent below: leaves with comparatively few and simple narrow-linear divisions.

E. TENUIFOLIA, Hook. Bot. Mag. t. 4812, not Benth. Name which may be retained, since the homonym of Bentham is a strict synonym of his *E. cæspitosa*. Moreover, it is what Greene took up for *E. tenuifolia*, and he first described the peculiar seeds. It is *E. Douglasii*, var. *tenuifolia*, Torr. Pacif. R. Rep. iv. 14, and the *E. Californica*, var. *cæspitosa*, Brewer & Watson, Bot. Calif. i. 23. It occurs in the valley of the Sacramento and the foot-hills of the Sierra Nevada, and probably was first collected by Fremont.

* * Petals quarter-inch long or mostly less, obovate, promptly deciduous or caducous: seeds with reticulate surface.

E. MINUTIFLORA, Watson, Proc. Am. Acad. xi. 122. A leafy-stemmed and small-leaved species, with petals only a line or two long, of the interior arid region.

E. RHOMBIPETALA, Greene, Bull. Calif. Acad. i. 71. A depressed-spreading low species, commonly scabro-hispidulous below, with stout subscapose peduncles, and fugacious rhombic-obovate petals, of 3 or 4 lines in length; found only in the valley of the San Joaquin and lower part of the Sacramento, by Mrs. Curran.

on the other hand, this appendage is present in the original *Calandrinia* (*caulescens*) and a good part of the other annual species, is developed even into an arillus in one of our perennial species, and is more or less conspicuous nearly throughout *Claytonia* and *Montia*. Indeed, Bonpland describes it in his *Claytonia Cubensis*, i. e. *C. perfoliata*.

It will be seen that *Lewisia*, instead of being quite anomalous in the order, is very closely related to *Calandrinia*, that is, to its thick-rooted species; and that these species all have the basally circumscissile dehiscence of the capsule, which was supposed to be peculiar to *Lewisia*.

PORTULACA. The three flat-leaved species remain as characterized by Dr. Engelmann in Pl. Lindheimerianæ. Of the terete-leaved species we seem to have four which may on the whole be distinguished, viz.: —

P. STELLIFORMIS, Moçino & Sesse: perennial by creeping tuberous-thickened and sometimes moniliform rootstocks: leaves quite terete, an inch long, those involucrating the flower-cluster radiating and much surpassing it: axillary clusters of hairs short and soft: petals copper- or buff-color, obcordate: seeds blackish, granulate-tuberculate, with metallic lustre. For the name see DC. Prodr. iii. 353. It is fairly represented, in the Ic. Fl. Mex. ined. Calques, t. 389, and is the *P. suffrutescens*, Engelm. in Bot. Gazette, vi. 326; but it is not suffrutescent. Plains of W. Texas to Arizona and Mexico.

P. HALIMOIDES, L.: a fleshy-rooted perennial, yet flowering as an annual: leaves short and flattish, with copious axillary hair: petals yellow: capsule-lid depressed and much shorter than the basal portion: seeds granulose, reddish, at least when young. Keys of Florida and W. Indies.

P. PILOSA, L.: annual, the base often indurating in age: leaves nearly terete, linear-subulate, half or quarter inch long, with copious hair in axils: petals carmine, crimson, or purple, a line or two long, retuse: capsule-lid hemispherical: seeds blackish and with metallic lustre, muriculate-granulose. Florida to Arizona, and widely dispersed over warm regions.

P. PARVULA. Annual, but sometimes fleshy-rooted, depressed and diffuse: leaves nearly terete, oblong-linear, obtuse, 2 to 5 lines long, copiously hairy in the axils: petals yellow and copper-colored, barely a line long: lid high hemispherical, fully as long as basal part of the capsule: seeds pale red, minutely granulate. This is a part of *P. pilosa*, Gray, Pl. Fendl., Pl. Wright., &c., was collected by Wright and by Fendler on the plains of W. Texas and New Mexico, and in Mexico by Schaffner (772), Pringle (543), &c.

TALINOPSIS, Gray. Mexican specimens of *T. frutescens*, collected by Pringle, Parry & Palmer, and Schaffner, well confirm the characters of this genus, which has no near relative on the American continent except *Grahamia* in Chili.

TALINUM, Adans. Although diverse in habit, the genus is very well marked.

T. PATENS, Willd., is our only flat-leaved and amply paniculate species. We have in Texas and Arizona both the rose-colored and the yellow-flowered forms. *T. spathulatum*, Engelm., is of the latter, and answers to *T. reflexum*, Cav.; and Var. SARMENTOSUM (*T. sarmentosum*, Engelm.) is a procumbent form of it.

T. LINEARE, HBK., a flattish-leaved and axillary-flowered fleshy-frutescent species, the *Calandrinia tuberosa*, Benth. Pl. Hartw. (in which probably the calyx falls from the mature capsule), is doubtless the name to be adopted for the Texano-Arizonian and Mexican *T. aurantiacum*, Engelm. in Pl. Lindh., Pl. Wright., &c.

T. BREVIFOLIUM, Torr. in Sitgreaves Rep. 156, is a little known dwarf species found on the Colorado Chiquito, in N. W. New Mexico; and to this (although they have not been compared) must belong *T. brachypodum*, Watson, in Proc. Am. Acad. xx. 355, which the Lemmons scantily collected in the same district.

The following species are of the section of which *T. teretifolium* is the type, having terete linear leaves, and flowers in terminal pedunculate and commonly scapiform naked cymes. There is a tendency in the capsule of all of them to a separation of the filiform sutures from the valves, the former persisting as a kind of replum.

T. HUMILE, Greene, in Bot. Gazette, vi. 183, thus far found only by the founder of the species on the Pinos Altos Mountains in New Mexico, is known by the short peduncle of its 5–20-flowered cyme, which is surpassed by the leaves, and by the "light yellow petals changing to orange."

The following have slender scapiform peduncles much surpassing the leaves.

T. SPINESCENS, Torr. in Wilkes Pacif. Ex. Exp. xvii. 250. Specimens from Brandegee and Suksdorf have made this species better known. The short and fleshy caudex is beset with little subulate spines, which are the indurated and persistent midribs of the older (half-inch long) leaves, thus formed in the same way as those of *Fouquieria*. The stamens are 20 or 30 in number, and the petals rose-red, as also in the two following species, viz.: —

T. TERETIFOLIUM, Pursh., our well-known Eastern species, and

T. CALYCINUM, Engelm., in Wisliz. Rep. 4; a species of the Upper Arkansas region.

T. PARVIFLORUM, Nutt., is paler-flowered and pentandrous. *T. confertiflorum*, Greene, in Bull. Torr. Club, viii. 121, appears to be a form of this species.

LEWISIA, Pursh. Sir Wm. Hooker was correct in figuring the embryo of *L. rediviva* as with *accumbent* cotyledons. So far as we know, it is not so in any other Portulacaceous plant, not even in *L. brachycalyx*, Engelm. (a badly chosen name), which connects the genus very closely with *Calandrinia*. In fact, the tetrasepalous calyx makes the only difference.

CALANDRINIA, HBK., was founded upon two species. The type is *C. caulescens*, an annual, with leafy stem and 3-valved persistent capsule. Of the other species, the stemless and very thick-rooted *C. acaulis*, the fruit was not known. It proves to be thin-walled, circumscissile at the very base, thence splitting upward more or less; indeed, it is just that of *Lewisia*. We have a good series of North American species of the same type; but the group cannot properly be regarded as generic, for the same dehiscence occurs in several Chilian caulescent perennial species of unlike habit, and probably in some annuals. Of this marked *Lewisioid* section, PACHYRRHIZEA, I recognize the following species.

1. With seeds not at all or not manifestly strophiolate, the testa mostly very smooth and shining.

a. Low, with large fleshy root (caudex and root together) napiform or conical: scapes 1–3-flowered, not surpassing the linear or spatulate radical leaves.

C. ACAULIS, HBK., of Mexico and northern part of the Andes.

C. NEVADENSIS, Gray, Proc. Am. Acad. viii. 623, and

C. PYGMÆA, Gray, l. c., species of the Rocky Mountains and the Western sierras.

b. Scapes or scapiform flowering stems a span or two high from a multicipital caudex and long thick root, paniculately several–many-flowered: leaves mainly rosulate on the caudex, very fleshy: sepals (as in the last preceding species) rounded or truncate, erose-dentate or fimbriate, very much shorter than the obovate rose-red petals.

C. COTYLEDON, Watson, Proc. Am. Acad. xx. 355. Mountains on the borders of California and Oregon. *C. oppositifolia*, Watson, l. c., also discovered by Mr. Howell in the same district, is thought to be a good allied species, but it may be only a more caulescent form of *C. Cotyledon*, a species very well named from the character of its foliage.

C. Leana, Porter, narrow-leaved and paniculately many-flowered, is now known from British Columbia down to the vicinity of Shasta in California; unless two nearly related species are concerned.*

The fact that all these species have basilar circumscissile dehiscence of the capsule was made known to me by Professor Henderson and the Brothers Howell.

2. Seeds conspicuously strophiolate; the testa granulate.

C. Tweedyi, Gray. Habit of *C. Cotyledon;* caudex and root very thick: leaves obovate, fleshy, 2 to 4 inches long, an inch or two wide, rather shorter than the 1–3-flowered fruiting scapes: sepals and bracts entire and glandless, the former orbicular: petals an inch long: stamens 10 or 11: capsule 20–30-seeded, 3-valved from the base upward: seeds with a large and loose orbicular and squamiform arillus rather than strophiole! — Wenatchee Mountains, Washington Territory; alpine, *Tweedy* and *Brandegee.*

Of the Eucalandrinia section we have the following species; all annuals.

C. caulescens, HBK., the undoubted type of the genus, S. American, Mexican, and extending into Arizona and to the Columbia River. *C. micrantha*, Schlecht., is evidently a small-petalled form of it. The seeds of this species are as obviously caruneulate as are most species of *Talinum.* Var. Menziesii, the *Talinum* (*Calandrinia*) *Menziesii*, Hook. Fl. i. 223, t. 70, very common on our western coast, I take to be only a variety of *C. caulescens*, with longer-pedicelled and larger 4–11-androus flowers; but the extreme forms seem to be different enough. Some of them approach the Chilian *C. pilosiuscula.*

C. Breweri, Watson, Bot. Calif. i. 74, differing mainly in the larger flowers on longer and soon refracted pedicels, and much exserted narrow capsule, is confirmed by a specimen gathered by Mr. Orcutt in Lower California.

C. maritima, Nutt., a depressed species, with most of the leaves rosulate at the root, and an obtuse ovoid capsule, has conspicuously strophiolate seeds.

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* The plant of the mountains of Oregon and Washington Terr. (coll. by Lyall as far north as lat. 49) is distinguished by Mr. Thomas Howell as *C. Columbiana*, because of its broader and less terete leaves, not glaucous, and flowering stems less scapiform, these after comparatively transient flowering disarticulating from the stock.

C. SESUVIOIDES. Depressed and spreading from a stout tap-root, but seemingly not perennial, very succulent, leafy: leaves linear-spatulate, flattish, strong-edged, very obtuse, inch or more long, some of them opposite: flowers in terminal and lateral subumbelliform clusters: pedicels rather longer than calyx: sepals broadly ovate, obtuse, nearly equalling the chartaceous capsule, as long as the 5 obovate white petals: stamens 5 to 8: style very short: stigma subcapitate, undivided: seeds shining, minutely puncticulate, not at all strophiolate. — *Claytonia ambigua*, Watson, Proc. Am. Acad. xvii. 365. Desert on the lower part of the Colorado River, at Indio, and at El Rio, on the Californian side, *Lemmon*, *Parish*.

CLAYTONIA, Gronov. A specially North American genus, with one singular outlier. Our species may be disposed as follows.

§ 1. EUCLAYTONIA. Perennial from a corm, thickened caudex and tap-root, or rootstock, sending up radical leaves and scapes or flowering stems bearing a single pair of opposite leaves (in one species sometimes a whorl of three, in another often alternate): flowers usually not ephemeral: stamens always 5: seeds smooth and shining.

* *Cormose*, the slender two-leaved stems and the few (seldom coetaneous) radical leaves from a deep globular corm: leaves linear to oblong: petals light-rose, usually with deeper-colored veins.

+ Intermediate between true *Claytonia* and the *Pachyrrhizea* section of *Calandrinia;* the oblong-conical capsule being 12–16-seeded, membranaceous, and dehiscent round the base: seeds smooth, not at all strophiolate: pedicels of the cymose inflorescence mostly subtended by small scarious bracts: anthesis seemingly ephemeral.

C. TRIPHYLLA, Watson, Bot. King Exp. 345. Leaves more frequently a single pair than a whorl of three. The basally circumscissile dehiscence was pointed out to us by Professor Henderson of Portland. Except for the strictly globose corm, I should refer this plant to *Calandrinia*.

+ + Typical *Claytonia*, the *Spring Beauty* of the Northern Atlantic States: capsule (as in the whole genus except the preceding species) 3-valved from the top and persistent: racemiform inflorescence mainly bractless: pedicels recurved or drooping in fruit: seeds with the small strophiole or white thickening at the hilum which is nearly universal in this genus.

C. VIRGINIANA, L. Seems nearly to pass into the next.

C. CAROLINIANA, Michx. An Atlantic species, extending to Saskatchewan and the mountains of New Mexico: along its western range seemingly confluent with

C. LANCEOLATA, Pursh. The cauline leaves of this are sessile, and vary from oblong to lanceolate, and the petals are emarginate or obcordate. Pursh's N. W. Coast and Siberian specimens, referred to this, probably are of *C. arctica*.

C. UMBELLATA, Watson, Bot. King Exp. 43, t. 6, f. 4, 5, & Bot. Calif. i. 77. The corm is usually obversely napiform: radical leaves not seen; cauline obovate and long-petioled. Known only from Nevada, near Virginia City (*Watson, Mann*), and from Stein Mountain, E. Oregon, where recently collected by *Howell*.

* * *Caudicose*, a rosulate cluster of radical leaves, surrounding scapiform flowering stems, directly from the very thick crown or perpendicular caudex, which is prolonged below into the fleshy tap-root: wing-margined petioles of radical leaves scarious-dilated and as it were sheathing at base: no sarmentose shoots or offsets: inflorescence racemiform or subcymose, with or without some small scarious bracts: petals white or pale rose-color.

C. MEGARRHIZA, Parry, in Watson, Bibl. Ind. 118. *C. arctica*, var. *megarrhiza*, Gray, Am. Jour. Sci. xxxiii. 406, & Proc. Acad. Philad. 1863, 59. This commonly bears two or three small alternate leaves or foliaceous bracts (spatulate-lanceolate or narrower and tapering at base) near the flowers, at least in the Colorado Rocky Mountains. In the mountains of Oregon, it nearly approaches the next.

C. ARCTICA, M. F. Adams. Distinguished from the preceding by the short racemiform cyme much surpassing the radical leaves, the cauline leaves ovate or broadly oblong and sessile by a broad base; from the next by the broad and obtuse leaves. It is the *C. Joanneana*, Rœm. & Schult. Syst. v. 434, a name happily two years later than that of Adams. It extends from the Alaskan shores and islands to adjacent Asia, and even to Altai.

C. TUBEROSA, Pall. May pass into the preceding, but has narrower and acute leaves, from lanceolate-obovate even to linear-lanceolate. It is the *C. acutifolia* as well as the *C. tuberosa* of Pallas, as published by Rœmer & Schultes from Willdenow's manuscript notes; the latter name to be preferred, the more so because the former has been used by Ledebour for a figure of the *C. arctica*. The most narrow-leaved form is *C. Eschscholtzii*, Cham. in Linnæa. This is mainly Asiatic, but comes near to us on Arakamtchetchene Island near Bering Strait, by Wright, and at Plover Bay by Rothrock; and Muir collected it somewhere in Arctic Alaska.

* * * *Rhizomatose*, the long-petioled radical leaves and flowering stems (bearing a pair of broad sessile leaves below the racemiform nearly bractless inflorescence) from creeping and little-thickened rootstocks: petals obovate and emarginate or obcordate, rose-color or white: pedicels in fruit erect or ascending.

C. SARMENTOSA, C. A. Meyer; also of Seem. Bot. Herald, as to char., but the figures suspected to be of a small form of *C. arctica;* they show no trace of the creeping filiform rootstocks or stolons which characterize the species. Here probably, and according to Ledebour, belongs *C. Chamissoi*, DC. Prodr., not of Spreng. Our specimens are from St. Lawrence, St. Paul, and St. George Islands; and it occurs on both adjacent shores.

C. ASARIFOLIA, Bongard, Veg. Sitch. 157. By its creeping rootstock and hardly bracted inflorescence, this belongs to the *Euclaytonia* section, while the habit is just that of the following species, although perhaps more fleshy. The radical leaves tend to be subcordate or somewhat reniform, enough so to justify the specific name, although as commonly rhombic-ovate. Here belongs *C. cordifolia*, Watson, Proc. Am. Acad. xviii. 365, and a dwarfed form of the same is *C. Nevadensis*, Watson, Bot. Calif. i. 77. The species ranges from the Rocky Mountains in Montana and Idaho (*Lyall*, *Nevius*, *Watson*), and the Cascades of Oregon (*Henderson*, *Suksdorf*), south to the Sierra Nevada (*Lemmon*) and north to Sitka. Also Bering Island, *Dr. Steiniger*.

§ 2. LIMNIA. Fibrous-rooted annuals or perennials, destitute of rootstocks, corms, &c., but in one species bulbilliferous: one sepal commonly a little larger than the other, and the two petals alternating with these disposed to be larger than the others, at least in some species.

* LIMNIA proper, including the species to which Linnæus gave this name in Act. Holm. 1746, and the two species taken up by Haworth: cauline leaves the single pair of *Euclaytonia*, near the mostly racemiform inflorescence; radical ones numerous and petioled: petals emarginate or obcordate: stamens always 5.

+ Green bracts accompanying most of the pedicels of the ample simply and loosely racemiform inflorescence: leaves thinnish; cauline pair distinct. Connects closely with the last preceding species.

C. SIBIRICA, L. Hort. Ups. 52, & Spec. i. 204; Gmel. Fl. Sibir. iv. 89; Sims, Bot. Mag. t. 2243; Sweet, Brit. Fl. Gard. t. 16, &c. *C. alsinoides*, Sims, Bot. Mag. t. 1309. *C. Unalaschkensis*, Fischer in Rœm. & Schult. Syst. v. 434. This came originally, as Gmelin states, from the vicinity of Mt. St. Elias on the American coast and from the Alaskan Islands. In the absence of all evidence that it inhabits any part of the Asiatic continent, one might be disposed to discard the Linnæan name: but Siberia was a very indefinite geographical term; and we have the species from Bering Island, not far from the Asiatic shore. Linnæus described this species as a perennial; yet the specimens generally show a clearly annual root. We now know, from memoranda and fine specimens supplied by the Messrs. Howell, that while in exsiccated soil it is a pure annual, yet when better nourished it is more enduring, and bears offsets on stout stolons from the crown, and so, in the absence of much winter's cold, its life is continued and extended from year to year.

Var. HETEROPHYLLA, includes the various forms with leaves (especially the radical and sometimes the cauline also) varying from ovate-lanceolate to linear-lanceolate or even linear. *C. Unalaschkensis*, var. *heterophylla*, Nutt., & *C. alsinoides*, var. *heterophylla*, Torr. & Gray, Fl. Not uncommon on the Columbia River, where the extreme forms are singularly unlike the ordinary broad-leaved plant.

Var. BULBILLIFERA, *C. bulbifera*, Gray, Proc. Am. Acad. xii. 54, found by Greene in the Scott Mountains of N. California, and recently by Howell in adjacent Oregon, appears to be only a form of *C. Sibirica*, with thickened bases of the radical leaves, which persist on the crown as bulblet-scales.

+- +- Bracts few and minute or none: leaves more succulent; cauline pair commonly connate into a disk. Species seemingly confluent in a series.

C. PERFOLIATA, Donn. A weedy species, not known to have linear radical leaves, with pedicels seldom longer than the fruiting calyx (2 lines long) and apt to be fascicled or in pairs; the seeds large, turgid-lenticular, very shining, but granulate.

C. PARVIFLORA, Dougl., seems on the whole to be a good species, with radical leaves varying from spatulate to filiform-linear; cauline pair usually less discoid-connate, sometimes distinct on one side; flowers smaller and scattered in a loose raceme (yet sometimes all glomerate on the disk in both species), on slender pedicels: petals commonly pale rose-color, hardly double the length of the calyx: seeds only half as large as those of *C. perfoliata*, obscurely if at all granulate.

Var. DEPRESSA. A depauperate and depressed form, rather of this than of the preceding species, of which it has the broadly rhomboidal or ovate radical leaves (only a quarter-inch broad); and the small flowers are, so far as seen, glomerate-clustered on the foliar disk; the calyx only a line long. On river-banks, probably sand-washes, Brit. Columbia to Oregon and adjacent Idaho.

C. SPATHULATA, Dougl. Small, but comparatively large-flowered, an inch to a span high, rarely taller, firm-fleshy and glaucous or pale: radical leaves terete and thickish-filiform, or becoming somewhat spatulate and flattish; cauline from lanceolate-ovate to narrowly lanceolate, rarely connate into a round peltate or cupulate disk, yet often connate on one side into an obcordate or 2-lobed body; in the typical form rather broad, only a quarter to half an inch long, and their broad bases slightly connate: raceme usually loose; the slender and mostly alternate pedicels a quarter to half an inch long: petals bright rose-color or white, thrice the length of the calyx: mature seeds conspicuously granulate. — Professor Greene, familiar with the living plant, first indicated to me the distinctions between this species and the preceding: I have settled the name and synonymy. The original *C. spathulata* of Hook. Fl. i. 225, t. 74, represents a common small form of it. *C. gypsophiloides*, Fisch. & Meyer, figured in Sert. Petrop. t. 35, and in Brit. Fl. Gard. ser. 2, t. 375, is a taller form. The species is taken up in Bot. Calif. ii. 435, as *C. exigua.* It occurs in open ground, especially where saline, from British Columbia to S. California, and it passes by various gradations into

Var. TENUIFOLIA. This has even the cauline leaves narrowly linear, or when growing filiform, half-inch to two inches long, little or not at all dilated at base, sometimes connate on one side; and the petals are commonly rose-color. It is *C. tenuifolia* and *C. exigua*, Torr. & Gray, Fl. i. 200, 201. In Pl. Fendl. 14, a seemingly thinner-leaved and taller form, of lax growth and somewhat dubious character, is mentioned. Same range as the typical form, the two sometimes growing together confluently.

* * ALSINASTRUM, Torr. & Gray, Fl. Habit and herbage, also the muriculate or tuberculate round-reniform seeds of *Montia*, but on a larger scale: stems elongated and bearing few or several pairs of opposite spatulate leaves, fibrous-rooting from lower nodes, and at least in one species flagelliferous and perennial by bulblets on the filiform runners: stamens 5.

C. CHAMISSONIS, Esch. in Spreng. Syst. i. 790 (but in the form of *C. Chamissoi*), & Cham. in Linn. vi. 562 (1831, the annexed note about esculent tubers to be excluded); Torr. & Gray, Fl. i. 676. *C. stolonifera,* C. A. Meyer, Act. Mosq. vii. 139, t. 3 (1829). *C. flagellaris*, Bong. Veg. Sitch. 137? *C. aquatica*, Nutt. in Torr. & Gray, Fl. i. 201.

C. Hallii, the *C. Chamissonis*, var. *tenerrima*, Gray, Proc. Am. Acad. viii. 378. Smaller, a span high, ascending, so far as known destitute of stolons and bulblets, apparently only annual: leaves only 2 or 3 pairs: pedicels in fruit ascending: fruiting calyx and capsule barely a line long: seeds one or two, more muriculate. — Wet ground, Oregon, *E. Hall.* Indian Valley in Plumas Co., California, *Lemmon.*

* * * Naiocrene, Torr. & Gray. Slender stems diffuse and at length reclined, bearing numerous alternate very fleshy leaves, or some flagelliform and less leafy, not rarely producing little fasciculate-leaved propagula in upper axils; the decumbent base fibrous-rooting, apparently perennial.

C. parvifolia, Moçino. *C. filicaulis*, Hook. Fl. i. 224, t. 72. The leaves, although so fleshy in the living state, are flat and thin in the dried specimens; the blade of the radical and lower cauline from a quarter to half an inch long, from spatulate or obovate to ovate. Petals from a quarter to a third of an inch long.

C. sarmentosa, Bongard, Veg. Sitch. 137, is still an imperfectly known and doubtful species. By the kind attention of Dr. Maximowicz, some of the original material has been submitted to my inspection. It would seem to be a species intermediate in certain respects between *C. parvifolia* and *C. Chamissonis*, with the alternate leaves of the former, and these broadly ovate, obovate, or the radical rotund, the larger of the latter with blade half an inch long: they evidently were fleshy, but seemingly less so than in *C. parvifolia.* I should still take it for a foliose and flaccid form of that species, except that the petals are said to be "more than half an inch long," and because *C. parvifolia* has not been received from Sitka. The stems or branches seem to terminate in a filiform stolon.

* * * * Montiastrum. Leafy-stemmed and alternate-leaved annuals: leaves not very fleshy,

+- Broad and long-petioled, not unlike those of *Stellaria media*, and now and then lower ones opposite or nearly so: stamens 5: seeds densely lineate and transversely lineolate!

C. diffusa, Nutt. This has now become well known, through specimens collected by *Kellogg & Harford*, *Suksdorf*, *Howell*, and *Rattan.*

+- +- Narrow-leaved annuals, but lower nodes of stem sometimes rooting: racemiform inflorescence secund and pedicels recurved after flowering: leaves with base partly scarious and clasping: *stamens three:* seeds lenticular, thin-edged, very smooth: petals obviously unequal, as in *Montia*, but narrowed at base and all but distinct.

C. LINEARIS, Dougl. According to Professor Henderson, the stamens are always three and the petals decidedly unequal.

C. DICHOTOMA, Nutt. in Torr. & Gray, Fl. The larger forms of this little plant are not very obviously distinguishable from *C. linearis.* The smallest and most depressed include *Montia Howellii*, Watson, Proc. Am. Acad. xviii. 191, which agrees not badly with some of Nuttall's originals.

MONTIA, Micheli. The Northern forms of *M. fontana*, from Greenland and Newfoundland to Lower Canada and New Brunswick, and from Arctic Alaska to British Columbia, all have the areolate-tuberculate seeds with smoothed and somewhat shining surface of *M. rivularis*, Gmelin, Fl. Bad., or *M. lamprosperma*, Cham.; while those of Oregon and California have the duller and rather sharply muriculate seeds of *M. minor*, Gmelin. These differences do not correspond with any clear difference in habit. The species is singularly absent from the Atlantic United States.

SPRAGUEA, Torr. Of a single species: for I can make nothing more than a casual variation of *S. paniculata*, Kellogg. Mr. Watson has indicated (in Proc. Am. Acad. xx. 356) the near approach which one species of *Calyptridium* makes to this otherwise peculiar genus; and Professor Greene has consequently united the genera. I think that *Spraguea* should still be retained upon the assigned characters.

CALYPTRIDIUM, Nutt. The genus was so named upon a partial misconception. The petals are not "united into a minute diaphanous conical corolla, slightly 3-toothed at the apex," as Nuttall supposed. They are quite separate, expanded in anthesis, which is ephemeral, then close over each other and over the pistil, are in this state detached from their insertion, and carried up on the forming fruit, just as in almost every plant of this family. Nuttall's conjecture that his plant might be the *Talinum monandrum*, Ruiz & Pav., was wrong. That is Fenzl's *Monocosmia*, of which it may here be remarked that the utricular capsule is just that of *Lewisia* and of *Calandrinia* § *Pachyrrhizea* on a small scale.

I distinguish four species of *Calyptridium* in two sections. The section which approaches *Spraguea* is here put foremost.

* Petals 4: stamens in the same species 1, 2, or 3: capsule little if at all surpassing the fructiferous calyx: seeds acute-margined.

C. QUADRIPETALUM, Watson, Proc. Am. Acad. xx. 356. A span high: leaves oblong-spatulate (larger 2 inches long, including tapering base and petiole): flowers crowded and as if imbricated in a naked and secund scorpioid spiciform inflorescence: sepals round-reniform, plane, at maturity fully 3 lines in diameter, white-scarious and rose-tinged with greenish centre: petals comparatively large: style very short: capsule oblong-oval, 10–20-seeded, not surpassing the fructiferous sepals. — Lake Co., California, *Torrey*, *Rattan*. Doubtless this half-Latin and half-Greek form of the name was an oversight; but, as *petalum* has a precarious lodgment in the Latin dictionary, it may pass.

C. Parryi. Depressed, small-leaved: leaves (only half-inch long) spatulate, or the rosulate radical ones cuneate-obovate with long tapering base: spikes in age secund and scorpioid: fructiferous sepals orbicular or oval, less complanate, herbaceous with narrow white margin, a line or two long, a little surpassed by the oblong capsule: style half the length of the ovoid ovary. — Bear Valley and vicinity, in mountains of San Bernardino Co., California, *Parry* (1876), *Parish*, 1885.

* * Petals 2 or 3: stamen one, between two petals: sepals moderately accrescent, green and herbaceous with white-scarious margin: seeds more turgid, obtuse-edged: inflorescence looser and more paniculate.

C. roseum, Watson, Bot. King Exp. 44, t. 6, f. 6–8. So far as known the flowers are dipetalous and monandrous; the capsule ovate-oblong and covered by the calyx; and the short style 2-parted.

C. monandrum, Nutt. The petals are oftener 3; the filament subulate; the very short style undivided; the mature capsule linear and much exserted.

Malvaceæ.

The elaboration of this order for the Synoptical Flora of North America brings out several points which need to be noticed. The general lines of the arrangement proposed in Genera Fl. Am. Bor.-Or. Illustrata are found to hold. But the tribe *Malveæ* must have its subtribes reduced to two, allowing the *Sideæ* to include all the genera with capitate stigmas; the number of ovules and seeds, whether one, two, or three, being quite incidental and variable. The first division of the *Sideæ* will be characterized by the reniform seeds with incurved embryo, at least the lower seed with inferior radicle (*Malvastrum*, *Sphæralcea*, *Meliphlea*, *Modiola*); the second, by the turgid seeds with more conduplicate embryo, the ovules when one or two resupinate-pendulous and the radicle superior (*Sida*, *Anoda*, *Wissadula*, *Abutilon*, &c.).

SIDALCEA, Gray. The annual species of this well-marked genus are quite clear, and have recently been noted in Proc. Am. Acad. xxi. 409. They are *S. diploscypha*, *S. hirsuta*, and the badly named *S. calycosa* of M. E. Jones (*S. sulcata* of Mrs. Curran), with the outer phalanges of the andrœcium broad and rather distant from the inner; and *S. Hartwegi* with its var. *tenella* (*S. tenella*, Greene), having the narrower outer phalanges closely approximate to the terminal ones. There is also the ambiguous annual species, *S. malachroides*, which in addition to its peculiar habit is nearly diœcious. But several of the perennial species produce individuals with wholly female flowers.

The perennial species are hard to discriminate; but those indicated by Prof. E. L. Greene may probably be maintained, as also one or two more. Hoping for more light upon some of them, I here merely indicate, in a foot-note, my tentative distribution.†

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† SIDALCEÆ PERENNES.

* Phalanges manifest, at least the exterior series: leafy-stemmed: some lowest cordate-orbicular leaves undivided.

+ Corolla uniformly white: anthers bluish.

S. CANDIDA, Gray.

+ + Corolla rose-color or mauve, rarely a white variety.

++ Herbage cinereous with soft and short pluriradiate stellular pubescence, no hirsute or hispid hairs: outer phalanges broad, bearing short filaments.

S. CALIFORNICA, Gray, Pl. Fendl. 19. *Sida Californica*, Nutt. in Torr. & Gray, Fl. i. 233. Abounds near Santa Barbara, in the Santa Inez Mountains.

++ ++ Herbage green, at least not cinereous: coarser pubescence when present of simple or geminate or some pauciradiate hairs.

= Mature carpels when dry rugulose-reticulated on the sides, mostly on the back also: petals half-inch to inch long.

S. MALVÆFLORA, Gray as to syn. *Sida malvæflora*, DC. *S. humilis*, Gray, Pl. Fendl. 20. The outline figure of Moçino & Sesse is perfectly decisive, and shows the characteristic hirsute hairs, the char. "glabriuscula" of the Prodromus notwithstanding. *Sida delphinifolia*, Nutt., is a form of it. Here also *Nuttallia malvæflora*, Fisch. & Meyer.

S. ASPRELLA, Greene, Bull. Calif. Acad. i. 78, founded on a lax and decumbent and unusually equably-leaved state of a usually erect and tall species, has no hirsute nor hispid pubescence, but is roughish with minute and dense almost scurfy stellular pubescence, or below glabrous; the petals are usually an inch long; the carpels rugose-reticulated throughout and glabrous at maturity, becoming concave or grooved on the back and acute-angled. I collected it at Chico, in the lower cañons.

S. CAMPESTRIS, Greene, l. c., is either glabrous up to the inflorescence, or with some hirsute hairiness below and cinereous stellular pubescence above; petals over half-inch but rarely full inch long, with emarginate summit usually more laciniate-erose than is common; calyx minutely canescent and with or without

MALVASTRUM and SPHÆRALCEA. When the first-named genus was founded, no one supposed that in the principal North American species it came so very near to *Sphæralcea*. Certainly not Mr. Bentham, who in the Genera Plantarum placed it in the *Eumalveæ* subtribe. The difficulty in this respect soon became apparent, and was alluded to by Mr. Watson in the Botany of King's Expedition, p. 48, and later by Prof. Rothrock in the Botany of Wheeler's Explorations. Although the two genera in question are essentially confluent through certain species, they really ought not to be combined under *Sphæralcea*, nor can they be distinguished, as was supposed, by the number of ovules or seeds. The practical course, in my opinion, is to retain in *Malvastrum* the species with cell of the carpels conformed to the solitary ovule and seed, therefore with no empty terminal portion ;

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some soft slender hairs, or rarely glabrous; carpels roughish-rugose or favose-reticulated and commonly pubescent, with rather rounded back and obtuse lateral angles. This is partly *S. Oregana*, Pl. Fendl., and is *Sida malvæflora*, Lindl. Bot. Reg. t. 1036, and Hook. Fl. i. 108. It grows either in moist meadows, where it is smooth, or on dry hills or plains, there more pubescent or hairy; it is common in the northern (and perhaps also southern) parts of California, and in Oregon and Washington Territory west of the Cascade Mountains. Some forms too nearly approach the next.

S. OREGANA, Gray, Pl. Fendl. l. c., partly. Generally more slender, but commonly tall, merely puberulent, or glabrous up to the simple or paniculate racemes, comparatively small-flowered, the canescent calyx only a third or half inch long and with broadly deltoid lobes; carpels obscurely rugulose-reticulated, at least on the dorsal angles and sides, the back smooth or smoothish. It is *Sida Oregana*, Nutt. in Torr. & Gray, Fl. Mainly of the dry interior region of Oregon, Washington Territory, and Idaho, but as far west as Portland.

S. GLAUCESCENS, Greene, l. c., is smooth and glabrous up to and even through the inflorescence, yet sometimes with obscure pubescence on the pale or light green foliage; slender stems seldom over a foot or two high and leaves only an inch or two wide; racemes loose; petals quarter to half an inch long, not rarely white; calyx from glabrous to cinereous-puberulent, the lobes attenuate or acuminate from a broad base; mature carpels relatively large and thin-walled, turgid, glabrous, with the coarse dorsal reticulations mostly longer than broad, or sometimes smooth and even. This is *S. malvæflora*, Watson, Bot. King Exp. 46, in large part; also some of E. Hall's no. 71 of Oregon distribution. It abounds in the higher Sierra Nevada, extends east to Utah, and northward apparently even to British Columbia.

= = Mature carpels smooth and even, glabrous or nearly so: flowers mostly small: calyx-lobes deltoid-ovate: hirsute pubescence not rare on stem and petioles, and even on the calyx.

S. NEO-MEXICANA, Gray, Pl. Fendl. 23. *S. malvæflora*, Gray, Pl. Wright. i. 20, mainly (excl. syn.); Greene, l. c. Mountains of New Mexico, N. Arizona, and Colorado; also adjacent Mexico.

and to refer to *Sphæralcea* those with solitary or occasionally two ovules, which when the upper ovule is either abortive or wanting have the upper part, usually the whole upper half, of the mature carpel empty, and of a different texture from the lower part, being thin and smooth, while the lower has rugose-reticulated sides. In these *Pseudo-Malvastrum* species, some of them more commonly bi-ovulate, the mature carpels fall away clean from the receptacle. In the true *Sphæralceæ* they usually, after separation from the axis and dehiscence, remain (as in some other genera) for some time attached by a thread passing from the receptacle to the dorsal base of each carpel, which at length tears away, sometimes from the receptacle, sometimes from the back of the carpel.

Our species of *Malvastrum* and of *Sphæralcea* are difficult, and have been not a little confused. I understand them as presented below.†

S. SPICATA, Greene, l. c. Differs from the preceding (perhaps not constantly) in the dense and oblong or interrupted spike of flowers, their pedicels shorter than the rather large calyx or hardly any. This is, as Professor Greene supposed, the *Callirrhoe spicata* of Regel in his Gartenflora. We have seen it in the gardens under the name of *Sidalcea Murrayana*, apparently an unpublished name. It occurs on both the eastern and western sides of the Sierra Nevada, where it was long ago collected by Anderson and by Torrey; recently Prof. Henderson found it in Grant Pass, on the borders of Oregon.

* * Phalanges crowded at the summit of the column and indistinct, most of the stamens being separate, the outermost combined more or less at base in threes or fours: scapose: radical and subradical leaves all pedately dissected.

S. PEDATA. A rather low species, with ascending scapes or scape-like stems and pedately 5–7-parted leaves rising from a tuberous-thickened root; petals (only 4 or 5 lines long) rose-purple; and carpels quite smooth and glabrous. — Bear Valley in the San Bernardino Mountains, S. California, collected by my valued correspondent, *S. B. Parish.*

† MALVASTRUM, Gray.

* Peduncles, at least the earlier ones, long and slender, one-flowered: calyx involucellate by 3 slender bracts: petals rose-color varying to white: carpels orbicular, rugose, muticous: annuals, not canescent nor tomentose. Arizono-Californian.

M. ROTUNDIFOLIUM, Gray, Proc. Am. Acad. viii. 333.

M. EXILE, Gray, Bot. Ives Colorado Exp. 8, & Proc. l. c.

Of a different group, with pedunculate clusters at length evolute into unilateral spikes, similar rugose carpels, and rose-purple petals, is *M. Peruvianum*, Gray, in Bot. Wilkes Ex. Exped., a Mexican form of which, weak and straggling, is *M. jacens*, Watson, Proc. Am. Acad. xxi. 417.

* * Peduncles or pedicels short or hardly any: petals yellow: pubescence appressed or dense,

MELIPHLEA, Zucc. Pl. Nov. fasc. ii. 51, t. 9, is a good genus, upon the characters assigned by its founder, except that the coalition

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+ Not canescent, of 2–4-rayed or some simple hairs, on the stems strigose: calyx involucellate.

++ Annual, narrow-leaved, comparatively northern.

M. ANGUSTUM, Gray, Pl. Fendl. 22, & Man. 101. Although this is *Sida hispida*, Hook. Jour. Bot. i. 198 (from St. Louis), it can hardly be Pursh's plant, said to have been collected in Georgia by Lyon, nor Elliott's plant of that name. Yet it is possible, for *M. angustum* occurs as far east as Nashville, Tennessee, and Lyon's explorations extended to the eastern border of that State.

++ ++ Suffrutescent perennials or in their most northern range becoming annual: broader-leaved, tropical or subtropical species.

M. RUGELII, Watson, Proc. Am. Acad. xvii. 367. Probably introduced rather than truly indigenous to S. Florida, where, however, it has thrice been collected; namely, by Rugel, in specimens distributed by Shuttleworth as *Malva Americana*, L., var.; by Garber; and later by Curtiss, in whose distribution it is named *Melochia serrata*. It is without doubt the *Malva scoparia*, Jacq. Collect. i. 59 & Ic. Rar. t. 39, said to come from San Domingo, but not the plant of L'Heritier. Discerning this, it was named *M. corchorifolia*, Desrousseaux in Lam. Dict. iii. 755, an excellent specific name, which should have been adopted; but Mr. Watson overlooked it on account of De Candolle's reference of it as a synonym to *M. scabra*. To go back to that now would be making a superfluous new name. We possess no W. Indian specimens, but they are probably extant in the large herbaria. The carpels are muticous, or with a mere vestige of a subapical cusp.

M. TRICUSPIDATUM, Gray, Pl. Wright. i. 16, & Bot. Wilkes Ex. Exped., where the synonymy is detailed. The wholly strigose (mainly Malpighiaceous) pubescence, and the subapical and two dorsal cusps of the carpels, are characteristic.

M. SCABRUM, Gray in Bot. Wilkes Ex. Exped. (excl. syn. *Malva scoparia*, Jacq. Ic. Rar., which is *M. corchorifolia*, Desrous.), comes between this and the next. It is not North American, but Dr. Palmer collected it in Mexico, it being the *M. tricuspidatum*, var. *bicuspidatum*, Watson, Proc. Am. Acad. xxi. 417. The absence of the subapical cusp to the carpels is one of its characteristics; the pubescence, although roughish, is not strigose-appressed in the way of *M. tricuspidatum*, but more stellular, and the leaves are more cuneate at base.

+ + Subcanescent with close and minute stellular pubescence, no strigose pubescence on the stems; otherwise like the last preceding species.

M. SCOPARIUM, Gray in Bot. Wilkes Ex. Exped., l. c. *Malva scoparia*, L'Her. Stirp. t. 27. Flowers sessile or nearly so in the axils and barely subspicate at end of branches: calyx canescent and lobes blunt: carpels 2-tuberculate on the back, but no subapical cusp. Collected in Mexico by Berlandier and Gregg, and within the U. S. in Arizona near Tucson by Pringle, distributed as *M. tricuspidatum*.

M. SPICATUM, Gray, Pl. Fendl. 22. *Malva spicata*, L. Spec. ed. 2; also *M. Americana*, L. Spec. ed. 1, at least the plant of Breyn. Cent. 124, t. 57, on which that species seems wholly to rest. *M. spicata*, *ovata*, and *polystachya*, Cav. An unmistakable species, not known within the U. S., but collected by Berlandier at Matamoras on the Mexican side of the Rio Grande.

of the bracts of the involucel is inconstant and of no account. The large and thin mellifluous disk, wholly adnate to the calyx-tube, is well

+ + + Cinereous with lepidote-stellular pubescence, perennial, with foliaceous-involucellate flowers solitary and subsessile in upper axils, and with rather large deep yellow petals: carpels coriaceous, smooth, hirsute at top, there dorsally bigibbous and ventrally subulate-pointed.

M. Wrightii, Gray, Pl. Fendl. 21, Pl. Lindh. ii. 160, & Gen. Ill. ii. 60, t. 131. *Malva aurantiaca*, Scheele in Linnæa, xxi. 469, therefore *Malvastrum aurantiacum*, Walp. Ann. ii. 153. Texas.

* * * Peduncles or pedicels short: petals scarlet, copper-color, or rose-color: carpels wholly pointless: involucel of slender deciduous bracts or hardly any. Western perennials, some shrubby, canescent or tomentose with many-rayed stellular pubescence.

+ Pubescence wholly lepidote and silvery, i. e. of peltate scales rather than hairs: leaves very narrow: carpels coarsely reticulated on the sides.

M. leptophyllum, Gray, Pl. Wright. i. 17, ii. 20. S. W. Texas to S. Utah.

+ + Canescent-tomentose with short pubescence, but calyx, &c., hirsute: mature carpels thin-walled, promptly 2-valved, smooth, suborbicular: flowers said to be rose-color.

M. Palmeri, Watson, Proc. Am. Acad. xii. 250, Bot. Calif. ii. 437. Has rather large long-petioled leaves, and a few rather large flowers in a capitate cluster at summit of a terminal peduncle. Collected only by Dr. Palmer near San Luis Obispo, California.

M. densiflorum, Watson, Proc. Am. Acad. xviii. 368. Has numerous rather small flowers crowded in sessile heads, forming an interrupted spike. S. California, Parish, Nevin.

+ + + Throughout densely stellate-tomentose, no hirsute hairs on calyx: carpels thin-walled, smooth, promptly 2-valved, oval with excised insertion: leaves thickish, obscurely lobed: calyx-lobes long-acuminate: petals rose-color.

M. marrubioides, Durand & Hilgard, in Jour. Acad. Philad. ser. 2, iii. 38, & Pacif. R. Rep. v. 6, t. 2. *M. foliosum*, Watson, Proc. Am. Acad. xx. 356. Orcutt collects this in the northern part of Lower California; with a var. paniculatum, having copious and loosely paniculate flowers, some of them rather slender-pedicelled.

M. Fremonti, Torr. in Pl. Fendl. 21. Throughout very densely soft-tomentose, and calyx most densely woolly; the plant so much resembling *Sphæralcea Lindheimeri* of Texas, that in Bot. Calif. i. 86 it was mistaken for that. This is wholly Californian, from Calaveras Co. southward.

+ + + + Both herbage and calyx canescent with close and fine almost scurfy stellular pubescence, no hispid or hirsute hairiness.

++ Frutescent or truly shrubby, 3 to 15 feet high: leaves barely lobed: mature carpels smooth, glabrate, thin-walled, 2-valved: petals rose-purple.

M. Thurberi, Gray, Pl. Thurb. 307; Bot. Calif. i. 85. *Malva fasciculata*, Nutt. in Torr. & Gray. Has sessile or short-peduncled flower-clusters, spicately or paniculately disposed on virgate and nearly naked branches: is common in Califormarked, and the clavate-introrse stigmas help out the character. *M. vitifolia*, Zucc., is the same as *Malva umbellata*, Cav. Ic. 95.

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nia from Monterey southward near the coast, and extends into Arizona and S. Utah. Passes into var. LAXIFLORUM, with somewhat loosely paniculate flowers, which is *M. splendidum*, Kellogg, Proc. Am. Acad. i. 65; Brewer & Watson, Bot. Calif. 185, where wrong carpels are described by an accident.

+ + Herbaceous, low, with pedately parted or dissected leaves: carpels round-reniform, tomentulose-pubescent, rugose-reticulated, tardily and incompletely dehiscent: petals copper-red.

M. COCCINEUM, Gray, Pl. Fendl. 21, 24 (partly), Pl. Wright. i. 17 (with var. DISSECTUM, *Sida dissecta*, Nutt, which is only a most narrow-leaved form), & Gen. Ill. ii. t. 121. The most eastward species, extending even to Iowa.

SPHÆRALCEA, St. Hil. char. auct.

According to the view now adopted, the following are the North American species. Some of them are not easy to be defined and probably run together.

* *Malvastriform* species, with more or less depressed fruit: carpels 1–2-ovulate, the upper ovule when present abortive or seldom maturing, at maturity more or less reniform, at length directly deciduous from the axis (no retaining thread): lower and commonly only seminiferous portion strongly and firmly reticulated over the thin or diaphanous sides; upper and usually empty part smooth and commonly thin, bivalvular or introrse-dehiscent from the top: perennial herbs, except perhaps the first species, which is indeed ambiguous between this and the preceding genus.

+ Root simple, perhaps a winter annual: mature carpel with the scarious empty summit short and inflexed, thus round-reniform in outline: petals orange-scarlet: stellular pubescence rather loose: leaves roundish-subcordate, slightly or moderately lobed and incised.

S. COULTERI. *S. Fendleri*, partly, Torr. Bot. Mex. Bound. 29. *Malvastrum Coulteri*, Watson, Proc. Am. Acad. xi. 125, & Bot. Calif. i. 85, but no internal projection in carpel detected. W. Arizona, first coll. by Coulter, then by Schott, Lemmon, &c. I collected it at Maricopa in the early spring of 1865.

+ + Perennials, mostly lignescent-rooted: carpels less reniform; the smooth upper half or more being moderately incurved or erect.

++ Leaves all or mainly palmately or pedately parted: mature carpels very blunt: petals brick-red or orange-scarlet: species with great resemblance to *Malvastrum coccineum.*

S. PEDATIFIDA, Gray. *Malvastrum pedatifidum*, Gray, Pl. Lindh. ii. 160, & Pl. Wright. i. 17, ii. 20. *Sidalcea Atacosa*, Buckley, Proc. Acad. Philad. On the Rio Grande from El Paso downward, also San Antonio, Texas.

S. PEDATA, Torr. in Pl. Wright. i. 17, name only. *Sida grossulariæfolia*, Hook. & Arn. Bot. Beech. 326, therefore *Malvastrum grossulariæfolium*, Gray, Pl. Fendl. 21. *M. coccineum*, Gray, Pl. Fendl. 21, partly (no. 21 *Fendler*), & Pl. Wright. i. 16. *M. coccineum*, var. *grossulariæfolium* (and some *Sphæralcea Emoryi*), Watson, Bot. King Exp. 47. *Malva Creeana*, Graham in Bot. Mag. t. 3698, probably came from this, perhaps is a hybrid. Extends from W. Texas to S. Arizona and N. W.

MODIOLA, Mœnch, with a partition between the two seeds and a habit of its own, will of course be kept up.

Nevada. Passes into var. ANGUSTILOBA, with very narrow divisions to leaves, the *Malvastrum coccineum*, var., Gray, Pl. Wright. i. 17.

++ ++ Leaves undivided, at most obtusely 3–5-lobed, of roundish outline, mostly cordate.

= Canescent throughout with short and close stellular pubescence, no loose woolliness: carpels wholly pointless.

S. MUNROANA, Spach. *Malva Munroana*, Dougl. in Lindl. Bot. Reg. t. 1306. *Nuttallia Munroana*, Nutt. in Jour. Acad. Philad. vii. 16. *Malvastrum Munroanum*, Gray, Pl. Fendl. 21, excl. syn. Chiefly of the northern interior region from the British boundary to Nevada, Utah, and probably Arizona, where with lobed leaves it comes very near the preceding. The flowers are brick-red, I believe, though the published figures make them rose-red, and the calyx is short, not surpassing the depressed small fruit.

S. AMBIGUA. *S. Emoryi*, Torr. in Ives Colorado Exp. Bot. 8; Watson, Bot. Calif. l. c., partly, not Pl. Fendl. nor Pl. Wright. Less leafy than the preceding, more tomentulose, with commonly thicker and merely crenulate-toothed leaves, more naked and racemiform inflorescence; petals rose-color varying to white, half-inch to inch long; calyx 4 to 6 lines long, with acute or acuminate lobes surpassing the moderately depressed fruit, the carpels of which are commonly 3 lines long, very like those of *S. Munroana*, but larger, quite unlike those of *S. Emoryi*, Torr., with which some forms have been confounded. It seems to be abundant over the arid plains of Arizona and Nevada; also coll. in S. California by Thurber, Nevin, Cleveland, &c.

S. SULPHUREA, Watson, Proc. Am. Acad. xi. 125, is a peculiar species of the Lower Californian Islands, with rather the habit of the original *S. cisplatina*, St. Hil. It is said to have pale yellow flowers.

= = Densely pannose-tomentose and calyx very woolly: corolla rose-red: ovules often 3: carpels when mature much constricted in the middle.

S. LINDHEIMERI, Gray, Pl. Lindh. ii. 162. S. Texas and adjacent Mexico.

++ ++ ++ Leaves undivided, of oblong-lanceolate outline, not rarely subhastately 3-lobed: pubescence close and canescent: petals orange-red: mature carpels ovate, with deep reniform excision, tipped with a small and deciduous cusp, often 2-seeded.

S. HASTULATA, Gray, Pl. Wright. i. 17, ii. 21. S. Texas and adjacent New Mexico and Mexico.

* * *True Sphæralceæ*, with fruit less or not at all depressed: carpels 2–3-ovulate, 1–3-seeded, mostly oblong and with some ventral excision, disposed to dorsal as well as ventral dehiscence, when separating from the axis cohering by their sides and at base held by a kind of thread which at length either tears away from the back of the carpel or else is carried away with it: perennial herbs.

+ Carpels canescent or glabrate on the back: leaves not Maple-like,

++ Lanceolate to linear, not lobed, rarely even incised.

S. ANGUSTIFOLIA, Spach, l. c. The genuine species, with wholly pointless carpels having rounded summit and smooth or obscurely rugose sides, is wholly

SIDA, L. Bentham has well indicated the conniving or erect tips or points (when there are any) of the carpels for a good character of

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Mexican. The corolla is said by Cavanilles to be violaceous, and the colored figures approach to that hue. On tickets the record is commonly "rose-color." As Watson states, in Proc. Am. Acad. xvii. 331, striking as the difference is, one cannot specifically separate the following.

Var. CUSPIDATA. Mostly smaller-leaved and smaller-flowered; petals "red"; carpels narrower, tipped with an erect cusp, which sometimes persists and becomes even a line long, sometimes is reduced to a mucronate point, the short basal portion either slightly or strongly rugose-reticulated on the sides. — *S. stellata*, Torr. & Gray, Fl. i. 228. *Sida stellata*, Torr. Ann. Lyc. N. Y. ii. 171. Texas to Arizona and S. Colorado; also Mexico.

++ ++ Leaves of oblong or roundish outline and often cordate, mostly 3–5-lobed, sometimes dissected: cusps of the carpels more or less extrorse.

= Leaves thickish, rugose and undulate: fruit depressed: carpels not at all rugose-reticulated: calyx mostly half an inch long, and brick-red petals longer.

S. EMORYI, Torr. in Gray, Pl. Fendl. 23, & Pl. Wright. i. 21, only partly of later authorities. Thus far known only from Arizona, on the Gila, coll. by Emory and by Parry, and from Chihuahua, Mexico, by Gregg and Thurber.

= = Leaves thinner, not rugose: fruit higher than wide, the carpels more or less reticulated on the sides.

a. More or less canescent, or stellular-pubescent: species perhaps confluent, certainly variable.

S. FENDLERI, Gray, Pl. Wright. i. 21, ii. 21. *S. miniata*, Gray, Pl. Fendl. 19, & Gen. Ill. ii. 70, t. 127, not Spach. Mountains of W. Texas to Arizona and northern part of New Mexico. Here also seem to belong some forms which have been variously referred to *S. incana*. The leaves are generally green or greenish, or only lower face canescent, and their outline ovate-oblong or subhastate, incised or lobed but not dissected; carpels prominently cuspidate.

S. INCANA, Torr. in Gray, Pl. Fendl. 23, & Pl. Wright. i. 21. Common in New Mexico, Arizona, and adjacent Mexico. Passes into var. DISSECTA, Gray, Pl. Wright. l. c., a form with small deeply 3–5-cleft or parted leaves, the divisions and lobes commonly narrow.

S. WRIGHTII, Gray, Pl. Wright. ii. 21, from N. E. Chihuahua not far below the U. S. boundary, has not since been collected; it is probably a good species.

b. Leaves wholly green, small, rather finely dissected, obscurely pubescent, or with the slender stems glabrous.

S. RUSBYI. This I know only from a specimen (no. 537) collected by Dr. Rusby near Prescott, Arizona, and belonging to the Torrey herbarium. The stems are spicately or racemosely few–several-flowered; lobes of the leaves linear or nearly so; petals red, not over a third of an inch long; calyx loosely and subcanescently pubescent, the ovate lobes barely equalling the hemispherical fruit; oblong carpels barely mucronulate, and sides at base obsoletely rugulose.

Sida, as distinguished from *Anoda*, &c. To the peculiar sections named in Pl. Fendlerianæ, viz. *Pseudo-Malvastrum* (the N. American species of which are *S. hederacea*, *S. lepidota*, and *S. cuneifolia*, Gray) and *Pseudo-Napæa*, a third may be added, CALYXHYMENIA, for species which have the ebracteolate calyx much accrescent around or under the fruit, and membranaceous or scarious, — the name taken from *S. calyxhymenia*, Gay, of Australia, and the section therefore including the *Fleischeria* of Steudel and Steetz. Our species, *S. physocalyx*, Gray, Pl. Lindh. ii. 163, in which the 5-parted and angulate-bladdery fruiting calyx imitates that of *Nicandra*, has rather peculiar and very thin-walled reticulated indehiscent carpels with a beak-like apex. The homonymous *S. physocalyx* of F. Müller, from Australia, is much later, and will find another name. Our species of the section *Malvinda* appear to be as follows.†

+ + Carpels hirsute or hispid on the back: leaves Maple-shaped, comparatively large and with acute serrate lobes: tall herbs, green or at least not canescent.

S. ACERIFOLIA, Nutt. in Torr. & Gray, Fl. i. 228. *S. rivularis*, Torr. in Pl. Fendl. 23. *Malva rivularis*, Dougl. British Columbia to Rocky Mountains, Dakota, and at a single station in Illinois.

S. LEPTOSEPALA, Torr. Bot. Wilkes Ex. Exped. Washington Territory on the Upper Columbia, coll. by Pickering and Brackenridge, and recently by Tweedy and Brandegee. Well marked by the slender peduncles and caudate-attenuate calyx-lobes.

† SIDA, § MALVINDA.

1. Species with a somewhat *Stylosanthoid* habit; the sessile or short-peduncled flowers mainly at the summit of the low stems or branches and involucrate by petioled leaves: petals reddish-purple.

S. CILIARIS, L. Reaches Florida, and includes *S. involucrata*, A. Richard, and *S. anomala*, St. Hil.

Var. FASCICULATA, the narrow-leaved Texan and Mexican form of the species. *S. fasciculata*, Torr. & Gray. *S. anomala*, var. *Mexicana*, Moricand, which appears to be likewise *S. muricata*, Cav. Ic. vi. 78, t. 597. *Malvastrum linearifolium*, Buckley, Proc. Acad. Philad. 1861, 449, is the same.

2. Species with flowers not involucrate, either solitary or clustered in most of the axils, or barely paniculate at the summit: calyx 5-angled, and petals mostly yellow.

* Stems diffusely decumbent or prostrate and filiform: petioles and peduncles long and slender: leaves somewhat cordate, small.

S. DIFFUSA, HBK., with hardly a doubt, although the flowers are not "violet," nor the fruit depressed at summit. *S. filiformis*, Moricand, and *S. filicaulis*, Torr. & Gray. Texan, Arizonian, and Mexican.

S. SUPINA, L'Her. W. Indian and on the Florida Keys.

ABUTILASTRUM is a name quite appropriate for another section, namely for *Sida Lindeniana*, which would be essentially an *Abutilon* of the section *Gayoides* except for the uniovulate carpels.

BASTARDIA, HBK. The wide-spread *B. viscosa*, HBK., seems not to be recorded from the eastern parts of Mexico. It is no. 748 and 2168 of Berlandier's collection, made between Tula and Tampico. There is also the following apparently very distinct and undescribed species.

BASTARDIA BERLANDIERI. Ut videtur elata et basi frutescens, patenti-ramosa, pube minuta subcinerea, secus ramulos glandulosa; foliis lato-cordatis cum acumine obtuso sinu sæpius clauso (caulinis 4–5-pollicaribus); pedunculis flore brevioribus; calycis lobis ovatis subito

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* * Stem erect: leaves rather long-petioled and nearly all cordate or subcordate; flowers not long-peduncled: carpels 10–12, bi-mucronate or 2-awned.

S. CORDIFOLIA, L. Reaches the Florida Keys.

S. TRAGIÆFOLIA, Gray, Pl. Lindh. ii. 164. Raised from Wright's seeds supposed to have been gathered in Texas, but probably in S. Arizona, as we now have a form apparently of this species; but leaves less cordate, smaller, and more cinereous, from Arizona, collected by Pringle and by Lemmon; and Palmer brought from Coahuila specimens connecting these with the type.

* * * Stems erect and branching: leaves slender-petioled and truncate-obtuse or retuse at base, from ovate-oblong to linear: a small tubercle under the base of the petiole (but this occasionally obsolete): flowers small and nearly all short-peduncled: carpels mostly 5. Species probably not indigenous, even on our southern borders.

S. SPINOSA, L., with comparatively broad and green leaves.

S. ANGUSTIFOLIA, Lam., with linear or at least narrow and canescent leaves, is doubtfully distinct. It is Engelmann's *S. heterocarpa*.

* * * * Stems erect: leaves mainly short-petioled or subsessile, acute or obtuse at base but never cordate, usually destitute of tubercle under the petiole, but this sometimes apparent in *S. rhombifolia*: carpels 8 to 12.

+ Leaves cuneate-obovate or oblong-obovate to lanceolate, green, at most cinereous puberulent: stems branching, leafy to the top: annuals in the U. S., probably incomers from Tropical America.

S. RHOMBIFOLIA, L., with var. CANARIENSIS, Griseb. The genuine plant known by the single subulate awn to the carpels.

S. CARPINIFOLIA, L. An equally variable species; includes *S. acuta*, Burm., *S. stipulata*, Cav., *S. glabra*, Nutt., &c.

+ + Leaves mainly linear or linear-lanceolate and obtuse at both ends: carpels bicuspidate or bimucronate just behind an inflexed short apex, or muticous: indigenous perennials.

S. ELLIOTTII, Torr. & Gray, is a completely glabrous species; with some peduncles or pedicels little shorter than the subtending leaf, but many shorter than caudato-acuminatis capsulam depressam 5-lobam æquantibus; carpellis obtusis arista tenui molli per dehiscentiam loculicidam bisecta apiculatis; semine pubescente. — Tantoyuca, Mexico, *Berlandier*, 747, 2167.

GAYA, HBK. By some oversight, Hemsley, in the Biol. Centr.-Am. Bot. i. 102, has named Parry & Palmer's no. 92 "*Gaya subtriloba.*" It is the common *Abutilon crispum.*

HORSFORDIA, Nov. Gen. inter *Sphæralceam* et *Abutilon.* Calyx basi nudus. Carpella 8–12, coalita, tarde secedentia, 3-ovulata, 1–3-sperma (ovulis 2 superioribus sæpe abortientibus, infimo resupinato-pendulo), matura difformia; pars superior sæpius vacua mox accrescens, membranaceo-scariosa, et bipartita in alas 2 parte infima firmiore grosse reticulata (modo *Sphæralcearum* plurimarum) 2–3-plo longior. Discus

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the calyx, even the long ones not articulated except with the insertion. As far as can be seen, the imperfect specimens from Key West referred by Chapman to *S. Lindheimeri* belong here.

S. Neo-Mexicana. A span to a foot high, diffusely many-stemmed from a ligneous base or root, minutely puberulent, not cinereous: peduncles not articulated, all short or very short: petals orange-yellow often changing to red: mature carpels muticous or barely mucronulate. — *S. Elliottii*, var.? Gray, Pl. Wright. ii. 21. *S. rhombifolia*, var.? *microphylla*, Hemsl. Bot. Biol. Centr.-Am. i. 106, small-leaved form. Eastern part of New Mexico, *Wright*, *Thurber*, *Greene*, &c. S. Arizona, *Lemmon.* Chihuahua, *Pringle.* San Luis Potosi, *Schaffner*, *Parry & Palmer.*

S. Lindheimeri, Engelm. & Gray, Pl. Lindh. i. 5. *S. Elliottii*, with var. *Texana*, Torr. & Gray, Fl. i. 681, not of 231. Cinereous-puberulent, at least the lower face of the leaves: slender peduncles about equalling the leaves, articulated above the middle: petals yellow: carpels bicuspidate. Texas, extending into adjacent Louisiana and adjacent Mexico; first coll. by *Berlandier.*

S. longipes, Gray, Pl. Wright. i. 19; name several years prior in publication to *S. longipes*, E. Meyer in the Flora Capensis. Well marked by its very long and strict peduncles, with articulation a little below the summit, and muticous carpels. It is wholly S. W. Texan.

An outlying species, not quite of this group, is the following.

S. Xanti. A foot or two high, woody below, scabro-puberulent: lowest leaves ovate or subcordate and slender-petioled; upper lanceolate; all an inch or less long, dentate; uppermost small: peduncles surpassing the leaves, articulated toward the summit: petals apparently white but perhaps yellow, almost an inch long: carpels about 10, rugose and glabrate at maturity, bimucronulate, the interior apex not inflexed. — *S. Elliottii*, var.? Gray, Proc. Am. Acad. v. 154. Cape San Lucas, Lower California, *Xantus.*

3. Species with calyx not at all angled: flowers in ours long-peduncled, and petals violet.

S. filipes, Gray, Pl. Lindh. ii. 164, Pl. Wright. i. 19. Texan and Mexican; of the *S. paniculata* group.

sub fructu vix ullus. Semen *Abutili.* — Frutices vel herbæ frutescentes, Crotoniformes, tomento albido stellulato denso scaberulo; foliis ovato-cordatis oblongisque; pedunculis axillaribus unifloris.

H. ALATA. Frutescens; petalis purpureis roseisve semipollicaribus calyce triplo longioribus; carpellis 10–12 monospermis (ovulis 2 superioribus abortivis); parte superiori vacua ante maturitatem bipartita et in alas 2 angusto-oblongas erectas scariosas parte seminifera reticulata triplo longiores mutata. — *Sida alata*, Watson, Proc. Am. Acad. xx. 356. N. W. Sonora, Mexico, about 100 miles below the U. S. boundary, *Pringle.* — It is most proper that one of the new plants which Mr. Pringle collected at much risk of life, in the northwestern corner of Sonora, should commemorate his able associate in practical botanical labors, *Frederick Hinsdale Horsford*, of Charlotte, Vermont. Having a second species to add, I may perhaps take leave to join the name of my own former associate, *Eben N. Horsford*, of Cambridge, the well-known chemist, whose services and gifts to the scientific department of Wellesley College will more worthily immortalize his memory. The second species is

H. NEWBERRYI. Fruticosa; petalis (ut dicitur) læte flavis dimidio minoribus; carpellis 8–9, di–trispermis, parte superiori scarioso-membranacea breviore latiore subdivergente; foliis inferioribus magis cordatis. — *Sphæralcea crotonoides*, Torr. in herb. *Abutilon Newberryi*, Watson, Proc. Am. Acad. xi. 125, & Bot. Calif. i. 87. — Arizona, on the Gila, &c., *Emory*, *Newberry*, *Parry*, and adjacent borders of California, *Parish*; also adjacent parts of Sonora, Mexico, *Pringle*, and of Lower California, *Palmer*, *Orcutt.*

ANODA, Cav. A critical examination brings to light carpological differences among the species of this genus which had only partially been detected before, and had not been worked out. The subjoined arrangement of the forms known to me will exhibit these points of structure, and to a certain extent set right the nomenclature of at least the North American species.†

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† ANODA, Cav.

§ 1. EVANODA. Seed and ovule horizontal or nearly so in the mostly beaked carpels of the much depressed and radiatiform fruit, naked, or in one species with an arilliform pellicular fragile coating, the disk or upper face of the fruit strongly hispid or hirsute.

* Corolla violet or purple, varying occasionally to white: fruit mostly surpassed by the widely spreading calyx, the top beset by scattered simple bristles:

ABUTILON, Tourn. The Mexican species need to be cleared up before we can well settle those of the North American flora. For this sufficient authentic materials are not at hand.

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herbage destitute of stellular, but commonly with some hispid pubescence: slender peduncles nearly all in axil of leaves.

A. HASTATA, Cav. Carpels 15 to 20, rather conspicuously beaked; the dorso-basal portion wholly thin-scarious and veinless, with slender midnerve, the sides or partitions completely obliterated at dehiscence: seed quite naked. — *A. hastata, triloba, & Dilleniana*, Cav. Diss. t. 10, 11. *A. cristata & A. hastata*, Schlecht. in Linnæa, xi. 210, 214. *Sida cristata*, L. *S. cristata, hastata, & Dilleniana*, Willd. — These I take to be all of one species, of which the larger-flowered forms, with petals about an inch long, are known only in cultivation. The typical *A. hastata*, with upper leaves truly hastate or deltoid, and which comes north to Texas and Arizona, has petals only half an inch, and in a depauperate form only a quarter of an inch long. I find the character of the fruit invariable. And this character of the fruit, as verified from the specimen in the Candollean herbarium, also refers here *A. triangularis*, DC. Prodr. i. 459. — Var. *depauperata* (Gray, Pl. Wright. ii. 23) is nothing more than a slender and very small-flowered form.

A. ACERIFOLIA, DC. Prodr. i. 459. Closely resembling *A. hastata* and with leaves similarly varying: carpels short-beaked or sometimes nearly pointless, the sides completely obliterated at dehiscence, the basal part of the dorsal portion thin-scarious as in the preceding, but the whole gibbous upper part thicker and with strong and coarse reticulations, in age bilamellar, its endocarpial portion (half embracing the seed) becoming coriaceous and clathrate. — *S. hastata*, Sims, Bot. Mag. t. 1541? ex DC., probably correctly so referred. *Sida deltoidea*, Hornem. Hort. Hafn. 650, is perhaps the same; perhaps also *A. brachyantha*, Reichenb.; but Schlechtendal, in his annotations on this genus, makes no mention of the neat and really decisive characters which distinguish the species. From the appended observations, *A. hastata*, A. Rich. Fl. Cub. 149, must be of the present species. My Mexican specimens are, one from Acapulco (*A. hastata*, Hook. & Arn. Bot. Beech. 411, at least in part), and from Batopolas in Chihuahua, Palmer, 234 (these with mainly hastate and short-petioled leaves and hardly any cusp to the carpels); and from Orizaba, Botteri, 1135, with subcordate or deltoid leaves and distinctly cuspidate carpels. No. 86 of Fendler's Venezuela collection is similar. This has some Maple-shaped leaves.

A. ARIZONICA. Slender, a foot or two high, with sparse and few hirsute hairs, otherwise nearly glabrous, small-flowered: petals 3 lines long: leaves and also the fruit (of 8 to 11 conspicuously beaked carpels) like those of *A. hastata*, var. *depauperata*, but seed invested more or less completely by a very thin and fragile veinless pellicular coating, which is probably of carpellary origin. — S. Arizona, *Lemmon*, 599. Leaves cordate, deltoid-ovate, or uppermost hastate.

Var. DIGITATA. Leaves mostly hastate-digitate, the prolonged middle lobe narrowly lanceolate or linear, and the two lobes on each side linear and half shorter. — S. Arizona, *Lemmon*, 517 of coll. 1881.

* * Corolla yellow: calyx shorter-lobed, and less explanate under the densely and stellately hirsute fruit, which it hardly surpasses; upper flowers naked-

Besides A. Avicennæ, which is more or less naturalized in the Atlantic States, I count A. Indicum, var. hirtum, of Grisebach, as a chance introduction from the West Indies into the southern parts of

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racemose: pubescence minute and stellular and above with some simple soft-hirsute hairs, viscidulous.

A. lanceolata, Hook. & Arn. Bot. Beech. 411, from the western side of Mexico, is nearly related to the following. It has the back of the mature carpels similarly but more delicately clathrate-reticulate, the epidermal epicarp apparently not separating, seed hispidulous-scabrous, and petals 9 lines long.

A. Wrightii, Gray, Pl. Wright. ii. 22. New Mexico, Wright; Mexico, Schaffner. This, having been received from the Berlin Botanic Garden under the name of *A. parviflora*, was taken for that species in Watson's Bibl. Index, and in Proc. Am. Acad. xvii. 330; but it will be shown that it is not the plant of Cavanilles. The dorsal portion of the 8 to 10 carpels is bilamellar at maturity, the endocarpial layer is not unlike that of *A. triangularis*, but larger and more clathrate-reticulate, loosely half enveloping the barely puberulent seed.

§ 2. Sidanoda. Seed more or less suspended in the 5 to 10 barely umbonate merely puberulent carpels of the moderately or hardly depressed fruit, destitute of endocarpial coating: flowers small: pubescence mostly fine and stellular, no bristly hairs.

* Corolla blue to bluish-white: calyx deeply cleft, rotately spreading under the depressed fruit.

A. acerifolia, DC. Prodr. i. 459. *Sida hastata*, Sims, Bot. Mag. t. 1541. Mexico. If I correctly refer to this species no. 78 of Parry & Palmer's Mexican collection (which has the general aspect of a small-flowered *A. hastata*, except as to pubescence of herbage and fruit), the species is distinguished from the following by the mainly axillary and larger flowers, the petals nearly half an inch long, perfectly glabrous seed, and thinner carpels destitute of nerves. I have seen only immature fruit.

A. Thurberi. Slender, a foot or two high, green and barely puberulent or glabrate below; the calyx, &c., puberulent-canescent: lower leaves cordate and dentate, upper hastate: flowers mostly paniculate-racemose: petals only 2 or 3 lines long: carpels 8 or 9, the whole dorsal and thickish apical portion strongly 3-nerved (or the nerves confluent near the base): seed puberulent. — S. Arizona, *Thurber*, *Wright*, *Lemmon*. Chihuahua, Mexico, *Pringle*, 283, distributed as "*A. parviflora*, var.?" To this belongs part of the specimens taken for a depauperate form of *A. hastata*, in Pl. Wright. ii. 23; also the plant referred to in Pl. Thurb. 308.

* * Corolla yellow, sometimes changing to pink in fading: calyx shorter and less deeply cleft, ascending or appressed to and seldom surpassing the little depressed fruit; its carpels (and closely enwrapped seed) nearly vertical, the inflexed apical portion short: plants paniculately branched and racemose-flowered, stellular-pubescent.

A. pentaschista, Gray, Pl. Wright. ii. 22. Slender, a foot or two high, minutely puberulent and more or less cinereous: lower leaves ovate or subcordate, somewhat 3-lobed; upper hastate or lanceolate, uppermost linear: calyx 2 lines

Florida; and am disposed to think the same of A. PEDUNCULARE, HBK., or what passes for that species.

A. JACQUINI, Don, (*Lavatera Americana*, L., *Sida abutiloides*, Jacq. Obs. t. 7, *S. crassifolia*, L'Her. Stirp. t. 60, *Abutilon lignosum*, A. Rich. Fl. Cub., and Griseb., to which may be added *A. hypoleucum*,

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long, little shorter than the yellow corolla: carpels 5, or not rarely 6 to 10, obovate-oval after dehiscence, the sides soon obliterated: seed puberulent. — S. Arizona to Texas, *Wright*, *Thurber*, *Havard*.

A. ABUTILOIDES. Taller and stouter, 3 or 4 feet high, canescent, and branches with some loose hairs: leaves all cordate, crenately serrate, caudate-acuminate, uppermost lanceolate: calyx 2 or 3 lines long, the lobes broadly ovate and apiculate: petals 4 or 5 lines long, obovate, yellow changing to pinkish in drying: carpels 5 to 7, when mature 2 lines high and less deep, obscurely umbonate, septicidally separating almost whole, the diaphanous inner walls tardily breaking up and uncasing the puberulent seed, the permanent dorsal portion deep-cymbiform, thin-membranaceous with thicker and firmer summit, disposed to split down the back into two valves. — Santa Catalina Mountains, S. Arizona, Pringle, 1882, distributed as "*A. pentaschista*" and as "*Sida Berlandieri*, var."

§ 3. CLEISTANODA. Seed (wholly smooth and glabrous) completely and permanently invested by a firm corrugate-reticulate or at length clathrate (doubtless endocarpial) arilliform covering: habit, flowers, and pubescence of § 2.

A. PARVIFLORA, Cav. Ic. v. 19, t. 431. Petals "yellow," but in dried specimens seeming rather to be purplish: radiate summit of fruit hirsute-pubescent, and with short cusps or points; dorsal and permanent portion of carpels comparatively firm in texture with a stout midrib below, or basal part reduced to a very stout rib. — Mexico. Structure of the fruit ascertained from specimens which were cultivated in the Paris Garden in 1814. Also indigenous ones from northern part of Mexico, i. e. in Chihuahua near Batopolas, *Palmer*, and near the city of Chihuahua, *Pringle*.

A. RETICULATA, Watson, Proc. Am. Acad. xvii. 368. This species, in which the arilliform covering of the seed was first discovered by Mr. Watson, has smaller and more lobed leaves, an at length elongated naked raceme of flowers, small and "blue" corolla, and a different fruit from that of *A. parviflora*. The carpels are more erect, wholly muticous, barely puberulent, at maturity with exocarp bivalvular, thus dividing the capsule into 10 narrowly oblong almost membranaceous and barely concave valves, liberating the still attached coarsely reticulated husks, each filled by a seed.

A. CRENATIFLORA, Ort. Dec. viii. 96. Not having this part of Ortega's Decades, I cannot say if Cavanilles rightly referred this species to his *A. parviflora*. If so the name has a year's priority in publication; but the petals being entire, the name may be passed by as false for this species.

A. INCARNATA, HBK. Nov. Gen. & Spec. v. 266, described from a plant cultivated in the Botanic Garden of Mexico, has not been identified and perhaps is not of the genus.

A. PUBESCENS, Schlecht. in Linnæa, xi. 218, from Mineral del Monte, Ehrenberg, is not made out.

Gray, Pl. Wright. i. 20,) cannot be *Sida lignosa*, Cav., with "capsulis durissimis." In Mexico it comes so near the boundary (coll. *Berlandier*, *Palmer*, &c.) that it is likely to reach Texas. It is known by its seemingly cordate sepals equalling the numerous subulately erect-awned and villous-hirsute carpels, which are as large as those of the preceding species.

A. Palmeri, Gray, and A. aurantiacum, Watson, are apparently good species of N. W. Mexico and Lower California, which come very near to our borders.

A. permolle, Don, is the Florida plant (otherwise only West Indian) which in Chapman's Flora is taken for *A. Jacquini*.

A. Wrightii, Gray, of Texas, Arizona, and adjacent Mexico, is the species most resembling *A. Jacquini*, Don.

A. Parishii, Watson, Proc. Am. Acad. xx. 357, is a recently added species of the same group, but wholly herbaceous, with short peduncles and short calyx.

A. Lemmoni, Watson, l. c., is a species near to the Mexican *A. Berlandieri*, Gray, which Mr. Watson has partly characterized: and to the latter may be referred the "306, *Abutilon*" of Pringle's Chihuahua distribution, a var. dentatum.

A. Xanti is a name which may be applied to the plant of Lower California, noted as "*A. Californicum*, Benth. var." in Proc. Am. Acad. v. 154, which cannot be Bentham's species. It goes with those two very closely related species, *A. Sonoræ*, Gray, and *A. reventum*, Watson, Proc. Am. Acad. xxi. 418, which are herbaceous, large-leaved, and with a very naked and ample compound panicle of small flowers. This one has neither the long beard-like hairs of *A. Sonoræ*, nor the smooth stems of *A. reventum*, and has a different and larger calyx, nearly equalling the cuspidate beaked fruit.

A. malacum, Watson, Proc. Am. Acad. xxi. 446, is quite well distinguished from the next by the more glomerate or paniculate flowers, and the longer as well as permanently erect calyx, and generally by the foliage.

A. incanum, Don. *A. Texense* & *A. Nuttallii*, Torr. & Gray, Fl. In the Botany of the Wilkes South Pacific Expedition, I noted that *A. incanum* of the Sandwich Islands was hardly distinguishable from *A. Texense*. I now find that the characters there mentioned are of no avail. The seeds of our plant, although quite glabrous when young, become minutely downy in age. We must combine the species, notwithstanding the disjointed range.

A. parvulum, Gray, to which belong some specimens which have been referred to *A. Texense* (as in Lemmon's and Pringle's Arizona collections), ought to be distinguished, not only by the spreading or trailing growth and the pubescence, but also by the color of the corolla. In the original description this is said to be yellow: but I find no authority for it in the collector's memoranda. It is noted as "brick-red" on the ticket of specimens collected by Sir Joseph Hooker and myself at Cañon City, Colorado, in 1877, and as "pink" by Dr. Havard in specimens from W. Texas.

A. Thurberi, Gray. A pentacarpellary species, of Grisebach's section *Anasida*, but wholly with one-flowered peduncles. Dr. Masters, in Fl. Trop. Africa, i. 186, takes it to be very near *A. ramosum* (*Sida ramosa*, Cav.); but that seems to be more like *A. umbellatum*. The latter was collected by Berlandier in Mexico, not far from the Texan boundary (no. 1549, 3049), is cinereous or somewhat canescent, usually more than pentacarpellary, and the peduncles 3–5-flowered, the seeds muriculate.

A. holosericeum, Scheele, which is figured in Gen. Ill. ii. t. 125, as *A. velutinum*, is interesting as the only one of our species which bears a pair of collateral ovules and seeds in the upper part of each of the five carpels, while the lower and narrower basal portion bears a single seed.

A. (Gayoides) crispum, Don. Common along the southern frontier, usually with villous branches, while in Florida the var. *imberbe*, Griseb. (*A. trichodum*, A. Rich., and *Sida imberbis*, DC.) prevails. To this species belongs no. 92 of Parry & Palmer's Mexican collection, which has been inadvertently referred to *Gaya subtriloba*.

HIBISCUS, L. Accepting this genus with the limits assigned by Bentham and Hooker, the subgenera, so far as North America is concerned, would seem to be *Euhibiscus*, *Abelmoschus*, and *Paritium;* the first, comprising the bulk of the genus, dividing into more or less well limited sections.

H. (Malvaviscoides) tubiflorus, DC. From the character and the original figure, the outlines of which have been reproduced by Alph. de Candolle, it seems safe to refer to this the *H. Bancroftianus* of Macfadyen, the synonymy of which (excluding *Malvariscus penduliflorus*) is correctly detailed in Watson's Bibl. Index. To it I refer, as a large-leaved form, no. 643 of Ghiesbreght, the leaves of which are sometimes 3-cleft.

H. lasiocarpus, Cav. Diss. iii. 159, t. 70, f. 1. This is the oldest and an appropriate name for the *H. incanus* of Schrader and Wendland (of which it is doubtful if the petals are ever sulphur-color), and the *H. grandiflorus* of Michaux. Cavanilles described and figured his species from a specimen in the herbarium of Jussieu, with upper leaves only. Var. OCCIDENTALIS, the *H. Moscheutos?* var. *occidentalis*, Torr. in Wilkes Expedition, and *H. Californicus* of Kellogg, which grows on the Sacramento and San Joaquin in California, appears to be a form with less hirsute but yet densely pubescent capsules. An intermediate form was collected by Thurber near Janos, in Chihuahua.

H. MOSCHEUTOS, L. We take it as fairly made out that *H. roseus* is the American species, somehow introduced into the South of Europe.

H. MILITARIS, Cav. To this apparently belongs *H. Carolinianus,* Muhl., and probably of Elliot.

H. TRIONUM, L. To this old-world species of the gardens belongs *H. Collinsiana,* Nutt., as to Nuttall's plant collected by Ware, if a specimen from herb. Collins may be trusted. But in the Torreyan herbarium that species is represented by a leaf or two of *H. Manihot,* and a leaf with two flowers of *H. esculentus.*

H. (PARITIUM) TILIACEUS, L., and THESPESIA POPULNEA, Correa, have reached the Keys of Florida, both probably rather denizens than natives.

ORDO CHEIRANTHODENDREÆ.

Calyx *valde quincunciali-imbricatus,* 5-partitus, pl. m. corollinus, persistens. Petala nulla. Stamina 5, ima calyce parum adnata, segmentis ejus alterna, monadelpha: antheræ biloculares, adnatæ, extrorsæ; loculis sat elongatis parallelis longitrorsum dehiscentibus: pollinis granulæ subtrigonæ, læves, reticulatæ. Ovarium 5-loculare, loculis sepalis antepositis: stylus filiformis indivisus, stigmate minimo indiviso terminatus. Ovula in loculis plurima, horizontalia, anatropa. Semina ovalia, testa crustacea lævi. Embryo in albumine carnoso rectus, eodem paullo brevior: cotyledones ovales, foliaceæ, leviter (*Gordoniæ* fere modo) subplicatæ, radicula 3–4-plo longiores. — Arbor et frutex, pube stellulata furfuraceo-pubescentes; foliis palmatilobatis alternis, stipulis parvis caducis, pedunculis terminalibus vel oppositifoliis unifloris, floribus sat magnis sub calyce 3-bracteolatis, sepalis basi intus fovea nectarifera instructis.

CHEIRANTHODENDRON, Larreat. Sepala coriaceo-petaloidea, dorso carinata, suberecta. Andrœcium obliquum, hinc altius fissum: antheræ declinatæ, incurvæ, digitiformes, validæ, ultra loculos longolineares in acumen subulatum productæ. Semen ad chalazam appendice granulata instructa. Sectio transversa cotyledonum ∽-formis. —

Chiranthodendron, Larreataqui (1795*), Baillon. *Cheirostemon*, Humb. & Bonpl. 1808. — The much older name, which Baillon has restored and which we cannot properly refuse to adopt, is well formed, being the Greek of the native name of the *Hand-flower Tree.* Humboldt and Bonpland deliberately superseded it, merely because they thought they could make a better and shorter name. It is only in the latter respect that they were successful.

FREMONTIA, Torr. Sepala plana, omnino petaloidea, patentissima. Andrœcium regulare: columna æqualiter 5-fida: antheræ oblongo-lineares, utrinque emarginatæ, connectivo tenui haud producto adnatæ, loculis reniforme-incurvatis mox anfractuosis. Semen haud appendiculatum. Cotyledones marginibus leviter homotrope incurvis. — Contrary to the original description and figure, (which also represents an anomalous four-celled ovary, the like of which has not again been met with,) the stamens alternate with the sepals. So they do in the Hand-tree flower, according to Adrien de Jussieu, who communicated a long and faithful description to the Flore des Serres (vii. 7–9) in 1851, probably his last botanical writing. Dr. Masters, in Gard. Chronicle, 1869, and in Seemann's Journal of Botany (vii. 298), with fresh flowers of *Fremontia* in hand, gives the position of the stamens correctly. When he insists, partly on this account, that the showy perianth of *Fremontia* is a corolla, he forgets that in *Sterculiaceæ* and probably all the Malval cohort the stamens, whenever isomerous, stand before the petals or the place for them, i. e. alternate with the sepals; so that this evidence tells the other way. As for the caducous bractlets, which Dr. Masters takes for a reduced calyx, the five which he found is a most unusual number. We find only three, answering to the larger and less deciduous ones of the Hand-tree, and to the bractlets of most *Sterculiaceæ.*

Bentham, adopting a suggestion of Torrey, included these two genera in his tribe or suborder *Bombaceæ* of *Malvaceæ*, describing the stamens as united in pairs with unilocular anthers, which was a forced hypothesis; also the calyx-segments as "leviter imbricatis," which was no slight diminution of the fact. But in the *addenda et corrigenda* to the first volume of the Genera Plantarum (two years earlier than Dr. Masters's note), he changes this view, and transfers his subtribe *Fremontieæ* to *Sterculiaceæ* as a new tribe.

It seems to me better frankly to recognize the peculiarities of these

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* With figure, &c., and a French translation, with two plates, published at Paris in 1805.

two genera, of which the leading one is the strongly quincuncial calyx, and not to force them into an order, nor into a cohort, of which a valvate calyx is an essential and substantially an unvaried character. As a small order, it takes a comfortable position between the Guttiferal and Malval cohorts in the Genera Plantarum, connecting the two, and with no technical character alien to the former.

Tiliaceæ.

TILIA. Although our species are not absolutely limited, it seems necessary to restore *T. pubescens* to specific rank, and so to recognize three species, viz.: —

T. AMERICANA, L., with ample leaves essentially glabrous, thickish and firm, green on both faces, the upper lucid; floral bract usually tapering into a stalked base (except the uppermost); fruit ovoid, usually lightly costate.

T. PUBESCENS, Ait., with smaller and mostly thinner leaves, distinctly pubescent beneath, yet often glabrate in age: floral bract usually rounded at base and sessile or hardly stalked: fruit globular. I do not adopt the older name of *T. Caroliniana*, Mill. Dict.; for the original character, as well as that of Marshall and of Wangenheim, points to *T. Americana* rather than to *T. pubescens*. Probably to that species also belongs the *T. pubescens* of the Nouveau Duhamel. — The var. LEPTOPHYLLA, Vent., is very well marked by its larger and thin leaves. It is hardly possible to combine this form with *T. Americana*, and its habitat is much more southern.

T. HETEROPHYLLA, Vent., the *T. alba* of Michx., but not of Aiton, is well marked by its ample leaves of ovate outline (not rounded as in the true *T. alba* of S. E. Europe), whitish or silvery beneath; floral bract tapering to a very short-stalked or sessile base, usually elongated, and the peduncles still longer; the fruit globular. It strictly belongs to the Alleghany region, from Southern Pennsylvania to Florida. The original reference of Aiton's *T. alba* to America was corrected in the second edition of the Hortus Kewensis. But, having been copied by Ventenat, under his *T. rotundifolia*, the mistake has been kept up by Bayer in his Monograph, who places it under his *T. heterophylla-nigra*, and has two forms from Kentucky, both undoubtedly *T. heterophylla*.

T. MEXICANA, Schlecht., which Bayer makes a variety of *T. pubescens*, is probably a good species. The floral bracts taper to a slender-stalked base.

Zygophyllaceæ.

TRIBULUS, Tourn. The genera *Kallstrœmia*, Scop., and *Tribulopis*, R. Br., which there had been some reason for retaining, are now effectually suppressed by finding that *Tribulus Californicus*, Watson, has a deciduous calyx along with a 10-carpellary ovary with uniovulate carpels, but the alternate ones abortive.

GUAIACUM, Plumier. It is noted in Pl. Wright. i. 28, that the position of the cotyledons of *Porlieria hygrometrica* is not uniform, these being sometimes incumbent and sometimes accumbent in respect to the floral axis. They are also incumbent, at least occasionally, in *G. officinale;* and in *G. arboreum* the filaments are more or less squamiferous, while *G. parvifolium* has tetramerous as well as pentamerous flowers; and a nearly related species, *G. Planchoni* (*G. parvifolium*, Planchon in herb. Hook., of which see Pl. Wright. l. c. 29, and of Hemsley as to Andrieux's plant), has naked filaments. It is therefore evident that the genus *Porlieria* cannot be kept up.

2. *Sertum Chihuahuense: appendix.*

The following are new *Gamopetalæ* of Mr. Pringle's collection in the State of Chihuahua, Mexico, in the summer and autumn of 1886.

BOUVARDIA GRACILIS. Undique glabra, ramulosa; ramis gracilibus crebre foliosis; foliis oppositis tenui-membranaceis ovato-lanceolatis brevissime petiolatis (majoribus sesquipollicaribus, ramealibus nunc parvulis), venis tenuibus parcis inconspicuis; floribus paucis brevissime pedicellatis in fasciculo subsessili; calycis lobis subulatis (lineam longis) tubo in anthesi multo longioribus capsula lævi (lin. 2 longa) brevioribus: corolla glaberrima alba, tubo fere filiformi semipollicari, lobis ovalibus lineam longis. — Mapula Mountains, twenty miles south of Chihuahua, in shade of cliffs.

BRICKELLIA SOLIDAGINIFOLIA. Multicaulis, puberula; caule ultrabipedali e caudice perenni herbaceo sursum crebre ramoso, ramis usque ad capitula corymboso-congesta brevi-pedicellata foliosis; foliis plerisque alternis lanceolatis integerrimis basi angusta sessilibus submembranaceis tenuiter venosis (1–2-pollicaribus); involucro 10-floro lin. 3 longo bracteis pauciusculis binervatis acutiusculis, interioribus floribus dimidio brevioribus lineari-lanceolatis, extimis brevibus subovatis;

achenii nervis hispidulo-scabris. — Cool slopes of the Mapula Mountains, twenty miles south of Chihuahua.

SENECIO PRINGLEI. *S. Parryi* peraffinis, pariter viscoso-puberulus, foliosus, subcymoso-pleiocephalus; radice perenni; foliis membranaceis (3–5-pollicaribus) obovatis argute dentatis pinnatifido-incisisque in petiolum alatum basi auriculatum semiamplexicaulem dentatum contractis, superioribus ramealibusque minoribus subpanduratis sessilibus; pedunculis setaceo-bracteatis; involucri semipollicaris vix calyculati bracteis angustissimis numerosis; ligulis fere semipollicaribus; acheniis strigoso-canescentibus. — Shady places in the Mapula Mountains.

PINAROPAPPUS JUNCEUS. Caulibus gracillimis 2–3-pedalibus superne corymboso-ramosis; ramis monocephalis; foliis minimis subulato-setaceis (radicalia desunt); capitulis iis *P. rosei* dimidio minoribus; floribus paucioribus. — Mapula Mountains, on grassy slopes.

IPOMŒA PRINGLEI. Bipedalis e caudice nodoso crasso, glaberrima; caulibus erectis patenti-ramosis; foliis subsessilibus pinnatipartitis in segmenta 5–7 lineari-filiformia integerrima imave bifida; pedunculis folium superantibus obsolete bibracteatis unifloris; sepalis rotundatis capsula fere semipollicari brevioribus; corolla purpurea infundibuliformi tripollicari! — Foot-hills of the Santa Eulalia and Mapula Mountains, near Chihuahua. A species of the *I. stans* rather than of the *I. capillacea* group, very handsome, and well worth bringing into ornamental cultivation.

PENTSTEMON ROTUNDIFOLIUS. Species insignis (e grege *P. centranthifolii?*), glaberrimus, glaucus; caulibus e basi lignosa aperte ramosis paniculato-plurifloris; foliis crasso-coriaceis orbiculatis integerrimis (majoribus sesquipollicaribus), imis in petiolum subalatum contractis, cæteris arcte sessilibus, ramealibus parvis, floralibus minimis subcordatis; pedunculis pedicellisque gracilibus; sepalis ovalibus lin. 2 longis; corolla miniata pollicari tubæformi apice subæqualiter 5-loba, lobis lato-ovalibus (lin. 2 longis), fauce genitalibusque glabris; antheris post dehiscentiam explanatis; capsulis lato-ovatis lin. 2–3 longis pedicello arcte recurvato pendulis. — Mapula, Potrero, and other mountains, near Chihuahua, hanging from seams of cliffs, long-enduring, apparently flowering for most of the year.

CORDYLANTHUS WRIGHTII, Gray, in Bot. Mex. Bound. 120, is in the collection, but the corolla is pure yellow. Perhaps it was so in Wright's and Rothrock's specimens. It should have been stated that the filaments are strongly and unilaterally villous.

3. *Miscellanea.*

ANEMONE OREGANA. E grege *A. nemorosæ*, *trifoliæ*, et præsertim *Udensis;* foliis involucralibus 2–3 (sæpius 2); foliolis indivisis inæqualiter dentatis vel integriusculis ovalibus oblongisve obtusis vel folii radicalis obovatis (1–2-pollicaribus); sepalis (½–¾-pollicaribus) cum filamentis læte purpureis vel cæruleis; stylo ovario haud longiore (nec ut in *A. Udensi* elongato). — Hood River, Oregon, *Mrs. Barrett*, and adjacent parts in Washington Territory, *Suksdorf.* The Pacific coast has various forms of *A. nemorosa*, some with less acute and less lobed leaflets than is common at the East. But I think it does not directly vary into the present species, which would rank between *A. trifolia* of the Old World and *A. Udensis* of Eastern Asia.

VIOLA HOWELLII. *Caninæ*, *V. mirabili* proxima; innovationibus basi haud squamoso-imbricatis; stipulis infimis laciniato-dentatis, iis ramorum vel sarmentorum brevium integris; scapis pedunculisve gracillimis; calcare corollæ brevi (lin. 2 longo) crasso. — *V. mirabilis?* Gray in Bot. Gazette, xi. 293, not L. — I had this only from damp fir woods in the vicinity of Portland, Oregon, collected by Mr. T. Howell, and doubtfully referred it to the old-world *V. mirabilis.* I now have abundant specimens collected by Mr. Suksdorf in Klickitat Co., Washington Territory, which show that it is quite distinct both from that well-marked species and from any of our forms of *V. canina.*

SOLIDAGO ERECTA, Pursh. This and *S. elata*, Pursh, were accidentally omitted both from the Synoptical Flora in 1884 and from the Supplement in 1886. They were to have been mentioned as among the uncertain species on pp. 143, 144. From my notes made, in 1881, upon the original specimens in the Banksian herbarium, it would appear that *S. erecta* answers to *S. bicolor*, var. *concolor;* and that *S. elata*, as to the plant of "New Jersey, Bartram," which may be taken as the proper original of that species, is the same. And a smoother form, which I have referred sometimes to this same variety and sometimes to *S. speciosa*, var. *angustata*, appears to be *S. erecta*, Ell. I think that a species under the name of *S. erecta*, Pursh, is to be reinstated, one which is well represented by a plant common in the vicinity of Washington, and that it will include most of *S. bicolor*, var. *concolor*, Torr. & Gray, and some of *S. speciosa*, var. *angustata*, Torr. & Gray. But the limits and the characters are not yet satisfactorily determined.

Pentachæta Orcuttii. *P. aureæ* subsimilis; capitulis parvulis; involucro villoso-pubescente, bracteis viridioribus; ligulis brevioribus; pappi setis 8–10 capillaribus basi haud dilatatis caducis! — Vallecito, in the northern part of Lower California, *C. R. Orcutt*, May 4, 1886.

Franseria camphorata, Greene, Bull. Calif. Acad. i. 192. Var. leptophylla. Gracilior, tomento tenuissimo evanescente; foliis minoribus tenuisectis, lobis minimis. — Near San Fernando, Lower California, *Orcutt*, 1886. The resinous atoms which give the balsamic odor are much more manifest than in Palmer and Greene's type, the tomentum being minute and evanescent. The minute coating of stipitate glands on the fertile involucres well characterizes the species.

Verbesina dissita, Gray, Proc. Am. Acad. xx. 299. Fine flowering specimens, from "La Grulla," show the species with larger heads and more showy rays than was supposed, and require the following modifications of the character: foliis papilloso-scabridis, superioribus sæpe alternis, inferioribus nunc basi lata sessilibus; capitulis latis semi- vel sub-pollicaribus; involucro campanulato, bracteis obtusis, extimis subspathulatis brevioribus, interioribus linearibus acutiusculis; ligulis 8–10 obovato-oblongis subpollicaribus læte aureis.

Gentiana linearis, Frœl., var. latifolia. Robusta; foliis omnibus basi haud contracta arcte sessilibus, imis oblongo-linearibus, superioribus ovato-lanceolatis, summis flores capitatos involucrantibus: appendicibus plicarum corollæ latis aut acutatis aut subtruncatis lobis sæpius dimidio brevioribus; bracteis (etiam formæ typicæ) nunc tenuissime scaberulis. — Of *G. linearis*, var. *lanceolata*, it is said in the Synoptical Flora that it "approaches narrow-leaved forms of *G. alba*." The variety here characterized is the form from Lake Superior which, in the work referred to, I had referred to *G. alba*, though there is no proof that it has the yellowish-white corolla of that species; and I have some reason to suppose that it is also *G. rubricaulis* of Schweinitz from the same region. It now comes to us from New Brunswick, ten or twelve miles north of St. Stephen, in Charlotte Co., where it was discovered in July and August last by Mr. J. Vroom and Mr. W. F. Ganong, with flowers as blue as those of *G. Saponaria* (which has quite different plicæ), and with foliage like that of *G. Andrewsii*. Although completely connecting forms are wanting, I must conclude that we have here only an extremely broad-leaved variety of *G. linearis*. It was collected at Lake Superior first by Prof. W. D. Whitney;

then, in 1848, by Gen. C. G. Loring (along with a narrower-leaved form, which I referred to var. *lanceolata*); afterwards, in 1863, by the late Dr. Robbins, in very broad-leaved specimens.

FRASERA CUSICKII. *F. nitidæ* soror, pariter glabra, humilior; caulibus subscapiformibus 3–8-pollicaribus quandoque folia radicalia haud superantibus; thyrso aut simplici capituliformi aut spiciformi interrupto; corolla majori cærulescente; lobis fere semipollicaribus ovalibus obtusis cum apiculo glandula viridi lineari instructis; squamis inter stamina pro genere maximis orbiculatis concavis cæruleis fere integerrimis ovarium superantibus. — Hillsides of Grande Ronde Valley, N. E. Oregon, *Cusick*, 1886.

PHLOX DOLICHANTHA. *P. longifoliæ* var. *Stansburyi* proxima; corollæ (pariter roseo-purpureæ et albescens) tubo sesquipollicari calyce triplo longiore, lobis rotundatis integerrimis; staminibus altioribus faucialibus; stylo capillari; stigmatibus ad antheras imas attingentibus. — S. E. Nevada in the Pahranagat Mountains, *Miss Searls*, 1871. S. E. California, station not recorded, probably in the Mohave region, *Parry & Lemmon*, 1876. Bear Valley in the San Bernardino Mountains, at 6,000 feet, *Parish*, June, 1886.

PHACELIA HIRTUOSA. *Eutoca*, hinc *P. loasæfoliæ* illinc *P. brachylobæ* affinis, cinereo-puberula et more prioris setis patentissimis pl. m. pungentibus hispida; caule pedali e radice annua; foliis oblongis sinuato-pinnatifidis imisve subpinnatisectis, lobis vel segmentis inciso-dentatis; floribus in spicis cymæ densis vix elongandis subsessilibus: corolla infundibuliformi-campanulata (lin. 3–4 longa) albido-cærulescente, squamulis internis semi-ovato-lanceolatis prorsus adnatis; staminibus *inclusis;* capsula oblonga 25–30-sperma sepalis fructiferis lineari-oblanceolatis (nunc uno latiore 4–5 lin. longis) subdimidio breviore; seminibus rugoso-tuberculatis. — San Telmo, Lower California, *Orcutt*, May 17, 1886.

ORYCTES NEVADENSIS, Watson. Mr. W. H. Shockley has recently supplied to us, from the neighborhood of Candelaria, Nevada, copious and good specimens of this rare Solanacea; from which the generic character may be improved as to the seed and embryo, but hardly in any other particulars. — Calyx herbaceus, alte 5-partitus, fructifer parum accrescens, lobis lanceolatis. Corolla (flavida) suburceolato-tubulosa, calycem parum superans, lobis 5 brevissimis fere deltoideis æstivatione subinduplicatis per anthesin vix patentibus. Stamina 5, basi corollæ inserta: filamenta filiformia, tria corollæ æquilonga, duo breviora: antheræ didymæ, loculis ovalibus. Stylus filiformis elongatus: stigma capitatum, bilobum. Ovarium glabrum, biloculare, pluri-ovulatum. Bacca sicca, sphærica, calyce immutato subinclusa, demum rumpens, 10–15-sperma. Semina fere orbiculata, plana, testa tenui scabroso-reticulata, ala angusta hyalina cincta. Embryo in albumini parco subcyclicus, fere filiformis.

Lycium Shockleyi. Inter *Calycina* et *Longiflora* quasi medium, humile, glabrum; ramis robustis; foliis subcarnosis angusto-spathulatis semipollicaribus; floribus e nodis fasciculifoliis *sessilibus* tetrameris; calyce angusto-campanulato, tubo (lin. 2–3 longo) dentibus oblongis obtusis patentibus subduplo longioribus; corolla cylindracea e calyce paullo exserta intus prorsus nuda, lobis brevibus rotundatis; staminibus sub fauce insertis, filamentis brevissimis, antheris oblongis; bacca globosa lin. 3 diametro in calyce distento inclusa.— "A low bush, in open sand," Candelaria, S. W. Nevada, *W. H. Shockley.*

Galvesia juncea. *Maurandia juncea*, Benth. Bot. Sulph. 41. *Saccularia Veatchii*, Kellogg, Proc. Calif. Acad. ii. 17, & Bull. Calif. Acad. i. 144, with colored plate, reproduced from *The Hesperian*, July, 1860. *Antirrhinum* (*Gambelia*) *junceum*, Gray, Proc. Am. Acad. vii. 377, & Syn. Fl. ii. 254, 439. Excellent specimens, in flower and fruit, have recently been collected by Mr. Orcutt in Lower California, where it appears to abound. As Mr. Ball has indicated (in Jour. Linn. Soc. xxii. 152), this is a strict congener of *Galvesia Limensis;* and so is the *Antirrhinum* (*Gambelia*, Nutt.) *speciosum*, notwithstanding the fact, as observed upon the plant once in cultivation here, that the palate actually closes the orifice of the corolla. Indeed, it may be seen that the palate nearly or quite does so in *G. juncea* and *G. Limensis*, at least in early anthesis; although the stamens soon lengthen so that the anthers slightly project from the gorge; and in dried specimens lateral flattening causes the lips to gape. But it is hardly less so in our Californian true *Antirrhina*, although the gorge is well closed in life. It becomes evident, therefore, that the genus *Galvesia*, properly including our two Lower Californian species (*G. juncea* and *G. speciosa*), should rest mainly on the narrow and strictly tubular corolla, confirmed by its marked habit and geographical distribution. *Gambelia*, Nutt., is accordingly reduced to a synonym.

Castilleia Suksdorfii. *C. miniatæ* peraffinis, villosula, surculis subterraneis filiformibus copiosis perennans; radicibus fibrosis; caulibus sparsis simplicissimis (1–2-pedalibus) strictis multifoliatis; foliis membranaceis angusto-lanceolatis sursum attenuatis integerrimis summisve trifidis, floralibus viridibus "superne subito læte miniatis linea flava interjecta." — Alpine meadows and springs of Mount Adams, Washington Territory, at 6,000 or 7,000 feet of elevation, *Suksdorf*, 1885, 1886. — Mr. Suksdorf calls my attention to the differences between this plant and all the forms of *C. miniata;* which, once seen, are conclusive as to the distinctness of the two species. *C. miniata* grows in clumps of many stems from a stout stock or perennial root, and is wholly destitute of the filiform subterranean creeping shoots by which the related species loosely spreads and multiplies; its stems commonly bear one or two flowering branches near the summit, and the red of the bracteal leaves is diffused, instead of ending abruptly.

BOSCHNIAKIA, C. A. Meyer. — In the supplement to the *Gamopetalæ* of my Synoptical Flora. I hurriedly noted that *B. strobilacea* extends northward to Oregon, and that it has a deeply favose seed-coat. I neglected to state that those seeds are globose and large, even as much as a line in length, which needed mention the more that, in the generic character, the seeds are said to be minute. Those of *B. glabra* I find to be only a quarter of a line long, not "subglobose" however, but mainly oblong. I ought also to have stated, what Mr. Howell's specimen plainly showed, that the capsule of *B. strobilacea* is four-valved, answering to the "four equidistant placentæ" in the character of the section, and that the style remains slender, and is at length deciduous from the summit of the globose capsule. These points are now (July, 1886) brought to my attention by my good correspondent, Dr. C. L. Anderson, of Santa Cruz, California, who also sends fine and large fruiting specimens. I have not seen the Himalayan species, which is described as having "orbicular" and "compressed" seeds, of about a third of a line in length, and large reticulations to the hyaline testa. Comparing these with the seeds of *B. glabra*, the latter are said to be ellipsoid and the hundredth of an inch long, with a close testa. Now in our specimens from Sitka they measure much more than that, as above stated, and they are, as Bentham described them, reticulated, the coat decidedly loose and minutely favose. I have now reason to think that *B. Hookeri* and my *B. strobilacea* may be the same species. For Dr. Macoun sends us a form of the latter of a size not larger than Hooker's figure of the former, still, however, with the broad and partially imbricating scales of *B. strobilacea*. However that may be, the two sections of the genus may be contrasted as follows, while *B. Himalaica* may be of a third.

§ 1. Stamina basi nuda: placentæ 2 bilobæ: capsula bivalvis, stylo diu persistente demum fisso rostrata. Semina parva, oblonga. — *B. glabra.*

§ 2. Stamina basi villosa: placentæ 4 æquidistantes: capsula globosa, 4-valvis: stylus tenuis demum deciduus: semina sat magna, sphærica, testa laxa favosa. — *B. Hookeri* is probably of this section in all its characters. *B. strobilacea* is perhaps only the well-grown form of it. An examination of the original at Kew should determine this.

Addendum to Papaveraceæ.

PAPAVER CALIFORNICUM. *P. dubio* perquam simile, pilis parcis forte tenuioribus; corolla crocea oculo citrina; capsula (circiter semipollicari) clavato-turbinata 6–11-mera, valvulis dentiformibus subquadratis lineam longis latisque placentas nudantibus dehiscente; seminibus rete grossa parca fenestrali. — Santa Inez Mountains, California, coll. *John Spence.*

One is naturally slow to believe in an indigenous Californian Corn Poppy. In the spring of 1886 that excellent florist and acute observer, Mr. Spence, of Santa Barbara, sent me some flowers of this plant which he had hastily picked up in the Santa Inez Mountains, at the elevation of 1,500 or 2,000 feet, far away from any cultivation, on ground which had been covered with Manzanita, but had been burned over the year before. These flowers and forming pods, so far as could be told by inspection, might have belonged to *Papaver dubium* or *P. Rhœas*, species which might be expected to abound in old Californian wheat-fields, although they had not there been met with to my knowledge. At this moment I receive from Mr. Spence a supply of mature capsules and seeds gathered last summer at the same station, or partly at another similar station, about forty miles farther west, "far away from any trail," on ground which had similarly been burned over; and with these some flowering materials raised from their seed in his conservatory. These capsules are so like those of *P. dubium* that, apart from their history, they might pass for such. But they all (nearly one hundred in number) have the peculiarity described in the character. They dehisce — just as do those of their compatriot and almost congener *Meconopsis heterophylla* — by decided valves, of a line in length, exposing the septa for that length, recurving, and at length breaking off square at their base. Moreover, the seeds — which are much like those of our *Meconopsis* — have far fewer and coarser and more quadrate reticulations than those of *P. dubium*. I conclude, therefore, that Mr. Spence's plant is an indigenous species. I suspect that it may not be so very rare and local, and that its close resemblance to our *Meconopsis* has allowed it to be overlooked. The habit of the two is quite similar. So far as I have seen the foliage, I could not certainly distinguish the two except by the sparse hairiness of the true Poppy. This discovery suggests a probable genealogy of our American *Meconopsis*.

Emendata.

Page 273, lines 11, 12, to be

Scarious or partly scarious rounded sepals plane: gynœcium 2-merous.
Sepals equal, emarginate at base and apex: petals 4: stamens 3, twice the length of the petals: filaments filiform: anthers linear-oblong: style long, filiform: stigma 2-lobed: capsule globose-ovate, few-seeded. 8. SPRAGUEA.
Sepals mostly unequal: petals 2 to 4, small: stamens 1, 2, or 3, shorter than the petals: filaments subulate: anthers oval or oblong: style short or hardly any: stigmas 2: capsule linear to oval, 6–24-seeded. 9. CALYPTRIDIUM.

Page 299, note, the paragraph beginning "A. ACERIFOLIA, DC. Prodr. i. 459," should be omitted.

Page 302, before "HIBISCUS," add

KOSTELETZKYA (ORTHOPETALUM) THURBERI. Herbaceous and merely scabrous-puberulent: leaves round-cordate and angulate-trilobed, uppermost oblong-ovate and acuminate, serrulate: flowers numerous in a loose and naked compound panicle: bractlets of involucel setaceous: calyx (3 lines long) not accrescent: corolla less than an inch long, rose-color: stamens rather few near the apex of the filiform column: capsule acutely 5-lobed, hispid along the angles. — *K. paniculata*, Torr. Bot. Mex. Bound. 40, not at all of Benth., which has recently been collected by Dr. Palmer.

XVI.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

ON MUCOXYBROMIC AND MUCOXYCHLORIC ACIDS.

By Henry B. Hill and Arthur W. Palmer.

Presented February 9, 1887.

The action of baric hydrate upon mucobromic acid was studied several years ago by O. R. Jackson and one of us.* It was found that mucobromic acid was decomposed by a large excess of baric hydrate with the formation of $\alpha\beta$ dibromacrylic and formic acids, while an essentially different reaction ensued in a feebly alkaline solution. The main product in this case was shown to be a dibasic acid containing four atoms of carbon; but it was not further studied. Somewhat later, E. K. Stevens and one of us † found that mucophenoxybromic acid was formed by an analogous reaction when mucobromic acid was treated with potassic phenylate; and the constitution of this acid was established with little difficulty by its conversion into phenoxybrommaleic and phenoxybromacrylic acids. The great stability of the latter acid in alkaline solution left no doubt that its structure was represented by the formula

$$\begin{array}{l} CHBr \\ \| \\ C - O \,.\, C_6H_5 \\ | \\ COOH\,. \end{array}$$

While it was thus rendered probable that in the corresponding decompositions by baric hydrate an atom of bromine in the mucobromic acid had been replaced by hydroxyl, and the empirical formula of the product formed also warranted this conclusion, it was difficult to obtain any definite experimental evidence in its support. The isomerism

* These Proceedings, Vol. XVI. p. 188.

† These Proceedings, Vol. XIX. p. 262.

of this acid with monobrommaleic and monobromfumaric acid, and its strongly marked dibasic character, made its constitution a question of decided interest. We therefore undertook its more extended investigation, as well as a study of the analogous chlorine compound, which could readily be obtained from mucochloric acid. Although our investigations are in many respects incomplete, they seem to us to leave little doubt as to the constitution of the compounds in question; and since we shall be unable to continue the work together, we have thought it best to present the results which we have already obtained.

Mucoxybromic Acid.

Whenever mucobromic acid is dissolved in a solution of an alkaline hydrate, more or less mucoxybromic acid appears to be formed. For its preparation, however, we have found it necessary to use baric hydrate, and the yield is then largely dependent upon the conditions under which the reaction takes place. We have found it most advantageous to suspend the mucobromic acid in thirty parts of cold water, and, after cooling well with ice, to add gradually, with constant shaking, finely powdered baric hydrate of known strength. After the mucobromic acid is neutralized, the baric hydrate must be added in small quantities, and the solution allowed to stand until the alkaline reaction has nearly disappeared before a fresh portion is added. The alkaline reaction disappears rapidly at first, afterwards more slowly, and when the amount of baric hydrate demanded by the equation

$$2\ C_4H_2Br_2O_3 + 3\ BaO_2H_2 = 2\ BaC_4HBrO_4 + BaBr_2 + 4\ H_2O$$

has been added, the reaction usually remains feebly alkaline, even after long standing. The slight excess of baric hydrate is then removed by carbonic dioxide, and an equal volume of alcohol added to the filtered solution. Baric mucoxybromate, which is very sparingly soluble in dilute alcohol, is thus precipitated in the form of fine, flattened, pointed needles, and may be purified by dissolving in cold water and reprecipitating with alcohol. With careful work, about sixty per cent of the theoretical yield may be obtained. The preparation of the free acid from the barium salt is a matter of considerable difficulty, since it cannot be extracted from aqueous solution by the ordinary solvents, and it is quickly decomposed during the evaporation of its solution, even at ordinary temperatures. We succeeded in preparing it only by moistening the salt with a little water, precipitating the barium exactly with sulphuric acid, and evaporating the concentrated solution of the acid thus obtained as rapidly as possible over sulphuric acid *in vacuo*. The viscous residue thus obtained gradually solidified at low temperatures, and yielded tolerably well formed thick prisms with bevelled ends. The substance, freed from the viscous mother liquors as completely as possible and dried over sulphuric acid, gave, on analysis, the following results: —

I. 0.7181 grm. substance gave 0.6451 grm. CO_2 and 0.1004 grm. H_2O.
II. 0.7504 grm. substance gave 0.6697 grm. CO_2 and 0.1010 grm. H_2O.
III. 0.2053 grm. substance gave 0.1977 grm. AgBr.
IV. 0.2348 grm. substance gave 0.2254 grm. AgBr.

	Calculated for $C_4H_3BrO_4$.	Found. I.	II.	III.	IV.
C	24.60	24.50	24.34		
H	1.54	1.55	1.50		
Br	41.03	. . .	. . .	41.00	40.86

Mucoxybromic acid is extremely soluble in water, alcohol, or ether, and almost insoluble in chloroform, benzol, ligroin, or carbonic disulphide. The melting point was found to be 111–112°; the true melting point may, however, be somewhat higher, since the substance could not be purified by repeated crystallization. The acid gives with ferric chloride an intense garnet-red coloration, which is readily seen, even in very dilute solutions. With argentic nitrate it gives a white crystalline precipitate of the silver salt. Baric acetate added to a concentrated aqueous solution throws down the highly crystalline barium salt. By the action of hydrobromic acid saturated at 0°, or of phosphoric pentabromide, no definite products were obtained.

Baric Mucoxybromate, $BaC_4HBrO_4 \cdot 2\,H_2O$. — The preparation of the barium salt has already been described. The salt is somewhat sparingly soluble in cold water, and its solubility is not sensibly increased by heat. It is rapidly decomposed by boiling its aqueous solution, and even in the cold decomposition ensues after long standing. On the evaporation of a solution saturated at ordinary temperatures over sulphuric acid *in vacuo*, the salt separates in long lustrous six-sided prisms, with perpendicular terminations. The air-dried salt loses over sulphuric acid, or at 100°, rather more than one molecule of water, and has then the composition $BaC_4HBrO_4 \cdot H_2O$. When heated to 105–115°, it slowly loses the second molecule of water, but at the same time it turns brown, and baric bromide is formed.

I. 1.5527 grm. of the salt, crystallized from water and dried by exposure to the air, lost over sulphuric acid 0.0953 grm. H_2O.

II. 1.0746 grm. of the salt, precipitated by alcohol and dried by exposure to the air, lost over sulphuric acid 0.0663 grm. H_2O.

III. 1.0502 grm. of the salt, precipitated by alcobol and dried by exposure to the air, lost over sulphuric acid 0.0631 grm. H_2O.

	Calculated for $BaC_4HBrO_4 . 2H_2O$.	Found. I.	II.	III.
1 H_2O	4.92	6.14	6.17	6.01

The salt dried over sulphuric acid gave, on analysis, the following results: —

I. 0.2769 grm. of the salt gave 0.1837 grm. $BaSO_4$.

II. 0.2052 grm. of the salt gave 0.1368 grm. $BaSO_4$.

III. 0.5470 grm. of the salt gave 0.3678 grm. $BaSO_4$.

IV. 0.4128 grm. of the salt gave 0.2079 grm. CO_2 and 0.0354 grm. H_2O.

V. 0.4988 grm. of the salt gave 0.2516 grm. CO_2 and 0.0477 grm. H_2O.

VI. 0.2120 grm. of the salt gave 0.1128 grm. AgBr.

VII. 0.2684 grm. of the salt gave 0.1457 grm. AgBr.

	Calculated for $BaC_4HBrO_4 . H_2O$.	Found. I.	II.	III.	IV.	V.	VI.	VII.
Ba	39.37	39.00	39.19	39.54				
C	13.77	...	...	...	13.74	13.76		
H	0.86	...	...	...	0.95	1.06		
Br	22.99	...	...	...	...	...	22.64	23.11

We have made many unsuccessful attempts to prepare an acid barium salt. In every case, when the acid solution was precipitated with alcohol, or evaporated *in vacuo* over sulphuric acid, we obtained only the neutral salt.

Potassic Mucoxybromate, $K_2C_4HBrO_4 . H_2O$. — The potassium salt was prepared from the barium salt by exact precipitation with potassic carbonate, and evaporation of the solution thus obtained *in vacuo*. It crystallized in well-formed rhombic plates, which were very soluble even in cold water. On warming the solution, decomposition quickly ensued. The air-dried salt lost nothing over sulphuric acid, turned somewhat brown at 70°, but did not lose sensibly in weight until heated to 100°.

I. 0.4951 grm. of the air-dried salt lost, at 100°, 0.0344 grm. H_2O, and gave 0.2991 grm. K_2SO_4.

II. 0.4604 grm. of the air-dried salt lost, at 100°, 0.0307 grm. H_2O, and gave 0.2780 grm. K_2SO_4.

III. 0.5428 grm. of the air-dried salt gave 0.3281 grm. K_2SO_4.

	Calculated for $K_2C_4HBrO_4 . H_2O$.	Found. I.	II.	III.
K	27.04	27.12	27.10	27.14
H_2O	6.64	6.95	6.67	

Argentic Mucoxybromate, $Ag_2C_4HBrO_4$. — Argentic nitrate added to a solution of the free acid, or one of its salts, throws down a crystalline precipitate of the silver salt. When this is warmed with water, argentic bromide is at first formed, then reduction takes place. When heated in a slightly ammoniacal solution, it is immediately blackened. It dissolves readily in dilute nitric acid, but the solution soon grows turbid with the separation of argentic bromide. The dry salt explodes on heating, or on moistening with concentrated nitric acid. For analysis, the salt was made by precipitating an excess of argentic nitrate with a dilute solution of the barium salt.

I. 0.3974 grm. of the salt dried *in vacuo* over H_2SO_4 gave, on precipitation with HBr, 0.3634 grm. AgBr.

II. 0.5478 grm. of the salt dried *in vacuo* over H_2SO_4 gave, on precipitation with HBr, 0.5034 grm. AgBr.

III. 0.5455 grm. of the salt dried *in vacuo* over H_2SO_4 gave, on precipitation with HBr, 0.4999 grm. AgBr.

IV. 0.5866 grm. of the salt dried *in vacuo* over H_2SO_4 gave, on heating in sealed tube with diluted nitric acid, 0.2672 grm. AgBr.

	Calculated for $Ag_2C_4HBrO_4$.	Found. I.	II.	III.	IV.
Ag	52.82	52.53	52.78	52.64	
Br	19.56	...	...	...	19.38

A solution of the barium salt yielded, with plumbic nitrate, a heavy yellow, semi-crystalline precipitate, which, when dried over sulphuric acid, gave on analysis percentages of lead and bromine which only approximated those required by the formula PbC_4HBrO_4.

Dimethyl Mucoxybromate, $C_4HBrO_4(CH_3)_2$. — The dimethyl ether of mucoxybromic acid can readily be formed by the action of methyl iodide upon the dry silver salt. If the methyl iodide is slowly added to the silver salt, so much heat is evolved that a violent and even dangerous explosion ensues. The silver salt must therefore be added in small portions to an excess of methyl iodide, or must be suspended in dry ether before adding the methyl iodide. The product of the reaction proved to be a viscous, sticky liquid, which showed no signs of crystallization after long standing over sulphuric acid *in vacuo*, and which could not be volatilized, even *in vacuo*, without decomposition. The substance dried over sulphuric acid *in vacuo* for several days gave somewhat too low a percentage of bromine.

0. 3653 grm. substance gave 0.3031 grm. AgBr.

	Calculated for $C_4HBrO_4(CH_3)_2$.	Found.
Br	35.88	35.30

Diethyl Mucoxybromate, $C_4HBrO_4(C_2H_5)_2$. — This substance we attempted to prepare by the action of ethyl iodide diluted with dry ether upon the silver salt. We obtained a thick viscous product, which we were unable to purify, and which, after long standing over sulphuric acid *in vacuo*, proved to contain iodine, and gave too high a percentage of halogen.

I. 0.2288 grm. substance gave 0.1911 grm. AgBr.
II. 0.2328 grm. substance gave 0.1920 grm. AgBr.

	Calculated for $C_4HBrO_4(C_2H_5)_2$.	Found. I.	Found. II.
Br	31.82	35.56	35.10

The ether was decomposed by an excess of baric hydrate, the excess of baric hydrate precipitated by carbonic dioxide, and alcohol added to the filtered solution. We obtained in this way a crystalline salt, which possessed all the properties of baric mucoxybromate.

0.5875 grm. of the air-dried salt gave 0.3720 grm. $BaSO_4$.

	Calculated for $BaC_4HBrO_4 . 2 H_2O$.	Found.
Ba	37.43	37.23

Monoethyl Mucoxybromate, $C_4H_2BrO_4 . C_2H_5$. — If ordinary ether is used instead of anhydrous ether in the preparation of the ethyl ether, the acid ether is obtained. We added the dry silver salt slowly to an excess of ethyl iodide, and, after the first reaction was over, warmed for a short time on the water-bath. The product was then extracted with ordinary ether, and the etheral extract allowed to evaporate spontaneously. The syrupy residue thus obtained gradually yielded an abundance of clear prisms, with oblique truncations, which were pressed out, and recrystallized from boiling benzol.

0.2068 grm. of substance dried over H_2SO_4 gave 0.1762 grm. AgBr.

	Calculated for $C_4H_2BrO_4 . C_2H_5$.	Found.
Br	35.88	36.25

The monoethyl mucoxybromate dissolves quite readily in water, its solution has a strongly acid reaction, and gives with ferric chloride an intense red coloration. It dissolves readily in alcohol, ether, chloroform, or hot benzol, more sparingly in ligroin or carbonic disulphide. The melting point of the substance repeatedly recrystallized from benzol was found to be 88–89°.

Decomposition in Alkaline Solution.

The instability of mucoxybromic acid and its salts in aqueous solution led us to study the reaction more closely, with the hope that the products of this decomposition might throw light upon the constitution of the acid. When a solution of the barium salt is heated to boiling, it soon acquires an acid reaction, and before long grows turbid, with the separation of acid baric oxalate. The reaction then appears to progress slowly, and even after long boiling the decomposition is incomplete. In an alkaline solution, however, complete decomposition is readily effected. Baric hydrate appears to have no action upon mucoxybromic acid in the cold. After standing for days the solution is still clear, and contains no baric bromide. On heating, baric oxalate and baric carbonate are soon thrown down, and in solution may then be found baric bromide and baric formiate. The barium salts which were precipitated on boiling were collected on a filter, and the presence of oxalic and carbonic acids proved by qualitative tests. The oxalic acid was then converted into the calcium salt, and its identity further established by analysis.

0.3141 grm. of the salt dried at 100° gave 0.2883 grm. $CaSO_4$.

Calculated for $CaC_2O_4 . H_2O$.	Found.
27.39	27.01

The alkaline solution filtered from the precipitated baric oxalate and carbonate was freed from the excess of baric hydrate by carbonic dioxide, and concentrated by evaporation on the water-bath. It gave with argentic nitrate a heavy precipitate of argentic bromide, and the filtered solution, containing an excess of argentic nitrate, deposited metallic silver on heating. After removing the barium with dilute sulphuric acid, the solution yielded an acid distillate, from which plumbic formiate was obtained by neutralizing with plumbic carbonate.

0.2498 grm. of the salt dried over H_2SO_4 gave 0.2542 grm. $PbSO_4$.

Calculated for $Pb . (CHO_2)_2$.	Found.
69.69	69.50

Beside baric formiate and baric bromide the aqueous solution contained, in small but not insignificant quantity, an amorphous gummy barium salt, whose nature we have been unable to determine, since all our attempts to convert it into a compound fit for analysis have proved unsuccessful. The formation of this gummy barium salt, together with the fact that quantitative determinations of the amounts of carbonic and oxalic acid formed in the reaction showed no simple ratio between the two, leaves little doubt that the reaction is essentially complex in its nature. When an aqueous solution of baric mucoxybromate is boiled with the addition of baric carbonate, the products of the decomposition appear to be the same. The action of water upon the free acid, which is doubtless similar, we have not yet studied in detail.

Action of Bromine in Aqueous Solution.

By the action of most of the ordinary oxidizing agents upon mucoxybromic acid or its salts, we were unable to obtain any definite oxidation products except oxalic acid. Bromine water, however, gave us more satisfactory results. On adding bromine slowly to an aqueous solution of the acid, the color of the bromine rapidly disappeared, oxalic acid was formed, and at the same time a well-defined product containing bromine could be isolated. We found that the same reaction ensued, and apparently rather more neatly, when the barium salt was taken instead of the free acid. Two molecules of bromine were therefore added to a dilute solution of the barium salt. After standing for several hours, the color of the bromine had completely disappeared, and crystals of acid baric oxalate had separated in abundance. The strongly acid solution was then neutralized with calcic carbonate, filtered, and extracted with ether. The ether left, on evaporation, a syrupy residue, which gradually deposited well-formed oblique prisms, which melted at 51–52°. The melting point of the substance, its characteristic crystalline form, and its reactions with alkalies and argentic nitrate, left little doubt that it was bromal hydrate, although the percentage of bromine which it gave on analysis was somewhat too low.

0.1351 grm. substance gave 0.2534 grm. AgBr.

	Calculated for $C_2Br_3H_3O_2$.	Found.
Br	80.26	79.84

We found that the purification of this substance by recrystallization was attended with so great loss, that we could hardly draw any definite conclusion as to the composition of the main product from analyses of the small purified residue, and we therefore determined to examine the products formed from it by the action of alkalies. Instead of extracting with ether the solution neutralized with calcic carbonate, we added to it a slight excess of potassic hydrate, and distilled, after neutralizing the slightly alkaline solution, with hydrochloric acid. In this way we obtained a colorless, heavy oil, which was easily recognized as bromoform. After drying over fused calcic chloride, it boiled at 147–150°, under a pressure of 748 mm. Its identity was further established by analysis.

I. 0.1739 grm. substance gave 0.3893 grm. AgBr.
II. 0.2202 grm. substance gave 0.4940 grm. AgBr.

	Calculated for $CHBr_3$.	Found. I.	II.
Br	94.86	95.28	95.48

The weight of bromoform thus obtained amounted to between sixty and seventy per cent of that required by the assumption that each molecule of the acid yielded one molecule of bromal.

The residue left after distilling off the bromoform was then acidified and distilled with steam. The acid distillate contained formic acid, as was shown by the ordinary qualitative tests, and by the analysis of the lead salt prepared from it.

0.3193 grm. of the salt dried at 100° gave 0.3256 grm. $PbSO_4$.

	Calculated for $Pb.(CHO_2)_2$.	Found.
Pb	69.69	69.66

One of the products of the reaction was therefore bromal. In the insoluble residue removed by filtration after neutralizing with calcic carbonate was found oxalic acid in abundance, which was identified by qualitative reactions and by the analysis of its calcium salt.

0.3779 grm. of the salt dried at 100° gave 0.3490 grm. $CaSO_4$.

	Calculated for $CaC_2O_4.H_2O$.	Found.
Ca	27.39	27.16

The decomposition of mucoxybromic acid by aqueous bromine may therefore be expressed by the equation

$$C_4H_3BrO_4 + 2\,Br_2 + H_2O = C_2HBr_3O + H_2C_2O_4 + 2\,HBr.$$

Although phenylhydrazine readily reacts upon mucoxybromic acid, even in dilute solution, the flocculent product formed rapidly turns brown, and we have not succeeded in obtaining it in a form fit for analysis. Hydroxylamine also yielded no more satisfactory results, although we tried the reaction under a variety of conditions. On the other hand, the primary aromatic amines in neutral or acid solutions gave beautifully crystalline products with the greatest readiness. Aniline, parabromaniline, para- and metanitraniline, ortho- and paratoluidine, all yielded similar products, but we have thus far studied in detail the aniline compound alone. Urea likewise gives a crystalline condensation product which has not yet been further investigated.

Anilmucoxybromic Acid.

When aniline chloride is added to a dilute solution of mucoxybromic acid, the solution soon becomes yellow, and after a short time solidifies, with the separation of finely felted, light yellow needles. A moderate excess of free hydrochloric acid in no way interferes with the formation of the product, so that it may be most conveniently prepared by dissolving baric mucoxybromate in a slight excess of dilute hydrochloric acid, and adding a molecule of aniline dissolved in hydrochloric acid. The product was recrystallized from hot water, dried over sulphuric acid, and proved then to be anilmucoxybromic acid, formed according to the equation

$$C_4H_3BrO_4 + C_6H_5NH_2 = C_4H_3BrO_3 . C_6H_5N + H_2O.$$

I. 0.2775 grm. substance gave 0.4540 grm. CO_2 and 0.0790 grm. H_2O.

II. 0.2602 grm. substance gave 0.1810 grm. AgBr.

III. 0.2526 grm. substance gave 0.1764 grm. AgBr.

IV. 0.5563 grm. substance gave 25.2 cc. of moist nitrogen at 19° and under a pressure of 748 mm.

	Calculated for $C_{10}H_8BrNO_3$.	Found. I.	II.	III.	IV.
C	44.44	44.62			
H	2.96	3.16			
Br	29.63	. . .	29.61	29.73	
N	5.18	. . .	. . .	. . .	5.21

The air-dried acid apparently contained one molecule of water, which it lost rapidly over sulphuric acid, or when heated to 70°. At 100° a slow decomposition appeared to take place. The loss of crystal water was accompanied by a change of color to brilliant yellow.

I. 0.5579 grm. of air-dried substance lost, at 62–65°, 0.0362 grm. H_2O.

II. 0.9504 grm. of air-dried substance lost, at 70°, 0.0630 grm. H_2O.

III. 1.0217 grm. of air-dried substance lost over sulphuric acid 0.0786 grm. H_2O.

	Calculated for $C_{10}H_8BrNO_3 . H_2O$.	Found. I.	II.	III.
H_2O	6.25	6.49	6.63	7.69

Anilmucoxybromic acid crystallizes from water in fine pale yellow needles, which are sparingly soluble in cold water, more readily in hot. On long heating of the aqueous solution decomposition sets in. The acid dissolves readily in alcohol, ether, or in hot chloroform or benzol, in ligroin or carbonic disulphide it is sparingly soluble. From chloroform it crystallizes in small compact oblique prisms, which melt, with decomposition, at 131–132°. The acid dissolves readily in solutions of the alkaline carbonates, and is reprecipitated unchanged on the addition of acids. With the salts of the heavy metals it gives brilliant yellow insoluble salts, and with ferric chloride it yields a deep brown precipitate. On heating with acids or alkalies, aniline is formed. On titration with baric hydrate two molecules of the acid were found to be neutralized by one molecule of baric hydrate, but salts containing two atoms of silver and potassium could also be prepared.

Monobaric Anilmucoxybromate, $Ba(C_{10}H_7BrNO_3)_2 \frac{1}{2} H_2O$. — By the action of baric carbonate upon the acid suspended in water, a salt is formed which is somewhat sparingly soluble in hot or cold water. On evaporation of the solution a portion of the salt separates in yellow needles, but decomposition soon ensues. On the addition of baric acetate to the acid neutralized with ammonic hydrate, an amorphous flocculent precipitate was thrown down, which dissolved on heating, and immediately in its place there appeared a highly crystalline bright yellow precipitate. As the solution cooled, still more of the salt separated in felted needles. The air-dried salt apparently contained a half-molecule of crystal water, which it lost at 100°.

0.5802 grm. of the air-dried salt lost, at 100°, 0.0075 grm. H_2O.

	Calculated for $Ba . (C_{10}H_7BrNO_3)_2 \frac{1}{2} H_2O$.	Found.
H_2O	1.32	1.25

0.5755 grm. of this salt dried at 100° gave 0.1970 grm. $BaSO_4$.

	Calculated for $Ba . (C_{10}H_7BrNO_3)_2$.	Found.
Ba	20.30	20.12

Diargentic Anilmucoxybromate, $Ag_2C_{10}H_6BrNO_3$. — When argentic nitrate was added to an aqueous solution of the free acid, a pale yellow gelatinous precipitate was thrown down, which apparently contained one atom of silver. If, however, the acid was dissolved in two equivalents of ammonic hydrate, and the solution was then added to an excess of argentic nitrate, a voluminous bright orange-yellow precipitate was thrown down, which on standing became dense and semicrystalline, and contained two atoms of silver. When warmed with an excess of argentic nitrate in a feebly ammoniacal solution, no immediate reduction took place.

0.4275 grm. of the salt dried over H_2SO_4 gave 0.3290 grm. AgBr.

	Calculated for $Ag_2C_{10}H_6BrNO_3$.	Found.
Ag	44.64	44.21

Dipotassic Anilmucoxybromate, $K_2C_{10}H_6BrNO_3$. — On the addition of an alcoholic solution of potassic hydrate to a solution of the acid in anhydrous ether, a pale yellow salt was thrown down, which was well washed with anhydrous ether and dried *in vacuo* over sulphuric acid and solid sodic hydrate.

0.3556 grm. of the salt gave 0.1805 grm. K_2SO_4.

Calculated for $K_2C_{10}H_6BrNO_3$.	Found.
22.58	22.79

While anilmucoxybromic acid forms by preference monobasic salts, it is evidently capable of exchanging two of its hydrogen atoms for metals.

Phenylhydrazine Anilmucoxybromate, $C_{10}H_8BrNO_3 . C_6H_8N_2 . H_2O$. — When phenylhydrazine hydrochlorate is added to anilmucoxybromic acid dissolved in a dilute solution of sodic acetate, a colorless crystalline precipitate soon separates, which after washing with cold water becomes somewhat discolored on drying. The compound is but sparingly soluble in cold water, more readily in hot, but it cannot be recrystallized from hot water without decomposition. It is readily soluble in alcohol, but nearly insoluble in ether. It is readily decomposed in the cold by dilute hydrochloric acid, or by a dilute solution of sodic carbonate, with the formation of phenylhydrazine. This behavior showed the substance to be a simple salt of phenylhydrazine, and analysis also failed to show the elimination of water.

0.3708 grm. of the air-dried substance gave 36.5 cc. of moist nitrogen at 25° under a pressure of 726 mm.

	Calculated for $C_{16}H_{16}BrN_3O_3 . H_2O$.	Found.
N	10.60	10.77

Mucoxychloric Acid.

W. Z. Bennett* and one of us several years ago studied the action of baric hydrate upon mucochloric acid. It was found that the acid was decomposed by a large excess of baric hydrate, and that $\alpha\ \beta$ dichloracrylic and formic acids were formed in nearly theoretical quantities. When the baric hydrate is carefully added, so that the solution is at no time very strongly alkaline, the reaction follows an entirely different course, and mucoxychloric acid is found in abundance. Since the $\alpha\ \beta$ dichloracrylic acid had already been shown to be more stable than the corresponding dibromacrylic acid, we were led to study mucoxychloric acid more in detail, with the hope that its derivatives would also prove more stable and more manageable than those of mucoxybromic acid. In the preparation of mucoxychloric acid we followed precisely the same method which we had found advantageous with the bromine compound. Mucochloric acid † was

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* These Proceedings, Vol. XVI. p. 206.

† Although W. Z. Bennett and I had succeeded in obtaining a fairly satisfactory yield of mucochloric acid, the method which we used was troublesome and tedious in the extreme when large quantities of material were involved, and necessitated the prolonged treatment of large quantities of liquid at 0° with chlorine gas. The slightest want of care also frequently diminished the yield most seriously. I therefore made many fruitless attempts to find some more advantageous method for its preparation. I at last hit upon an extremely convenient and simple method, which allows the preparation of any quantity of mucochloric acid desired in the course of a few hours. The yield is also quite satisfactory, and falls not far short of that which is attainable by the old method. Pyromucic acid is suspended in 14½ times its weight of common strong hydrochloric acid (Sp. Gr. 1.16), and somewhat more than four molecules of finely powdered manganic dioxide is then gradually added. At first the mixture is kept cold (ice cooling is unnecessary). The temperature is then allowed to rise, and finally the solution is heated and boiled gently for twenty minutes. Since it is difficult to filter the hot strongly acid liquid from the impurities contained in the manganic dioxide, the solution is allowed to cool, and the mucochloric acid which separates collected upon a filter of coarse cloth. It is then dissolved in hot water, and the filtered solution concentrated by evaporation if necessary. From 100 grm. of pyromucic acid suspended in 1250 cc. of ordinary hydrochloric acid and 380 grm. of manganese dioxide (83% MnO_2), 50 grm. of pure mucochloric acid are readily obtained, and the mother liquors yield 2–3 grm. of a somewhat dark-colored acid. Bennett and I obtained by the much more laborious method, as the result of many separate operations, 129 grm. of mucochloric acid from 202 grm. pyromucic acid. This method accordingly yields in a short time about 83 per cent of the amount attainable by the more tedious method. — H. B. H.

suspended in 35 times its weight of water, and, after cooling well with ice, the theoretical quantity of finely powdered baric hydrate was slowly added, taking care to avoid at any time a large excess. After the requisite amount of baric hydrate had been added, we allowed the solution to stand over night, and removed the slight excess of baric hydrate which was then usually found present by means of carbonic dioxide. The filtered solution gave, when mixed with an equal volume of alcohol, a voluminous highly crystalline precipitate of baric mucoxychlorate, which could be purified by reprecipitation from aqueous solution by alcohol. In this way we have obtained 73 per cent of the theoretical amount of barium salt demanded by the equation.

$$2\,C_4H_2Cl_2O_3 + 3\,BaO_2H_2 = 2\,BaC_4HClO_4 + BaCl_2 + 4\,H_2O.$$

The mother liquors contain, beside baric chloride, baric $\alpha\ \beta$ dichloracrylate, which may be obtained without difficulty by the evaporation of the solution. Although ether extracts the acid from aqueous solution, it does not take it up very readily, and we have found it more advantageous to precipitate the barium salt exactly with dilute sulphuric acid, and evaporate the aqueous solution thus obtained *in vacuo* over sulphuric acid. The acid may readily be recrystallized with care from a little warm water. For analysis the acid was dried over sulphuric acid.

I. 0.2925 grm. substance gave 0.3420 grm. CO_2 and 0.0615 grm. H_2O.
II. 0.1990 grm. substance gave 0.1915 grm. AgCl.
III. 0.2000 grm. substance gave 0.1918 grm. AgCl.

	Calculated for $C_4H_3ClO_4$.	Found. I.	II.	III.
C	31.89	31.88		
H	1.99	2.33		
Cl	23.59	. . .	23.79	23.71

Mucoxychloric acid is readily soluble in water, alcohol, or ether, and almost insoluble in chloroform, benzol, ligroin, or carbonic disulphide. From water it crystallizes in stout prisms with bevelled ends, which melt at 114–115°. With ferric chloride it gives, even in extremely dilute solutions, a deep garnet-red coloration. With argentic nitrate it gives an immediate crystalline precipitate of the silver salt. Although more stable than mucoxybromic acid, it is soon decomposed by warming its aqueous solution.

Baric Mucoxychlorate, $BaC_4HClO_4 . 2 H_2O$. — The preparation of the barium salt has already been described. It is sparingly soluble in cold water, more readily in hot, and is nearly insoluble in dilute alcohol. Although it is decomposed by heating its aqueous solution, the decomposition is not particularly rapid, and small quantities of the salt may be recrystallized from hot water with little difficulty. It crystallizes then in fine clustered needles, and is obtained in the same form by precipitating its aqueous solution with alcohol. In evaporating a cold aqueous solution *in vacuo* over sulphuric acid, the salt may be obtained in long lustrous prisms with perpendicular terminations. The salt crystallized from water, or precipitated by alcohol, when air-dried, loses over sulphuric acid somewhat more than one molecule of water, and has then the composition $BaC_4HClO_4 . H_2O$.

I. 2.5352 grm. of salt recrystallized from water and dried by exposure to the air lost over sulphuric acid 0.1706 grm. H_2O.

II. 2.2127 grm. of salt recrystallized from water and dried by exposure to the air lost over sulphuric acid 0.1480 grm. H_2O.

III. 1.9160 grm. of salt precipitated by alcohol and dried by exposure to the air lost over sulphuric acid 0.1288 grm. H_2O.

IV. 1.5273 grm. of salt precipitated by alcohol and dried by exposure to the air lost over sulphuric acid 0.1054 grm. H_2O.

	Calculated for $BaC_4HClO_4 . 2 H_2O$.	Found. I.	II.	III.	IV.
1 H_2O	5.60	6.73	6.69	6.73	6.90

The salt dried over sulphuric acid contained a percentage of barium agreeing closely with that required by the formula, $BaC_4HClO_4 . H_2O$. It lost weight slowly at 100–105°, but only the compact salt crystallized from water could be brought to constant weight at this temperature without essential decomposition. The voluminous salt precipitated by alcohol after many weeks still lost in weight, contained baric chloride, and had become badly discolored.

I. 1.4644 grm. of salt recrystallized from water and dried over sulphuric acid lost, at 100–105°, 0.0820 grm. H_2O.

II. 1.4771 grm. of salt recrystallized from water and dried over sulphuric acid lost, at 100–105°, 0.0827 grm. H_2O.

III. 0.8947 grm. of salt recrystallized from water and dried over sulphuric acid gave 0.6871 grm. $BaSO_4$.

IV. 0.5865 grm. of salt recrystallized from water and dried over sulphuric acid gave 0.4498 grm. $BaSO_4$.

V. 0.3261 grm. of salt precipitated by alcohol and dried over sulphuric acid gave 0.3266 grm. $BaSO_4$.

	Calculated for $BaC_4HClO_4 . H_2O$.	Found. I.	II.	III.	IV.	V.
H_2O	5.93	5.60	5.60			
Ba	45.14	...	...	45.16	45.08	45.06

Although the crystallized baric mucoxychlorate suffers no change when exposed to the air for a week or more, after months of exposure it loses in weight and the clear prismatic crystals become opaque. The salt is then more sparingly soluble in water, and crystallizes in small oblique prisms. These same oblique crystals are also occasionally deposited together with the long rectangular prisms on evaporating *in vacuo* the aqueous solution of the salt originally obtained. An analysis showed that these oblique prisms contained a percentage of barium required by a salt crystallizing with one molecule of water. Although the crystalline form appeared to be persistent, we were able to detect no differences in the chemical behavior of the salt, or of the acid prepared from it, which would warrant the assumption that any radical change in its structure had taken place.

For analysis, the oblique prisms were well washed with cold water, and dried by exposure to the air. The air-dried salt lost nothing over sulphuric acid, and lost weight but slowly at 100°.

0.4076 grm. of air-dried salt gave 0.3131 grm. $BaSO_4$.

	Calculated for $BaC_4HClO_4 . H_2O$.	Found.
Ba	45.14	45.15

Potassic Mucoxychlorate, $K_2C_4HClO_4$. — The potassium salt we prepared by decomposing the barium salt with potassic carbonate and evaporating the filtered solution *in vacuo* over sulphuric acid. The salt separated in small tabular crystals, which were recrystallized from warm water. The air-dried salt lost nothing when heated at 100°.

I. 0.4344 grm. of the salt gave 0.3334 grm. K_2SO_4.
II. 0.4631 grm. of the salt gave 0.3547 grm. K_2SO_4.

	Calculated for $K_2C_4HClO_4$.	Found. I.	II.
K	34.49	34.45	34.39.

Argentic Mucoxychlorate, $Ag_2C_4HClO_4$. — The silver salt was made by precipitating a solution of argentic nitrate with a solution of the potassium salt. On heating, argentic chloride was rapidly formed. On warming with a little ammonic hydrate, immediate reduction ensued. From a solution of the free acid, argentic nitrate threw down the neutral salt (III.).

I. 0.5024 grm. of the salt dried over H_2SO_4 gave 0.3948 grm. AgCl.
II. 0.4125 grm. of the salt dried over H_2SO_4 gave 0.3240 grm. AgCl.
III. 0.3704 grm. of the salt dried over H_2SO_4 gave 0.2891 grm. AgCl.

	Calculated for $Ag_2C_4HClO_4$.	Found. I.	II.	III.
Ag	59.27	59.17	59.13	58.76

Diethyl Mucoxychlorate, $C_4HClO_4(C_2H_5)_2$. — Finely powdered argentic mucoxychlorate, which had been well dried over sulphuric acid, was gradually thrown into an excess of ethyl iodide. The heat evolved by the reaction was so great that the boiling point of the ethyl iodide was soon reached, and the decomposition was afterward completed by heating for a short time on the water-bath. The product of the reaction was then extracted by dry chloroform, the chloroform distilled off under diminished pressure, and the viscous residue placed over sulphuric acid *in vacuo*. After long standing *in vacuo* the product showed no signs of crystallization, but proved to contain a percentage of chlorine which agreed tolerably well with that required by the diethyl ether.

0.2314 grm. substance gave 0.1553 grm. AgCl.

	Calculated for $C_4HClO_4(C_2H_5)_2$.	Found.
Cl	17.19	16.59

Monoethyl Mucoxychlorate, $C_4H_2ClO_4 \cdot C_2H_5$. — When the viscous diethyl ether just described was allowed to stand exposed to the air, or when it was mixed with a small quantity of water, it rapidly acquired an acid reaction, and gradually deposited well-formed crystals of the monoethyl ether. The latter could also readily be prepared by extracting with ordinary aqueous ether the product formed by the action of ethyl iodide upon the silver salt, and allowing the ethereal solution to evaporate spontaneously. The crystals which separated were thoroughly pressed and recrystallized from boiling benzol.

I. 0.2337 grm. substance gave 0.3445 grm. CO_2 and 0.0870 grm. H_2O.
II. 0.2659 grm. substance gave 0.2147 grm. AgCl.
III. 0.2572 grm. substance gave 0.2080 grm. AgCl.

	Calculated for $C_4H_2ClO_4 \cdot C_2H_5$.	Found. I.	II.	III.
C	40.33	40.20		
H	3.92	4.13		
Cl	19.89	. . .	19.95	20.00

Monoethyl mucoxychlorate crystallizes in clustered, obliquely truncated prisms, which melt at 94–95°, and sublime unchanged at higher temperature. It dissolves readily in water, alcohol, ether, or chloroform, quite readily in boiling benzol, more sparingly in cold, and but sparingly in ligroin. Its aqueous solution is strongly acid to litmus, dissolves carbonates with effervescence, and gives a deep red coloration with ferric chloride. When baric hydrate is slowly added to the aqueous solution, a yellow color is developed, and products formed which we have not yet more fully studied. If, however, the ether is dissolved in an excess of baric hydrate, it is saponified and baric mucoxychlorate formed. The alkaline solution was precipitated with carbonic dioxide, and alcohol added to the filtered solution. The crystalline salt which separated was dissolved in cold water, and the solution evaporated over sulphuric acid *in vacuo*.

0.7070 grm. of air-dried salt lost over sulphuric acid 0.0482 grm. H_2O.

	Calculated for $BaC_4HClO_4 . 2H_2O$.	Found.
$1 . H_2O$	5.60	6.82

0.6588 grm. of the salt dried over H_2SO_4 lost, at 100°, 0.0385 grm. H_2O.

	Calculated for $BaC_4HCl . H_2O$.	Found.
H_2O	5.93	5.85

0.6203 grm. of the salt dried at 100° gave 0.3535 grm. $BaSO_4$.

	Calculated for BaC_4HClO_4.	Found.
Ba	47.98	47.85

Decomposition in Alkaline Solution.

The instability of mucoxychloric acid and its salts when heated in aqueous solution has already been mentioned. We have, however, as yet studied more closely only the reaction which takes place when baric mucoxychlorate is heated with an excess of baric hydrate. The solution soon grows turbid on boiling, and throws down baric oxalate and baric carbonate, while the solution then contains baric chloride and formiate. The insoluble salts were collected upon a filter, and the presence of carbonic and oxalic acids established by qualitative tests. The presence of oxalic acid was still further confirmed by an analysis of the calcium salt.

0.1740 grm. of the salt dried at 100° gave 0.1608 grm. $CaSO_4$.

	Calculated for $CaC_2O_4 . H_2O$.	Found.
Ca	27.39	27.17

The aqueous solution filtered from the insoluble salts was freed from the excess of baric hydrate by means of carbonic dioxide. It gave then with argentic nitrate an abundant precipitate of argentic chloride, and blackened when heated with an excess of argentic nitrate. The barium was removed by dilute sulphuric acid, and the filtered solution distilled. The acid distillate when neutralized with plumbic carbonate yielded plumbic formiate in characteristic form.

0.3244 grm. of the salt dried at 100° gave 0.3327 grm. $PbSO_4$.

	Calculated for $Pb(CHO_2)_2$.	Found.
Pb	69.69	70.06

As was the case with the corresponding decomposition of mucoxybromic acid, quantitative determinations of the amounts of oxalic and carbonic acid formed in the reaction showed no simple relation between the two, and at the same time products were formed in small but significant amounts, whose nature we have as yet been unable to determine.

Action of Bromine in Aqueous Solution.

Bromine acts readily upon an aqueous solution of mucoxychloric acid, and forms products strictly analogous to those formed from mucoxybromic acid under the same conditions. Since the chlorobromal hydrate proved to be even less manageable than the bromal hydrate, we thought it best to determine its presence, as before, from its decomposition products. Since the reaction seemed to be quite as neat with the salts as with the free acid, we added to a diluted aqueous solution of the barium salt two molecules of bromine, and allowed the mixture to stand at ordinary temperatures until the color of the bromine had completely disappeared. We then neutralized the strongly acid solution with calcic carbonate in the cold, and filtered. The insoluble residue thus obtained contained oxalic acid in abundance, and we were unable to detect in it any other organic constituent. The oxalic acid was converted into its calcium salt and analyzed.

0.3489 grm. of the salt dried at 100° gave 0.3212 grm. $CaSO_4$.

	Calculated for $CaC_2O_4 . H_2O$.	Found.
Ca	27.39	27.08

To the clear aqueous solution we added a slight excess of potassic hydrate, neutralized after a short time with hydrochloric acid, and distilled the neutral solution with steam. We obtained in this way a colorless heavy oil, which when dried with calcic chloride boiled without decomposition at 119–120° under a pressure of 748 mm.* Analysis showed it to be dibromchlormethan.

I. 0.1545 grm. substance gave 0.3855 grm. AgCl + AgBr.
II. 0.1418 grm. substance gave 0.3536 grm. AgCl + AgBr.

	Calculated for $CHClBr_2$.	Found. I.	II.
Cl + Br	93.74	93.91	93.85

The weight of dibromchlormethan thus obtained was about sixty per cent of the theoretical amount.

The residue left after distillation was acidified, and again distilled with steam. The acid distillate thus obtained was neutralized with plumbic carbonate, and yielded upon evaporation plumbic formiate.

0.3936 grm. of the salt dried at 100° gave 0.4003 grm. $PbSO_4$.

	Calculated for $Pb . (CHO_2)_2$.	Found.
Pb	69.69	69.47

The decomposition of mucoxychloric acid by aqueous bromine may therefore be expressed by the equation,

$$C_4H_3ClO_4 + 2\ Br_2 + H_2O = H_2C_2O_4 + CClBr_2CHO + 2\ HBr.$$

Anilmucoxychloric Acid.

Mucoxychloric acid, like mucoxybromic acid, readily gives with phenylhydrazine a condensation product. It has, however, little stability, and we have therefore not studied it more closely. With aniline, however, it gives even in dilute acid solutions a beautifully crystalline product. For its preparation we added one molecule of aniline hydrochlorate to a solution of the barium salt in a slight excess of dilute hydrochloric acid. The solution soon turned yellow, and after standing for a short time solidified with the separation of pale yellow finely felted needles. At low temperatures the crystals formed were often nearly colorless. When recrystallized from hot water, and dried over sulphuric acid, the substance was shown by analysis to be anilmucoxychloric acid formed according to the equation,

$$C_4H_3ClO_4 + C_6H_5NH_2 = C_4H_3ClO_3 . NC_6H_5 + H_2O.$$

* According to O. Jacobsen and R. Neumeister (Ber. d. deutsch. chem. Gesellsch., xv. 601), chlorobromoform boils between 123 and 125°, with slight decomposition.

I. 0.2146 grm. substance gave 0.4170 grm. CO_2 and 0.0791 grm. H_2O.
II. 0.1797 grm. substance gave 0.1142 grm. AgCl.
III. 0.1865 grm. substance gave 0.1186 grm. AgCl.
IV. 1.0389 grm. substance gave 60.6 cc. moist nitrogen at 23° and under a pressure of 746 mm.

	Calculated for $C_{10}H_8ClNO_3$.	Found. I.	II.	III.	IV.
C	53.21	52.99			
H	3.54	4.10			
Cl	15.74	...	15.71	15.72	
N	6.21	...	...	...	6.60

The air-dried acid apparently contains one molecule of water of crystallization, which it loses readily over sulphuric acid, or when heated to 100°. With the loss of water the pale yellow or almost colorless needles become brilliant yellow.

I. 0.7579 grm. of air-dried acid lost, at 100°, 0.0597 grm. H_2O.
II. 0.9022 grm. of air-dried acid lost, at 100°, 0.0702 grm. H_2O.
III. 0.5646 grm. of air-dried acid lost over H_2SO_4 0.0460 grm. H_2O.

	Calculated for $C_{10}H_8ClNO_3$.	Found. I.	II.	III.
H_2O	7.39	7.88	7.78	8.15

Anilmucoxychloric acid is sparingly soluble in cold water, more readily in hot, and appears to suffer slow decomposition when its aqueous solution is boiled. It dissolves readily in alcohol or ether, sparingly in cold benzol or chloroform, more freely on heating. In ligroin or carbonic disulphide it is nearly insoluble. From chloroform it crystallizes in small compact oblique prisms, which melt with decomposition at 145–147°. The acid dissolves readily in solutions of the alkaline carbonates, and is reprecipitated unchanged by the addition of acids. In heating with acids or alkalies aniline is formed. An aqueous solution of the free acids gives deep yellow precipitates with salts of most of the heavy metals. With ferric chloride it gives a deep brown precipitate. It forms by preference monobasic salts, but we have prepared also dibasic salts.

Baric Anilmucoxychlorate, $Ba(C_{10}H_7ClNO_3)_2\,\frac{1}{2}\,H_2O$. — If baric carbonate is added to anilmucoxychloric acid suspended in cold water, carbonic dioxide is disengaged, and a barium salt readily soluble in water is formed. If the concentrated filtered solution is then heated nearly to boiling, it soon deposits abundant bright yellow clustered needles, which increase somewhat in quantity as the solution cools. The air-dried salt lost slightly in weight at 100°. This loss corresponded to about one half-molecule of crystal water; it is possible, however, that it was hygroscopic moisture alone.

I. 0.2819 grm. of the air-dried salt lost, at 100°, 0.0052 grm. H_2O.
II. 0.9735 grm. of the air-dried salt lost, at 100°, 0.0196 grm. H_2O.

	Calculated for $Ba(C_{10}H_7ClNO_3)_2 \frac{1}{2} H_2O$.	Found. I.	II.
H_2O	1.51	1.85	2.01

I. 0.2767 grm. of the salt dried at 100° gave 0.1102 grm. $BaSO_4$.
II. 0.3918 grm. of the salt dried at 100° gave 0.1561 grm. $BaSO_4$.

	Calculated for $Ba(C_{10}H_7ClNO_3)_2$.	Found. I.	II.
Ba	23.37	23.42	23.42

Diargentic Anilmucoxychlorate, $Ag_2C_{10}H_6ClNO_3$. — When argentic nitrate is added to a cold aqueous solution of anilmucoxychloric acid, a pale yellow gelatinous precipitate is formed, which is hard to wash and prepare for analysis, and doubtless contains one atom of silver. If, however, the acid is dissolved in two equivalents of dilute ammonic hydrate, and this solution poured into an excess of argentic nitrate, a bright orange-yellow flocculent precipitate is thrown down, which becomes more compact on standing, and contains two atoms of silver. This salt showed but slight discoloration when warmed for some time with an excess of argentic nitrate in a feebly ammoniacal solution.

0.5431 grm. of the salt dried over H_2SO_4 gave 0.3516 grm. AgCl.

	Calculated for $Ag_2C_{10}H_6ClNO_3$.	Found.
Ag	49.15	48.73

Dipotassic Anilmucoxychlorate, $K_2C_{10}H_6ClNO_3$.—When an alcoholic solution of potassic hydrate was added, in slight excess, to a solution of anilmucoxychloric acid in dry ether, a pale yellow salt was precipitated, which when dried *in vacuo* over sulphuric acid and powdered sodic hydrate proved to contain two atoms of potassium.

0.6070 grm. of the salt gave 0.3579 grm. K_2SO_4.

	Calculated for $K_2C_{10}H_6ClNO_3$.	Found.
K	25.92	26.47

Phenylhydrazine Anilmucoxychlorate, $C_{10}H_8ClNO_3 . C_6H_8N_2 . H_2O$. — When phenylhydrazine hydrochlorate is added to anilmucoxychloric acid dissolved in a dilute solution of sodic acetate, a white crystalline substance soon separates, which becomes somewhat discolored on drying. It is sparingly soluble in cold water, readily soluble in alcohol, but insoluble in ether. It is decomposed in the cold by dilute hydrochloric acid, or by a dilute solution of sodic carbonate, with the formation of phenylhydrazine. This behavior shows that it is simply a salt of phenylhydrazine rather than a characteristic condensation product. The substance was well washed with cold water, and dried over sulphuric acid.

I. 0.3000 grm. substance gave 0.1189 grm. AgCl.

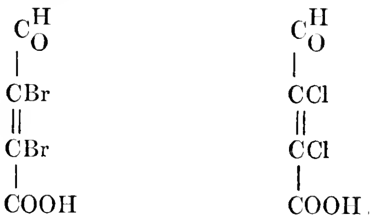
II. 0.3218 grm. substance gave 34 cc. of moist nitrogen at 18° and under a pressure of 748 mm.

III. 0.2248 grm. substance gave 23.5 cc. moist nitrogen at 20° and under a pressure of 741 mm.

	Calculated for $C_{16}H_{16}ClN_3O_3 . H_2O$.	Found. I.	II.	III.
Cl	9.98	9.80		
N	11.81	. . .	12.20	11.87

Theoretical Considerations.

Although the facts which we have observed are in certain respects difficult of interpretation, it seems to us that, on the whole, they warrant tolerably definite conclusions as to the constitution of mucoxybromic and mucoxychloric acids. We may safely assume that mucobromic and mucochloric acids are to be represented by the formulæ,*

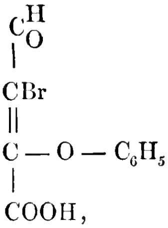


It is evident that the carboxyl group is not affected by the reaction in question, and, furthermore, that the aldehyde group is also still contained in the mucoxybromic and mucoxychloric acids. The latter fact is sufficiently proved by the behavior of the two acids with argentic nitrate, by the ready formation of condensation products with aniline, and, lastly, by the appearance of substituted aldehydes among the

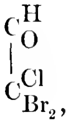
* These Proceedings, Vol. XVI. p. 218; Vol. XVII p. 150.

products formed from them by the action of aqueous bromine. The two central carbon atoms are therefore alone concerned in the transformation of mucobromic and mucochloric acids into the corresponding oxy-acids; and the first steps at least in this change must be the replacement of one of the halogen atoms by hydroxyl.

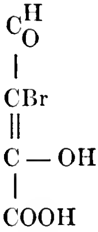
Since potassic phenylate acts upon mucobromic acid with the formation of mucophenoxybromic acid, whose constitution has been shown to be *

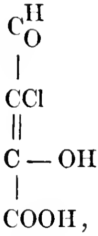


it could safely be assumed that in the analogous reaction with baric hydrate the *α* halogen atom would also be first replaced. The formation of dibromchlor aldehyde,



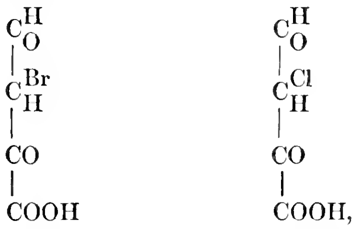
by the action of bromine upon mucoxychloric acid, proves that this assumption is correct, since the *β* chlorine atom has here retained its place. It follows, therefore, that the mucoxybromic and mucoxychloric acids are either hydroxyl acids formed by the replacement of the *α* halogen atoms by hydroxyl,





* These Proceedings, Vol. XIX. p. 268.

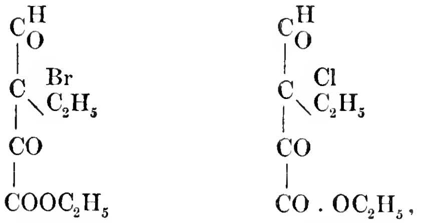
or that they are the ketone acids,



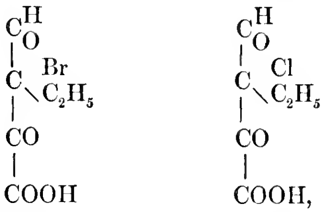
formed from them by the ordinarily observed molecular rearrangement.

While a satisfactory explanation of the persistent dibasic character of the two acids can hardly be found in these formulæ, the formation of dibasic salts from either cannot be pronounced impossible, and no definite argument in favor of either formula can be based upon this behavior.

The ready and complete saponification of the ether of the two acids with the formation of the original dibasic metallic salts seems on the other hand an insurmountable objection to the ketone formula. The diethyl ethers of the ketone acids,



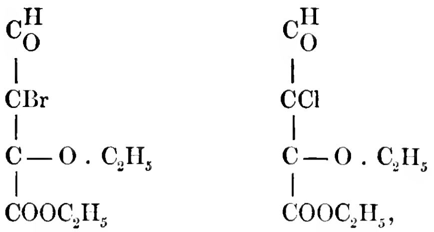
must of necessity yield upon saponification homologous monobasic acids,



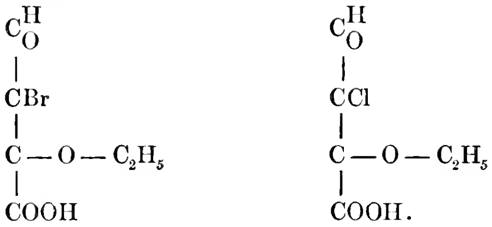
unless indeed a complete destruction of the molecule ensues.

We are therefore unable to resist the conclusion, that mucoxybromic and mucoxychloric acids contain hydroxyl, — that they are in fact phenol acids of the paraffine series, in which the hydroxyl has strongly marked acid properties on account of its peculiar environment.

The anomalous removal of the ethyl groups from the ethers,

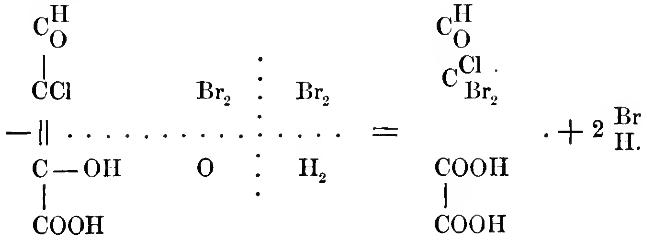


by saponification with baric hydrate, seems to us to be conditioned by the strongly acid character of this hydroxyl, a character which is usually wholly wanting. To the acid ethers formed by the action of water in the cold must be assigned the formulæ,

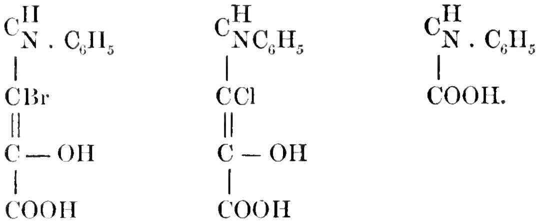


That these ethers are saponified by alkalies while the corresponding phenyl compounds are converted into derivatives of acrylic acid may possibly be due to the great difference in character between the phenyl and ethyl groups.

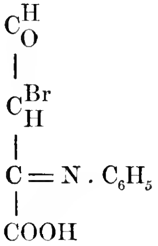
In other respects the behavior of the two acids finds ready explanation in the hydroxyl formulæ. While we are unable to follow in detail the somewhat complex reaction which ensues when the acids are heated with an excess of baric hydrate, the formation of oxalic, carbonic, and formic acids under these conditions is not unintelligible. The decomposition with aqueous bromine, on the other hand, evidently takes place according to the reaction



The aniline derivatives are then strictly analogous to the anilglyoxylic acid of Böttinger.*



That the dibasic character of these compounds has been impaired by the introduction of the aniline residue is but natural, while the persistence of this dibasic character shows that they cannot be derived from the ketone formula by the replacement of the ketone oxygen. A compound of the form



could hardly form dibasic salts.

Moreover, the fact that these aniline derivatives do not form stable condensation products with phenylhydrazine may be taken as further evidence that they contain hydroxyl, and not the ketone or aldehyde group. That we have not yet been able to reverse the reaction, and replace the hydroxyl groups again by the halogens, we cannot but think due simply to the instability of the acids themselves.

While we feel that the constitution of mucoxybromic and mucoxychloric acids is thus determined with reasonable certainty, further investigations upon the subject will be made in this laboratory.

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* Ann. Chem. u. Pharm., cxcviii. 222.

XVII.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

Presented by Josiah P. Cooke, Director, March 9, 1887.

A DETERMINATION OF THE RELATION OF THE ATOMIC WEIGHTS OF COPPER AND SILVER.

By Theodore W. Richards.

In the Report of the Committee on Electrolysis made to the British Association at Birmingham, of which an advance copy has been received by Professor Cooke through the kindness of Dr. Oliver Lodge, a direct determination is given of the ratio between the atomic weight of copper and that of silver, based on the electrolytic experiments of W. N. Shaw. As the value of the ratio thus obtained is quite different from that usually accepted, it seemed to Professor Cooke desirable that the results should be confirmed by a direct chemical method, and the writer was intrusted with this investigation.

Of the work worthy of consideration which has thus far been done upon the atomic weight of copper, first in chronological order comes that of Berzelius,* who made two determinations of the weight of copper formed by the reduction of pure cupric oxide by hydrogen. He found the percentage of copper in this compound to be $79.823 \pm .002$. This corresponds to an atomic weight of 63.153, taking oxygen $= 15.963$, with Clarke. The next determination was by Erdmann and Marchand,† who used the same method. They found the percentage of copper in cupric oxide to be $79.8645 \pm .0038$ as a mean of four determinations, — a value which makes $Cu = 63.316$. Millon and Commaille,‡ in three determinations, — which did not, how-

* Poggend. Annal., viii. 177.
† Journ. für Prakt. Chem., xxxi. 389. 1844.
‡ Fresenius' Zeitschrift, ii. 475. 1863.

ever, closely agree with one another, — found the relation, CuO : Cu = 100 : 79.7787; and calculating from this relation the atomic weight of copper, the value 62.979 is obtained. Dumas * made several determinations of the reduction of cupric oxide and the synthesis of cuprous sulphide; and calculates the value Cu = 63.5.

Hampe,† whose work gave the most concordant results thus far secured, obtained from three determinations of the percentage of copper in cupric oxide the mean value of 79.8347 ± .0013; and from two analyses of anhydrous cupric sulphate by electrolytic precipitation he found the proportion $CuSO_4$: Cu = 100 : 39.725 ± .0007. The atomic weights of copper from these two methods are respectively 63.197 and 63.173.

This was in 1874; and the subject has rested undisturbed until last year, when W. N. Shaw, in the paper before referred to, sought to prove the accuracy of Faraday's law of electrolysis in atomic proportions, by means of the actual weights of silver and copper deposited in cells in the same circuit. For the particulars of his method the Report of the Committee on Electrolysis should be consulted; it is sufficient here to say that as the mean of many determinations he finds the ratio of the silver and copper precipitated to be 3.39983 : 1. Correcting this result for variations in current density, he obtains the value 3.39888, and finally adopts the practically identical value 3.400, which makes the ratio Ag : Cu = 17 : 10. This last value makes Cu = 63.333, while the corrected value gives as the atomic weight the quantity 63.360.

Below is a summary of all the results : —

Berzelius, from CuO	63.153
Erdmann and Marchand, from CuO	63.316
Millon and Commaille, from CuO	62.979
Dumas, from CuO and Cu_2S	63.5
Hampe, from CuO	63.197
" from $CuSO_4$	63.173
W. N. Shaw, by relation to silver	63.333
" " " corrected	63.360

The most obvious chemical method for the determination of the relation of the atomic weights of silver and copper, is by the precipi-

* Ann. d. Chim. et Phys., (3,) lv. 129.
† Fresenius' Zeitschrift, xiii. 352. 1874.

tation of silver from a solution of a pure silver salt by means of pure copper; and this was the method adopted in the present determination. Hampe, in his work on the atomic weight of copper, attempted the same method, but rejected it for two reasons, — the first being that the silver dissolved, or appeared to dissolve, to a slight extent in the hot water used for washing; and the second being that it was impossible to prevent copper from coming down with the silver, no matter how long the precipitate was digested with the argentic nitrate solution. As will be seen, however, both of these difficulties have been entirely overcome.

The silver salt selected for the precipitation was the nitrate, on account of its ready crystallization, its easy solubility in water, and the facility with which it can be obtained pure. For the preparation of the salt used in the work, ordinary pure argentic nitrate was crystallized many times from hot water, and finally fused for two hours in an air-bath kept at 205° C., — a few degrees above its melting point. This preparation was a white translucent substance interspersed with transparent crystals, dissolving completely in water and giving a colorless solution which was wholly neutral.

The copper used was prepared by electrolysis from cupric sulphate, through the kindness of Mr. Wilson, of the University Press. It was cut into small pieces, and these were digested in succession with weak potassic hydrate, dilute sulphuric acid, and then a very large amount of water. The copper was then boiled with water for about half an hour and washed with a large amount of distilled water, then dried and reduced at a low red heat by means of perfectly pure hydrogen, and allowed to cool in a stream of the gas. The metal thus prepared had a beautiful red metallic lustre, and showed no trace of oxidation after keeping a month. Before use it was dried in an air-bath at 110°, allowed to cool in a desiccator, and weighed by itself on a balance which was distinctly sensible to a twentieth of a milligram. In addition to receiving the treatment described above, the copper used in the fifth and sixth experiments was oxidized in a stream of pure air for half an hour, and then again reduced by hydrogen; but the concordance of those two results with the others shows that this precaution was not necessary.

In a few preliminary experiments it was found that on the temperature of the solution, and on the temperature alone, depended the regularity with which the silver was precipitated by the copper. At 90° the deposition is very rapid, nitrous fumes are evolved, and a large amount of copper comes down with the silver. As the temperature of the solutions used is lower, the reaction becomes less rapid, and the amount of copper deposited with the silver less, until at ordinary temperatures it is comparatively small; and below 0° the silver comes down absolutely pure, and not the least evolution of gas is observed. One of the difficulties of Hampe can then be overcome by keeping the beaker containing the solution in a freezing mixture; and the perfect definiteness of the reaction, which before might have been questioned, is thus established. The duration of the reaction at —1° is from twelve to twenty-four hours, according to the dilution of the argentic nitrate. The more dilute the solution is, the longer the precipitation takes, and the more finely divided is the deposited silver; but when the solution is very concentrated, the reaction is completed in a comparatively short time, and the silver comes down in a beautiful compact crystalline crust which takes the form of the copper.

The silver which was formed was collected in a Gooch crucible and washed with cold water, of which less than 250 c. c. were necessary to give a filtrate in which no trace of silver or copper could be detected.

The fact that the determinations given below agree so exactly with each other is of itself proof that no silver was dissolved, — first, because the precipitate in the different experiments was of very different degrees of fineness; and secondly, because the precipitate in each experiment was washed with a different amount of water, the silver of the last experiment having at least four times as much water passed over it as that of the first. And the fact that the results are not affected by either circumstance shows clearly that no perceptible amount of silver could have been dissolved; for if so, the loss must have varied both with the condition of the precipitate and with the amount of the wash-water. The different result obtained by Hampe was probably the effect of hot water on a very finely divided precipitate.

The silver, whether in crystalline plates or in crystalline powder, formed a very convenient precipitate with which to work; it was easily transferred and easily washed, did not adhere to the glass, and was in every way adapted for quantitative work.

The conditions of the following experiments as regards the quantity of water and the excess of argentic nitrate used above the amount required to dissolve the copper, were varied as much as possible. In some determinations barely enough of the argentic nitrate was used to effect the solution; while in others the excess of the silver salt amounted to nearly two grams. The time allowed the reactions was also varied from twenty-four to seventy-two hours.

Relation of Silver to Copper.

No. of Expt.	c. c. H_2O used.	Weight Cu taken.	Weight Ag formed.	Equivalent $Ag_2 : Cu = 1 : n$.	Atomic Weight Cu $Ag = 108$.	$Ag = 107.675$.
1	20	0.53875	1.8292	0.29452	63.618	63.427
2	25	0.56190	1.9076	0.29456	63.624	63.432
3	120	1.00220	3.4016	0.29462	63.639	63.447
4	30	1.30135	4.4173	0.29462	63.638	63.447
5	20	0.99870	3.39035	0.29457	63.628	63.437
6	25	1.02050	3.4646	0.29456	63.623	63.434
			Average,	0.29457	63.628	63.437

The mean value, 63.437, has a greatest variation of $\pm.01$, and a probable error of $\pm.0023$.

The value obtained by Shaw was	63.333
" " " corrected	63.360
The value given by Clarke is	63.173

It remains only to prove the absolute purity of the copper used and the silver formed. The only metals which could affect the atomic weight of copper to an appreciable extent, if present in traces, are bismuth and silver. The former was tested for with great care, using a delicate spectroscope, and not the faintest trace of the very well-defined blue bismuth line was apparent; further, ten grams of the copper were dissolved in nitric acid, a little potassic hydrate added to the diluted solution, and the whole boiled and shaken for three hours. According to Hampe, all the bismuth present will be found in the basic precipitate; this was tested qualitatively for the metal, and not a trace was found. The solution of a portion of the copper in pure nitric acid gave not the faintest trace of opalescence with hydrobromic acid, excess of ammonic hydrate, or baric chloride. A gram of the copper was tested for arsenic and antimony in a Marsh-Berzelius apparatus, and no trace of a mirror was obtained. As the presence of so much copper would cause the generator to run too rapidly, the solution was treated with just enough potassic ferrocyanide to effect precipitation, and the colorless filtrate was run into the apparatus. This method has been found to give good results. The copper and the precipitated silver each dissolves in nitric acid without leaving a trace of residue.

If the copper is pure, the only possible impurity which the silver could contain is copper; and this was tested for with great care in each precipitate by dissolving one to two grams in nitric acid and adding excess of ammonic hydrate. In no case was the slightest blue color noticed; and as under the same circumstances a tenth of a milligram of copper gave a distinct bluish tinge, it may be assumed that the silver contained no copper. This method is a convenient one for the preparation of chemically pure silver, and avoids the necessity of fusion and the concomitant absorption of oxygen and possible admixture of silicic anhydride.

Although the value of the atomic weight of copper obtained, 63.44, does not exactly coincide with Shaw's results, it is at least very much nearer to them than is the old accepted value of 63.17; especially if we take his result as corrected for current density. The new value is very nearly that found by Dumas from cuprous sulphide, and it falls within the limits assigned by L. Meyer and Seubert as the possible error of the accepted value.

XVIII.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

ON BENZOLTRISULPHONIC ACID.

By C. Loring Jackson and John F. Wing.

Presented March 9, 1887.

The benzoltrisulphonic acid has been prepared up to this time only by Senhofer,* who made it by heating a mixture of benzol, fuming sulphuric acid, and phosphoric pentoxide to 280°–290° in a sealed tube, and studied its potassium, barium, lead, and silver salts, while in a subsequent paper † he made a thorough investigation of the action of melted potassic hydrate upon it, — a large amount of work when the extreme difficulty of the method of preparation is considered.

Our attention was first drawn to this substance while we were trying to make the potassic benzolparadisulphonate by the method of Barth and Senhofer,‡ and encountered in one preparation large well-formed crystals, giving with phosphoric pentachloride a chloride melting above 180°, which proved on analysis to be Senhofer's potassic benzoltrisulphonate. As we could find no mention of the appearance of the trisulphonate under these conditions in the papers of Barth and Senhofer,‡ Koerner and Monselise,§ or of any other chemists who have studied the action of sulphuric acid on benzol, we searched for the cause of this abnormal result, and soon found it in the fact that we had heated the crude potassic disulphonate a second time with fuming sulphuric acid. After this a few experiments were enough to prove that the action was due to the presence of potassic sulphate, and, to our great surprise, that common sulphuric acid in presence of potassic sulphate was capable of converting a benzolsulphonic acid into the trisulphonic acid, and was as efficient in this respect as the fuming sulphuric acid.

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* Ann. Chem., clxxiv. 243.

† Wien. Acad. Ber., Ser. 2, lxxviii. 677.

‡ Ber. d. ch. G., 1875, p. 1478.

§ Gazz. Chim., 1876, p. 133.

This result, it seems to us, throws light on the beautiful method of preparing trisulphonic acids, the application of which to toluol was published by Claësson* in 1881, and which consists in heating a potassic sulphonate with chlorsulphonic acid, since it makes it probable that the reaction is due to the acid potassic sulphate formed during the process, rather than to the chlorsulphonic acid itself. In a general way also our process resembles that of Neville and Winther † for converting the amido compounds into their monosulphonic acids by the action of heat on their acid sulphates, although it is doubtful whether the mode of action of the two processes is the same, since in ours the presence of an excess of sulphuric acid is essential.

As our process converts the benzoltrisulphonic acid from one of the least into one of the most accessible of the less common aromatic compounds, we have devoted some time to its study, and in this paper, after giving the details of our preliminary experiments, and the methods for preparing the benzoltrisulphonic acid, we describe the first results that we have obtained; which consist of the determination of the crystalline form and solubility of the potassium salt, ‡ the preparation and study of the chloride, the ester, which exhibits a strange instability, the amide with several of its metallic derivatives, and its benzoyl compound, and as this, like the corresponding compound of the benzolmonosulphamide is an acid, its sodium and barium salts and chloride with the phenylamidine derived from it, the anilid, and finally the proof by two different methods that the benzoltrisulphonic acid has the symmetrical constitution 1, 3, 5.

Formation of Benzoltrisulphonic Acid.

To prove that the presence of potassic sulphate was the cause of the formation of the trisulphonic acid, a solution of benzol in fuming sulphuric acid, to which its own volume of common sulphuric acid had been added, was divided into two equal parts, (*a*) and (*b*), and, after adding a quantity of potassic sulphate to (*a*), both parts were heated in retorts under precisely the same conditions until half of the liquid had passed over. The residues were converted into potassium salts, and recrystallized, when (*a*) furnished the very characteristic crystals of the potassic benzoltrisulphonate, and gave a chloride which, after washing with ether and one crystallization from chloroform, melted at

* Ber. d. ch. G., 1881, p. 307.

† Ibid., 1880, p. 1940.

‡ Also some attempts to prepare substituted trisulphonic acids, which led to negative results.

182° ($C_6H_3(SO_2Cl)_3$ melts at 184°), proving that the trisulphonic acid had been formed, while (*b*) gave a potassium salt crystallizing in an asbestos-like * mass, which yielded a viscous chloride, from which no trace of the benzoltrisulphochloride could be obtained; and, as both the potassic benzoltrisulphonate and its chloride are very characteristic substances, there can be no doubt that in this latter case no appreciable amount of the trisulphonic acid was formed. In a second experiment the benzolmetadisulphonic acid (made by heating the chloride with water to 150° in a sealed tube) was used, and the result was the same; the specimen heated with sulphuric acid and potassic sulphate gave benzoltrisulphonic acid recognized as in the previous experiment, while that heated with sulphuric acid alone gave no trace of this product.

The experiments just described having proved that the presence of potassic sulphate is necessary for the formation of the trisulphonic acid, we next considered the question, "Cannot the trisulphonic acid be formed by the action of acid potassic sulphate alone without an excess of sulphuric acid?" and found that potassic benzolmetadisulphonate fused with acid potassic sulphate remained unaltered, even at a temperature where the mass began to char. It is evident, therefore, that the potassic sulphate serves only to render the sulphuric acid more efficient, and it remained to determine by experiment, if possible, the manner of its action. Since in Senhofer's method, the only one beside ours by which the benzoltrisulphonic acid has been obtained, the action was due to the presence of a powerful dehydrating agent (phosphoric pentoxide), the most plausible theory was that the acid potassic sulphate acted simply by the removal of water. To test this hypothesis we substituted for the potassic sulphate in one experiment argentic sulphate, and in another zincic sulphate, as, if the action of the salt is due only to its attraction for water, like that of the phosphoric pentoxide in Senhofer's method, the latter should produce quite as good a result as potassic sulphate, whereas the argentic sulphate would be entirely without action. Upon heating three portions of benzolmetadisulphonic acid with the same proportion of sulphuric acid, (*a*) without the addition of a salt, (*b*) with addition of zincic sulphate, and (*c*) with addition of argentic sulphate, we found that, while no trace of the trisulphonic acid could be detected in (*a*), or (*b*),

* We have not succeeded in determining the nature of this potassium salt. It does not resemble the potassic benzolmonosulphonate, which crystallizes in glistening plates, nor have we found any disulphonate corresponding to it in properties. We hope to return to this subject hereafter.

it was formed in large quantity in (*c*), and, if anything, was accompanied with less of the tarry secondary products than when potassic sulphate was used, so that argentic sulphate could perhaps be used advantageously in place of potassic sulphate in the manufacture of the trisulphonic acid, since, owing to its slight solubility, it can be filtered out with little loss after the addition of water to the product of the reaction, and is then ready to use again after drying. It follows from the above results that the salt does not act as a dehydrating agent, but rather as a carrier of the sulphuric acid, owing to the formation of an acid salt.

The experiments just described have led us to the following hypothesis to explain the formation of the benzoltrisulphonate by the action of potassic sulphate and sulphuric acid; but we wish it distinctly understood that we could find no way of submitting this hypothesis to a complete experimental proof, and therefore offer it simply as the most plausible explanation of the observed facts that we have been able to find. The acid potassic sulphate formed by the sulphuric acid and potassic sulphate is first, we suppose, converted into the potassic pyrosulphate by loss of water, and the pyrosulphate in its turn decomposed by the sulphuric acid, giving potassic sulphate and fuming sulphuric acid, which, breaking up into H_2SO_4 and SO_3, furnishes the nascent sulphuric anhydride to form the benzoltrisulphonic acid, while the potassic sulphate goes through the same series of reactions again, which can be written as follows: —

$$K_2SO_4 + H_2SO_4 = 2\ KHSO_4$$
$$2\ KHSO_4 = K_2S_2O_7 + H_2O$$
$$K_2S_2O_7 + H_2SO_4 = K_2SO_4 + H_2S_2O_7 = K_2SO_4 + H_2SO_4 + SO_3.$$

Of these reactions the second can be considered well established, since the proportion of acid to potassic sulphate in the mixture used by us is almost exactly one molecule of K_2SO_4 to two of H_2SO_4; and it has been found,* when such a solution is allowed to cool, that it deposits first the neutral salt K_2SO_4, and afterward the potassic pyrosulphate $K_2S_2O_7$. But the last reaction is certainly not above criticism, since in it sulphuric acid is made to displace pyrosulphuric acid, which last, it is fair to suppose, is the stronger of the two. In answer to this we would suggest, that the reaction either may be brought under Berthollet's law on account of the formation of the volatile sul-

* Gmelin Kraut., 1875, ii. 48.

phuric anhydride, or, what seems to us more probable, it is brought about by the concurrent attraction of the sulphuric anhydride for the benzoldisulphonic acid. It is possible, however, that one of the two following reactions may express the action more correctly, —

$$KHSO_4 + C_6H_4(SO_3H)_2 = C_6H_3(SO_3H)_2SO_3K + H_2O.$$
$$K_2S_2O_7 + 2\,C_6H_4(SO_3H)_2 = 2\,C_6H_3(SO_3H)_2SO_3K + H_2O.$$

But in these reactions the excess of sulphuric acid must be supposed to act as a dehydrating agent, and thus produce the action, since we have proved experimentally that no action takes place when an excess of sulphuric acid is absent; and this observation seems to us to make these two reactions less probable than the series in which sulphuric anhydride is formed.

We have not multiplied experiments with different metallic sulphates, as it has not seemed to us that such work would throw any additional light on the theory of the process; we may mention, however, that we have also tried aluminic sulphate, which gave rise to the formation of a little trisulphonate when heated with metadisulphonic acid and sulphuric acid, but, as far as we could judge, was much less efficient in its action than the potassic sulphate.

Preparation of Benzoltrisulphonic Acid.

As the result of many experiments we have worked out the following process for preparing benzoltrisulphonic acid from potassic benzolmetadisulphonate, — 15 grams of potassic benzolmetadisulphonate, which need not be freed from its water of crystallization, are mixed in a porcelain dish with 18 grams of common strong sulphuric acid,* and heated with the free flame, care being taken to avoid heating the edges of the liquid too intensely during the first stage of the process, as at this time there is danger of charring. After the salt has dissolved, the sulphuric acid begins to come off in heavy white fumes, but without the formation of bubbles; in fact, there is no bumping or tumultuous evolution of vapor in any part of the process. If the operation is stopped at this point, the disulphonate will be found unaltered. After heating for a few minutes, little bubbles appear in

* Double these quantities can be used, but it is not convenient to work with much larger quantities than 30 grams at a time. The benzolmetadisulphonate may contain a small quantity of potassic carbonate or sulphate without injury to the process, but should be free from colored tarry impurities.

large numbers, and soon after the mass becomes pasty, and begins to puff up, while the evolution of fumes slackens; at this point the lamp is to be removed. The product, if charring was avoided in the early part of the process (there is little danger of it later), is of a reddish brown color, and almost completely solid. The loss in weight should be about 7 grams, and the whole operation takes little more than fifteen minutes. After the residue is cold, it is dissolved in water, and treated with an excess of baric carbonate to remove sulphuric acid, when the greater part of the colored impurity is carried down by the baric sulphate, so that the filtrate is usually of a pale wine-yellow. The precipitate should be boiled out with water once or twice, and the washings added to the filtrate, which, after converting any barium salt into potassic trisulphonate by potassic sulphate, is evaporated until its surface after cooling is covered with little crystals, when it usually deposits fine crystals after a short time, which can be increased in size by the spontaneous evaporation of part of the mother liquor, and purified by recrystallization from boiling water. The mother liquors, when sufficiently concentrated, solidify to a brownish pasty mass of a finely granular consistency, filled with larger crystals of potassic benzoltrisulphonate, which can be separated mechanically by scraping with a flat-pointed platinum stirrer the semi-liquid finer-grained impurity through the holes in a perforated platinum cone placed in a funnel. The larger crystals left behind are then purified by crystallization from water. The yield from this process can be raised by careful work to 44 per cent of the theoretical yield, and it is possible to increase it still further by boiling the precipitate formed by baric carbonate with a solution of potassic carbonate, as the baric benzoltrisulphonate is very sparingly soluble in water. We cannot recommend this treatment, however, as the potassic benzoltrisulphonate extracted in this way is contaminated to such an extent with the colored impurities carried down by the precipitate of barium salts, that it is very hard to obtain white and pure crystals from it; in fact, it is easier to prepare fresh from the benzolmetadisulphonate.

The benzoltrisulphonic acid can also be prepared from benzol without isolating the lower sulphonic acids, and this method is sometimes convenient when large quantities of the substance are desired; but it is decidedly inferior to that just described, for two reasons, first, because the yield is very much smaller, and, second, a certain amount of benzolparadisulphonate is formed, which it is not easy to separate from the trisulphonate by crystallization. For this purpose 100 (or more) grams of benzol are dissolved in the same volume of common sulphuric acid by boiling them together in a flask with a reverse cooler;* when the solution is complete, the product is mixed with its own volume of common sulphuric acid and between 60 and 70 grams of potassic sulphate, and distilled in an untubulated retort till about one third of the total amount of sulphuric acid used has passed over. The liquid boils quietly without bumping. The residue is then divided into two parts, and these are heated in porcelain dishes precisely as in the previous process. The product is much more impure than when made from the potassic disulphonate, and it is better therefore to decolorize it by treatment with plumbic oxide after a part, but not the whole, of the large excess of sulphuric acid has been removed by marble or baric carbonate, since the greater part of the coloring matter is precipitated on adding an excess of plumbic oxide if the solution is acid, and still more comes down with the plumbic carbonate when potassic carbonate is added to the filtrate; but if the solution is thoroughly neutralized by the marble, very little, if any, of the colored impurity comes down with the lead salts, and in that case it is very hard to get rid of it. The yield was very small, and, although we could have raised it undoubtedly by working up the insoluble residues, we have never tried to do so, because we have found it easier to prepare a fresh portion than to purify the highly colored salts which would be obtained in this way. It is advisable, however, to heat once more with sulphuric acid the brown impure residues left by the evaporation of the mother liquors, from which no more crystals of benzoltrisulphonate can be separated, as in this way an additional quantity of the trisulphonate can be obtained. We have tried also to purify the impure residues left after the removal of the crystals by treatment with phosphoric pentachloride, and washing the product with ether or chloroform, but have obtained only unsatisfactory results.

The secondary products formed in this process are of little or no interest. They consist principally of a dark reddish brown to black substance giving a potassium salt of tarry consistency more soluble than the potassic benzoltrisulphonate, which it will not be easy to purify. There appears also on evaporation of the mother liquors a dark-colored granular potassium salt, whose viscous chloride solidifies after standing for some weeks, and it is then possible to obtain much benzoltrisulphochloride from it by treatment with chloroform; it is probable, therefore, that it consists principally of the benzoltrisulphonate prevented from crystallizing by the presence of the dark-colored impurity just mentioned, or of some potassic benzolmetadisulphonate.

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* Michael and Adair, Ber. d. ch. G., 1877, p. 585.

If the trisulphonic acid was made direct from the monosulphonic acid, some benzolparadisulphonic acid was also formed, which made the purification of the benzoltrisulphonate by crystallization more difficult. It was recognized by the melting point of its chloride, 139°, whereas Koerner and Monselise* give 131°, and the following analysis of the chloride dried at 100°.

0.1008 grm. of substance gave after decomposition by boiling with a solution of pure sodic carbonate 0.1054 grm. of argentic chloride.

	Calculated for $C_6H_4(SO_2Cl)_2$.	Found.
Chlorine	25.82	25.86

We are inclined to consider the melting point (139°) given by us for the benzolparadisulphochloride as more accurate than that of Koerner and Monselise (131°), since their product was prepared from a mixture of the para and meta compounds, and a small quantity of the latter, melting at 63°, would have been enough to lower the melting point very considerably, and its presence could not be determined by analysis; the impurity in our product, on the other hand, would have been benzoltrisulphochloride, and that there could have been no appreciable amount of this substance present is shown conclusively by our analysis.

Benzoltrisulphonic Acid and its Salts.

We have little to add under this head to the excellent work of Senhofer. The free acid, when heated, became charred, and gave off a smell like caramel; but the soluble part of the residue consisted of the unaltered acid, as was shown by the crystalline form of its potassium salt and the melting point of its chloride. The experiment gave so little promise of interesting results, that it was not repeated on a larger scale. The following analysis of the free acid dried at 100°, which it was necessary to make in the course of our work, confirms Senhofer's statement that it retains three molecules of water at that temperature.

0.3772 grm. of the acid dried at 100° gave by the method of Carius 0.7004 grm. of baric sulphate.

	Calculated for $C_6H_3(SO_3H)_3\,3\,H_2O$.	Found.
Sulphur	25.80	25.51

We add also an analysis of the potassium salt, which yielded the same amount of water of crystallization (three molecules) as given by

* Gazz. Chim., 1876, p. 140.

Senhofer; but, whereas he states that only one and a half molecules of the water are given off at 100°, we found that the whole was evolved at this temperature.

0.3768 grm. of air-dried salt at 100° lost 0.0431 grm.

	Calculated for $C_6H_3(SO_3K)_3\ 3H_2O$.	Found.
Water	11.11	11.43

0.7404 grm. of dry salt gave 0.442 grm. of potassic sulphate.

	Calculated for $C_6H_3(SO_3K)_3$.	Found.
Potassium	27.13	26.80

We have determined the solubility of the potassium salt as follows: —

I. 3.6594 grm. of a solution of $C_6H_3(SO_3K)_3$ saturated at 20° left on evaporation 1.3074 grm. of the salt dried at 260°.

II. 2.034 grm. of the solution gave 0.716 grm. of the dried salt.

Therefore a saturated solution of potassic benzoltrisulphonate at 20° contains the following percentages of the salt free from water of crystallization.

I.	II.
35.72	35.21

Dr. O. W. Huntington has at our request determined the crystalline form of the potassium salt $C_6H_3(SO_3K)_3\ 3H_2O$, and kindly furnishes us with the following statement: —

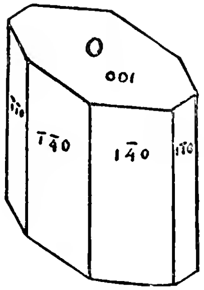

Fig. 1.

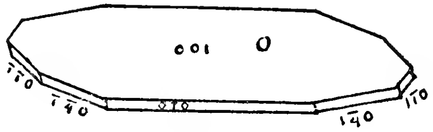

Fig. 2.

"Monoclinic, with marked variation of type. As no planes were observed except the basal plane and vertical domes, and pinacoids, it was impossible to make a complete determination of the crystal. The following measurements were obtained: —

$001 \wedge 1\bar{1}0 =$ **65° 28′**
$1\bar{1}0 \wedge 110 =$ **50° 55′**
$1\bar{1}0 \wedge 1\bar{4}0 = 24° \ 40′$
$1\bar{4}0 \wedge 140 = 79° \ 45′$

Most of the faces of the crystals were uneven, and the angles printed in heavy type are the only ones which could be measured with accuracy.

"From these angles the inclination of the axes and the ratio of the ortho diagonal to the clino axis may easily be calculated.

$$\beta = 68° \, 38' \, 30'' \qquad a : b = 1 : 2.10.$$

The crystals vary between the form shown in Fig. 1 and that of Fig. 2. In the second form the clino pinacoid is a characteristic feature which is absent in crystals of the first type, and the forms of both types run out into needles, in one case parallel to the vertical axis, and in the other parallel to the clino diagonal."

The potassium salt is not acted on by a cold solution of potassic permanganate, but, if heated with it, is oxidized, and we were unable to find any organic matter in the product.

The following attempts were made to obtain substituted benzoltrisulphonic acids. The silver salt was made by boiling the chloride with argentic oxide and water, and to the filtered solution bromine was added in order to make brombenzoltrisulphonic acid by the method of Nölting and Plawski,* which has been proved to be of wide application to monosulphonic acids by Limpricht.† A heavy precipitate of argentic bromide was formed at once, but the filtrate after being freed from compounds of bromine by evaporation gave a chloride melting at 184°, the melting point of benzoltrisulphochloride. It was analyzed also, as it was barely possible that the brombenzoltrisulphochloride might melt at the same temperature as the non-substituted compound.

0.2374 grm. of the substance gave 0.2718 grm. of argentic chloride.

	Calculated for $C_6H_3(SO_2Cl)_3$.	Found.
Chlorine	28.52	28.32

The argentic benzoltrisulphonate, therefore, is affected by bromine in an entirely different way from the monosulphonates. The filtrate

* Ber. d. ch. G., 1875, p. 819.

† Ann. Chem., clxxxvi. 134.

before evaporation contained bromic acid, as was proved by the following experiments. Some of the filtrate containing no free bromine gave no precipitate when argentic nitrate was added, but upon boiling with alcohol a heavy precipitate of argentic bromide was formed; to another portion of this filtrate potassic iodide was added, when iodine was set free in large amount. The reaction must run as follows: —

$$C_6H_3(SO_3Ag)_3 + 3\ Br_2 + 3\ H_2O = 3\ AgBr + C_6H_3(SO_3H)_3 + HBrO_3 + 2\ HBr.$$

Iodine acts on the argentic benzoltrisulphonate in a similar way. We have tried also to obtain a bromine compound by heating the potassium salt with bromine to 140° for sixteen hours, and also by heating it dissolved in strong sulphuric acid with bromine; but in neither case was hydrobromic acid given off, the trisulphonic acid remaining unaltered. It is possible, however, that longer heating with bromine might produce the desired result.

Our attempts to obtain a nitro acid were no more successful than those to make the bromine acid, as the potassic benzoltrisulphonate can be boiled with fuming nitric acid, or even with a mixture of fuming nitric acid and sulphuric acid, for over an hour without undergoing any alteration. When, however, the chloride is heated to 140° for sixteen hours with a large excess of fuming nitric acid, it is converted into a new substance with the most uninviting properties, which we have not studied further because sulphuric acid is eliminated in the process, and we propose to confine our attention to the trisulpho compounds.

Benzoltrisulphochloride, $C_6H_3(SO_2Cl)_3$.

This substance is prepared by heating the potassic benzoltrisulphonate, previously dried at 150°, with a little more than the calculated amount of phosphoric pentachloride (10 parts of the salt to 15 of the pentachloride) in a test-tube, or flask to 150° in an air-bath. If the substances are heated in a dish, there is little or no action. After the phosphoric oxychloride has distilled off, the product is treated with water, and finally warmed with it, but this warming should not be long continued, as the trisulphochloride is much more easily attacked by hot water than the benzolmetadisulphochloride. After washing the chloride thoroughly with warm water, it is purified by crystallization from boiling chloroform. The yield was between 80 and 90 per cent of the theoretical. Samples contaminated with lower sulphochlorides often can be freed from them by washing with ether. The substance dried at 100° gave the following results on analysis.

I. 0.2984 grm. gave after decomposition by boiling with a solution of potassic hydrate 0.3488 grm. of argentic chloride.

II. 0.1300 grm. treated in the same way gave 0.1530 grm. of argentic chloride.

III. 0.2374 grm. gave after decomposition with a boiling solution of pure sodic carbonate 0.2718 grm. of argentic chloride.

	Calculated for $C_6H_3(SO_2Cl)_3$.	Found. I.	II	III.
Chlorine	28.52	28.90	29.10*	28.32

Properties. — The benzoltrisulphochloride crystallizes from chloroform in little silky flattened needles, which under the microscope are seen to have the ends bevelled, or occasionally terminated by two planes forming an obtuse angle; frequently groups are observed made up of a number of needles united longitudinally, giving a characteristic comb-like appearance to the ends. Out of benzol it forms good-sized plates, apparently belonging to the triclinic system. It melts at 184° (uncorr.), and sublimes with some difficulty at temperatures above 200°, forming good-sized flattened needles similar in shape to the crystals from benzol. It is insoluble in water, hot or cold, but is slowly decomposed and dissolved when boiled with it; very slightly soluble in cold alcohol, or methyl alcohol, but freely dissolved with decomposition when boiled with them, very slightly soluble in ligroine, slightly soluble in ether, freely in benzol, carbonic disulphide, glacial acetic acid, or chloroform. Chloroform is the best solvent for it, as it is much more soluble in it when hot than when cold. As already mentioned, the chloride is slowly converted into the acid by boiling water, and is much more easily attacked in this way than the benzolmetadisulphochloride, so that the acid can be prepared conveniently by heating it with water in open vessels, whereas with the di compound this reaction does not take place readily at temperatures below 140°. With boiling alcohol the product is also the acid; but this point will be discussed more fully under the ester. Solutions of potassic hydrate or carbonate, or a mixture of argentic oxide and water, when boiled with the chloride, convert it quickly and easily into the corresponding salt. The study of the action of reducing agents on the chloride will be reserved for a future paper.

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* The potassic hydrate used in I. and II. was not perfectly free from potassic chloride.

Benzoltrisulphonic Ester, $C_6H_3(SO_3C_2H_5)_3$.

This substance was prepared by the action of ethyliodide on argentic benzoltrisulphonate, made by boiling the chloride with argentic oxide, and, after filtering out the argentic chloride and excess of argentic oxide, evaporating to dryness on the water-bath, and drying at 100°. The ethyliodide acts on the silver salt with violence even in the cold, so that the process must be carried on in a flask with a return-condenser, and, after it has come to an end, which can be made sure by heating for a short time on the water-bath, the product is extracted with ether, and the extract purified by crystallization from benzol, and dried *in vacuo*. Ethylbromide may be used instead of ethyliodide, but in this case the mixture must be heated to 100° in a sealed tube to obtain complete action.

The ester can also be prepared by the action of benzoltrisulphochloride, mixed with a large excess of benzol, on the proper amount of sodic ethylate made from as little alcohol as possible; but this method is not so good as the preparation from the silver salt and ethyliodide. If the attempt is made to prepare the ester by the action of sodic ethylate dissolved in alcohol upon the benzoltrisulphochloride, the product is sodic benzoltrisulphonate, or, if absolute alcohol is substituted for sodic ethylate, benzoltrisulphonic acid, the ester at first formed being afterward decomposed by the absolute alcohol, according to the reaction given under the properties of the ester. The ester cannot be made by the action of hydrochloric acid gas on an alcoholic solution of the trisulphonic acid. The composition of the ester dried *in vacuo* was determined by the following analyses.

I. 0.2646 grm. of the substance gave by the method of Carius 0.4662 grm. of baric sulphate.

II. 0.156 grm. of the substance gave 0.2719 grm. of baric sulphate.

	Calculated for $C_6H_3(SO_3C_2H_5)_3$.	Found. I.	Found. II.
Sulphur	23.88	24.16	23.94

Properties. — The benzoltrisulphonic ester forms well-developed shining white crystals, often more than a centimeter long, which belong to the triclinic system; a careful measurement of their angles was, however, impossible, because we could not obtain them with smooth enough faces. It melts at 147°, but if heated for some time to 110° is decomposed, leaving a residue of the benzoltrisulphonic acid; the reaction which takes place is probably the following,

$$C_6H_3(SO_3C_2H_5)_3 = C_6H_3(SO_3H)_3 + 3\ C_2H_4,$$

as 0.1674 grm. of substance lost 0.0324 grm.

Calculated for a loss of 3 C_2H_4.	Found.
20.89	19.36.

It is essentially insoluble in water, freely soluble in ether, chloroform, carbonic disulphide, or benzol, — the last being the best solvent for it, — insoluble in ligroine, decomposed and dissolved by glacial acetic acid, dissolves freely in alcohol, but is decomposed by it, as upon evaporating the solution, even if absolute alcohol is used, the benzoltrisulphonic acid is left. This reaction seemed to us so curious that we studied it more carefully, as follows. 10 grm. of benzoltrisulphochloride were boiled in a flask with a reverse cooler with 12 grm. of absolute alcohol; after half an hour the solid had completely dissolved, and upon examining the flask it was found that much hydrochloric acid had been formed, also apparently a little ethylchloride due to a secondary reaction, but no ethylene could be detected. The contents of the flask, after being freed from hydrochloric acid with potassic hydrate, were distilled fractionally with a Hempel's column, when it appeared that the principal product of the reaction was ethylether, recognized by its boiling-point, 35°, and by its smell. The following reactions, therefore, probably take place: —

I. $C_6H_3(SO_2Cl)_3 + 3\ C_2H_5OH = C_6H_3(SO_3C_2H_5)_3 + 3\ HCl$;

II. $C_6H_3(SO_3C_2H_5)_3 + 3\ C_2H_5OH = C_6H_3(SO_3H)_3 + 3\ (C_2H_5)_2O$;

and the action is exactly analogous to the ordinary method of making ethylether. Methylalcohol seems to act on the ester in the same way as ethylalcohol, — the residue left after evaporating a methylalcohol solution of it being benzoltrisulphonic acid. The ester was not acted on in the cold by sodium or sodic ethylate.

Benzoltrisulphamide, $C_6H_3(SO_2NH_2)_3$.

This substance was made by adding a very strong solution of ammonia to the benzoltrisulphochloride and allowing the mixture to stand a short time. It was purified by crystallization from boiling water. It can be formed also by the action of ammonic carbonate on the chloride, but the result was less satisfactory than with the solution of ammonia. The mother liquors from the crystallization contain a quantity of ammonic benzoltrisulphonate, which, after conversion into the potassium salt by boiling with potassic hydrate, can be reconverted into the chloride. The substance dried at 100° gave the following results on analysis.

I. 0.2358 grm. of substance gave after heating with soda-lime 0.1162 grm. of ammonic chloride.
II. 0.3739 grm. of substance gave according to the method of Carius 0.8318 grm. of baric sulphate.

	Calculated for $C_6H_3(SO_2NH_2)_3$.	Found. I.	II.
Nitrogen	13.33	12.89	
Sulphur	30.47	. . .	30.56

Properties. — The benzoltrisulphamide crystallizes from boiling water in shining flattened needles with very sharp ends, sometimes nearly a centimeter long. It can also be obtained from water in square prisms with oblique ends, apparently of the monoclinic system, or in rhombic plates. From alcohol it crystallizes in long slender needles. Its melting point is 310°–315° (uncorr.); it is only slightly soluble in cold water, as shown by the following determination of its solubility.

I. 12.367 grm. of the solution saturated at 25° gave on evaporation 0.0172 grm. of the amide.
II. 11.164 grm. of the solution gave 0.0186 grm. of the amide.

The solution of the benzoltrisulphamide saturated at 25° contains, therefore,

I.	II.
0.14%	0.17%

It is much more freely soluble in boiling water than it is in cold, and this is the best solvent for it; soluble in alcohol, rather more so in methyl than in common alcohol; not very soluble in benzol; insoluble, or nearly so, in ether, ligroine, chloroform, or glacial acetic acid either hot or cold. The amide is much more soluble in a solution of ammonia than in water, but it is thrown down unaltered when the ammonia is driven off from such a solution by heat; it also dissolves very easily in a solution of potassic hydrate, and this solution is not decomposed, even when it is boiled for a short time. The hot aqueous solution of the amide gives a white precipitate with mercuric nitrate, but none with mercuric chloride; a difference in behavior which is not surprising when it is remembered how differently these two reagents act with acid sodic carbonate, sodic phosphate, oxalic acid, and even water. The composition of the precipitate formed with mercuric nitrate is discussed below. The hot solution of the amide also gives with mercurous nitrate a white precipitate, which becomes gray on standing, but no precipitate with solutions of the salts of any of the other common metals.

The *Silver Salt* $C_6H_3(SO_2NHAg)_3$ was made by adding argentic nitrate to a hot solution of the amide, and then ammonic hydrate, but not in excess, as this dissolves the precipitate; if by accident an excess has been added, the precipitate can be obtained again by boiling off the ammonia. The flocculent white precipitate thus formed was washed with water, dried *in vacuo*, and analyzed.

0.2778 grm. of the salt gave by precipitation from its solution in dilute nitric acid 0.1886 grm. of argentic chloride.

	Calculated for $C_6H_3(SO_2NHAg)_3$.	Found.
Silver	50.94	51.11

It is a tolerably stable white powder, insoluble in water, soluble in nitric acid or ammonic hydrate. When a little tincture of iodine is added, the silver is converted into argentic iodide. Compare the analogous reaction with the mercuric salt.

Mercuric Salts of Benzoltrisulphamide. — When the amide is boiled with yellow mercuric oxide suspended in water, a white precipitate is formed, the composition of which varies according to the proportion of oxide and amide used.

$C_6H_3(SO_2NHHgOH)_3$. — To prepare this salt, 0.65 grm. of mercuric chloride was converted into the oxide by precipitation with sodic hydrate, and the washed but not dried oxide boiled with a solution of 0.25 grm. of the amide. The action takes place very slowly even under these conditions (much more slowly and imperfectly if the oxide has been dried); but after boiling for twenty-four hours it was nearly complete, although there were still a few yellow specks of oxide visible. These were separated mechanically, as far as possible, and the precipitate washed and dried at 100°; its analysis is given under I. The same salt is obtained much more conveniently by adding a solution of mercuric nitrate to a boiling solution of the amide, and washing with boiling water. An analysis of the salt thus prepared, and dried at 100°, is given under II. It is probable that the mercuric nitrate forms at first the compound $C_6H_3(SO_2NHHgNO_3)_3$, and that this is decomposed by the hot water in the same way that mercuric nitrate itself is.

We do not pretend to determine, however, whether the hydroxyl is attached to the mercury or to the nitrogen, which in the latter case would be in the quinquivalent condition.

I. 0.299 grm. of substance dissolved in hydrochloric acid and treated with sulphuretted hydrogen gave 0.2164 grm. of mercuric sulphide.

II. 0.2756 grm. of substance gave 0.1994 grm. of mercuric sulphide.

	Calculated for $C_6H_3(SO_2NHHgOH)_3$.	Found. I.	Found. II.
Mercury	62.30	62.38	62.38

$[C_6H_3(SO_2NH)_3]_2Hg_3$. This salt was prepared like the preceding, by boiling the moist mercuric oxide from 0.65 grm. of mercuric chloride with 0.5 grm. of the amide in aqueous solution. Even greater difficulties were encountered than in the preceding case, the reaction taking place as slowly, and being less complete; on this account we have not succeeded in preparing the substance in a state of purity, as the following analysis shows; the difference is due to a slight excess of mercuric oxide, which could not be removed, but the result is near enough to leave no doubt about the formula of the compound.

0.3416 grm. of substance dried at 100° gave 0.2056 grm. of mercuric sulphide.

	Calculated for $[C_6H_3(SO_2NH)_3]_2Hg_3$.	Found
Mercury	49.02	51.88

Both substances are white powders, insoluble in water, soluble in hydrochloric acid, which form mercuric iodide when boiled with water and iodine for some time; the filtrate, however, contains no organic substance except unaltered benzoltrisulphamide.

The aqueous solution of the amide boiled with plumbic oxide formed white flocks, but the action took place with so much difficulty that we did not try to prepare the substance for analysis. With cupric oxide we could observe no action. A solution of the sulphate of cuprammonium took up the amide with great avidity, forming a dark blue solution, which deposited azure blue disks of so deep a tint as to look nearly black, while the mother liquor showed only a very pale blue color. The solid was but sparingly soluble in water, being decomposed by it, but tolerably stable in the dry state; dissolved in dilute hydrochloric acid, it gave no precipitate with baric chloride. It was dried in a desiccator, and its composition determined by the following analyses.

I. 0.1628 grm. of substance dissolved in hydrochloric acid and precipitated with sodic hydrate gave 0.0356 grm. of cupric oxide.
II. 0.2564 grm. gave 0.0596 grm. of cupric oxide.

	Calculated for $[Cu(NH_3)_4]_3[(SO_3)_3C_6H_3]_2$.	Found. I.	Found. II.
Copper	18.57	17.46	18.57

No better agreement between these results could be expected, when it is remembered that the substance could not be recrystallized. It is evidently cuprammonic benzoltrisulphonate, but we were unable to prepare it by the action of cuprammonic sulphate on a solution of potassic benzoltrisulphonate.

Several attempts to obtain the *imide* $[C_6H_3(SO_2)_3]_2(NH)_3$, although they led to no definite results, may be mentioned here. The benzoltrisulphochloride mixed with absolutely dry benzol and the silver salt of benzoltrisulphamide, and heated to 100° in a sealed tube for two days, remained entirely unaltered. The experiment could not be repeated at a higher temperature for fear of decomposing the silver salt. If the chloride was heated with the amide, in the proportion of one molecule of each, to 190°, there was no action; but if the temperature was raised to 200°–210°, and maintained at this point for some hours, hydrochloric acid was given off, and a black product formed, which, when treated with cold water, swelled up to a gelatinous mass, the water becoming acid with hydrochloric acid. The jelly thus obtained, after being thoroughly washed with water, dried to a more or less colored powder, insoluble in all the solvents that we have tried, so that we have not been able to purify it properly for analysis. Some nitrogen determinations made with a substance extracted with all the common solvents gave results not far removed from the numbers required by the imide; but they are entitled to little, if any, confidence, as the substance still contained some chlorine. We satisfied ourselves by a special experiment that the substance mentioned above was not formed from the benzoltrisulphamide alone, since the amide was not altered by heating it to a temperature of 230° for an hour and a half.

Benzoylbenzoltrisulphamide, $C_6H_3(SO_2NHCOC_6H_5)_3$.

Benzoylchloride has no action on benzoltrisulphamide when the two substances are heated together on the water-bath; if, however, the mixture of these substances in the proportion of three molecules of the chloride to one of the amide (1.3 grm. to 1 grm.) is heated in a flask with a return-cooler to 140° by means of an oil-bath, hydrochloric acid is given off, and the benzoyl derivative is formed. During the process great care must be taken that the temperature does not rise above 150°, as at a point but little above this (150°–180°) decomposition sets in, and in that case the principal product of the action is kyaphenine. After the action has come to an end, which usually takes from five to seven hours, the product is extracted with benzol to remove any undecomposed benzoylchloride, and purified by crystallization from hot alcohol. Dried at 100° it gave the following results on analysis.

I. 0.2234 grm. of substance gave 13.3 c.c. of nitrogen under a pressure of 766 mm., and at a temperature of 22°.

II. 0.1632 grm. of substance gave by the method of Carius 0.1784 grm. of baric sulphate.

	Calculated for $C_6H_3(SO_2NHC_7H_5O)_3$.	Found. I.	II.
Nitrogen	6.69	6.79	
Sulphur	15.31	. . .	15.02

Properties. — The benzoylbenzoltrisulphamide crystallizes from alcohol in rather short and stout well-formed prisms, with an unmodified basal plane, which seem to belong to the hexagonal system. It has no definite melting point, since it decomposes at comparatively low temperatures (below 200°), and the melting point is therefore modified by the length of time during which the substance has been heated. The highest point which we have observed is 285°, but this can be materially modified by altering the conditions under which the melting point is taken; for instance, two tubes were filled with portions of the same preparation, and one of them was allowed to hang in the bath in the usual way, when it melted at 264°, while the other, which was not allowed to remain in the bath, but only dipped into it occasionally, did not melt till 275°. The two observations were made at the same time, so that in all other respects the conditions were the same. The melting is accompanied with blackening and effervescence. By long continued heat at temperatures between 150° and 180°, the substance is completely decomposed, giving kyaphenine as the principal product, which was recognized by its melting point, 230° (Pinner and Klein * give 231°). The decomposition is undoubtedly similar to that of

* Ber. d. ch. G., 1878, p. 764.

the corresponding mono compound, which, according to Wallach and Gossmann,* gives kyaphenine or benzonitrile and benzolmonosulphonic acid. The benzoyl compound is nearly insoluble in water, whether hot or cold, but not absolutely so, as a moist crystal, after being boiled with water, if laid upon litmus paper, gives an acid reaction. It is tolerably soluble in alcohol or methylalcohol, especially when boiling, nearly insoluble in ether, chloroform, or glacial acetic acid, essentially insoluble in ligroine, benzol, or carbonic disulphide. It is easily soluble in sodic, ammonic, or baric hydrates, or in sodic carbonate; hydrochloric acid precipitates the original substance from these solutions. The solution in ammonic hydrate, if evaporated to dryness on the water-bath, leaves a colorless varnish, which dissolves again in water; this solution, however, gives no characteristic precipitates with the common reagents, although we may mention the white precipitates produced by argentic nitrate and basic plumbic acetate (neutral plumbic acetate gives no precipitate). We have studied the sodium and barium salts, and intended also to analyze the silver salt, but found that it was too soluble to be purified conveniently by washing, and came down from its hot aqueous solution as a varnish.

Sodic Benzoylbenzoltrisulphamide, $C_6H_3(SO_2NNaC_7H_5O)_3$. — This salt was made by boiling a solution of the calculated amount of sodic carbonate with benzoylbenzoltrisulphamide, and evaporating to dryness, finally spontaneously. Upon drying at 100° it lost varying amounts of water, but in no case so much as one molecule; we are therefore inclined to think it was only hygroscopic water, as the salt was of a varnish-like consistency, which would offer great resistance to air-drying.

0.2466 grm. of the salt dried at 100° gave 0.0794 grm. of sodic sulphate.

	Calculated for $C_6H_3(SO_2NNaC_7H_5O)_3$.	Found.
Sodium	9.95	10.43

The salt is a white varnish, which we did not succeed in obtaining in crystals; it dissolves in water very slowly, but does not need a large amount for complete solution. The solution is neutral, and we did not succeed in preparing an acid salt, as when the free benzoylbenzoltrisulphamide was boiled with one molecule of sodic carbonate, nearly two thirds of the amide remained undissolved, and the solution was barely acid.

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* Ber. d. ch. G., 1878, p. 754.

Baric Benzoylbenzoltrisulphamide, $[C_6H_3(SO_2NC_7H_5O)_3]_2Ba_3 12 H_2O$. — This salt was made by boiling the benzoylbenzoltrisulphamide with a solution of baric hydrate, and removing the excess of baric hydrate with carbonic dioxide. The solution was evaporated at last spontaneously.

I. 0.3192 grm. of the air-dried salt dried at 100° lost 0.0372 grm.
II. 0.3406 grm. at 120° lost 0.0408 grm.

	Calculated for $[C_6H_3(SO_2NC_7H_5O)_3]_2Ba_3 12 H_2O$.	Found. I.	Found. II.
Water	11.53	11.65	11.97

The air-dried salt loses *in vacuo* 3.66 per cent, which corresponds to $3\frac{1}{2}$ molecules of water (calculated 3.36 per cent).

I. 0.2820 grm. of the dry salt gave 0.1184 grm. of baric sulphate.
II. 0.2998 grm. gave 0.1214 grm. of baric sulphate.

	Calculated for $[C_6H_3(SO_2NC_7H_5O)_3]_2Ba_3$.	Found. I.	Found. II.
Barium	24.77	24.69	23.80

It forms a white varnish soluble in water.

Chloride of Benzoylbenzoltrisulphamide, $C_6H_3(SO_2N{=}CClC_6H_5)_3$.

This substance was made by heating the benzoylbenzoltrisulphamide with phosphoric pentachloride. Equal weights of the two substances were used, and they were heated in an open test-tube by means of an air-bath at 110°. After one hour the reaction was complete, and the product was purified by washing it with ligroine, and afterward with absolute ether, which converts it from a viscous liquid to a powder. It was dried at 100° and analyzed.

I. 0.2314 grm. of substance gave, after boiling with a solution of pure sodic carbonate, 0.1514 grm. of argentic chloride.
II. 0.2502 grm. of substance gave 0.1614 grm. of argentic chloride.

	Calculated for $C_6H_3(SO_2NCClC_6H_5)_3$.	Found. I.	Found. II.
Chlorine	15.61	16.17	15.95

Properties. — It forms colorless cubic crystals, which, like the benzoyl compound from which they are derived, show no definite melting point; they begin to decompose at 225°, and become liquid in the neighborhood of 245°, but the melting point may vary as much as 30°. The substance is insoluble in water, benzol, ligroine, and chloroform, somewhat soluble in ether.

Benzoltrisulphobenzenylphenylamidine, $C_6H_3[SO_2N{:}C(NHC_6H_5)C_6H_5]_3$.

The chloride just described was converted by warming it gently with aniline into a viscous mass, which solidified after long standing. The substance was purified by washing with water, ether, and benzol, and then crystallizing from hot alcohol until it showed a constant melting point. It was then dried at 100°, and analyzed.

0.1658 grm. of substance gave 14.1 c.c. of nitrogen at a pressure of 760 mm., and a temperature of 20°.

	Calculated for $C_6H_3(SO_2N_2C_{13}H_{11})_3$.	Found.
Nitrogen	9.86	9.73

Properties. — It forms white needles, which melt at 196° (uncorr.), and are insoluble in water and ligroine, soluble with difficulty in alcohol, which, however, is the best solvent for it, soluble in ether, benzol, and chloroform.

A number of attempts to make the dibenzoylbenzoltrisulphamide $C_6H_3[SO_2N(C_7H_5O)_2]_3$ led to no result. The substance was not formed when the sulphamide was heated to 140° with six molecules of benzoylchloride instead of three, or when the sodium salt of the benzoylbenzoltrisulphamide was heated to 150° for a day with an excess of benzoylchloride, or when the silver salt of the benzoylbenzolsulphamide (made by adding argentic nitrate to the sodium salt) was heated to 100° in a sealed tube with an excess of benzoylchloride. In every case the monobenzoylbenzoltrisulphamide remained unaltered.

Benzoltrisulphanilid, $C_6H_3(SO_2NHC_6H_5)_3$.

This substance was prepared by warming benzoltrisulphochloride with aniline. The product was boiled out with water, and purified by crystallization from alcohol. Dried at 100°, it gave the following result on analysis.

0.2408 grm. of the substance gave, according to the method of Carius, 0.315 grm. of baric sulphate.

	Calculated for $C_6H_3(SO_2NHC_6H_5)_3$.	Found.
Sulphur	17.68	17.97

Properties. — It forms good-sized short, thick, white prisms, which melt at 237°, and are very slightly soluble in boiling water, soluble in alcohol, ether, benzol, or acetone, but insoluble in ligroine.

Constitution of Benzoltrisulphonic Acid.

We have determined the constitution of the acid in the two following ways.

First Method. — Dry potassic benzoltrisulphonate was mixed thoroughly with exactly the theoretical amount of potassic cyanide (1 grm. to 0.45 grm.), — if an excess of the cyanide is used, the yield is very much diminished, — and heated by means of a gas-furnace in a piece of combustion-tubing closed at one end; the white crystalline sublimate which collects in the cold part of the tube was removed, and saponified by boiling with alcoholic potassic hydrate, a process which lasts several days. When the evolution of ammonia ceased, the contents of the flask were acidified with hydrochloric acid, and shaken with ether; the ether extract was an acid which melted at 320°–325°, and this melting point remained unaltered after crystallization from water. It was converted into the silver salt, which gave the following result on analysis.

0.1528 grm. of the salt gave on ignition 0.093 grm. of metallic silver.

	Calculated for $C_6H_3(CO_2Ag)_3$.	Found.
Silver	61.02	60.86

No other acid could be detected in the product of the reaction. The melting points of the three tribasic acids derived from benzol are, hemimellitic acid, 185°; trimellitic acid, 216°; trimesic acid, above 300°. So there can be no doubt that our acid is *trimesic acid*, and therefore, if there has been no intramolecular transformation, the benzoltrisulphonic acid has the symmetrical constitution 1, 3, 5.

Second Method. — The benzoltrisulphochloride was heated with an excess of phosphoric pentachloride, according to the method of Barbaglia and Kekulé* for replacing a sulpho-group by an atom of chlorine. For this purpose 3 grm. of the chloride were sealed with 5.2 grm. of phosphoric pentachloride (one molecule of the sulphochloride to six of the phosphoric pentachloride), and heated for some hours to 200°–210°. Upon treating the product with water long needles were deposited, which were purified by washing with sodic hydrate, and several crystallizations from alcohol, when they melted at 63°. The yield was about 62 per cent of the theoretical. The melting point of this substance would indicate that it is the symmetrical trichlorbenzol 1, 3, 5, which melts, according to Beilstein and

* Ber. d. ch. G., 1872, p. 875.

Kurbatow,* at 63°.5. To confirm this indication we treated a portion of the substance with fuming nitric acid at a temperature of about 50°, when, instead of getting the trichlormononitrobenzol of Beilstein and Kurbatow,† melting at 68°, we obtained a substance crystallizing in long, thick prisms, and melting at 130°. This observation made it necessary for us to study the action of fuming nitric acid on symmetrical trichlorbenzol, the results of which research are described fully in the following paper. It is sufficient to state here, that we found the nitric acid used by us, even when acting in the cold, converted the symmetrical trichlorbenzol into the trichlordinitrobenzol, melting at 129°.5, thus proving that the trichlorbenzol derived from benzoltrisulphochloride is the symmetrical compound (1, 3, 5), and confirming the result obtained by the first method.

The study of the action of reducing agents on the benzoltrisulphochloride will be described in a subsequent paper, and Mr. G. T. Hartshorn has undertaken the extension of this method of making sulpho acids to other organic substances, obtaining results which will soon be ready for publication.

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* Ann. Chem., cxcii. 233.

† Ber. d. ch. G., 1877, p. 271.

XIX.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

ON THE ACTION OF NITRIC ACID ON SYMMETRICAL TRICHLORBENZOL.

By C. Loring Jackson and John F. Wing.

Presented March 9, 1887.

We were led to take up the study of this subject by our work upon the constitution of benzoltrisulphonic acid, described in the preceding paper, since the trichlorbenzol derived from that substance by replacing its sulpho groups with chlorine, although melting at 63° like the symmetrical compound (melting point 63°.5 according to Beilstein and Kurbatow*), gave on treatment with nitric acid a body melting at 130°, whereas Beilstein and Kurbatow obtained in this way trichlormononitrobenzol,† melting point 68°. To find the cause of this discrepancy we have prepared the symmetrical trichlorbenzol, and treated it with nitric acid in the cold, when we found that the product was the substance melting at 130° (or more accurately at 129°.5) mentioned above, which proved on analysis to be trichlordinitrobenzol. This result was the more strange, because our nitric acid had a specific gravity of only 1.505, whereas that used by Beilstein and Kurbatow showed 1.52, and in order to get their trichlormononitrobenzol we found it necessary to dilute our acid to 1.46. Since these experiments seemed to show that our nitric acid was more efficient in its action than that used by Beilstein and Kurbatow, we determined to study the subject more carefully, and next attempted the preparation of the trichlortrinitrobenzol, which we obtained without difficulty by boiling the trichlordinitrobenzol for about two hours with a mixture of our nitric acid and fuming sulphuric acid. Both this substance

* Ann. Chem., cxcii. 233.

† Ber. d. ch. G., 1877, p. 271.

and the dinitro compound are new, the difficulty of the preparation of symmetrical trichlorbenzol having prevented a thorough study of this substance. On the other hand, the corresponding tribrombenzol can be made with great ease, and, as its action with fuming nitric acid has been studied frequently, we decided to extend our experiments to it to see whether in this case also our nitric acid proved more reactive than that of the chemists who have worked in this field heretofore. The complete description of our results with tribrombenzol will be postponed till a later paper, and we shall give here only that portion of them which shows that the action of our nitric acid on the tribrombenzol is similar to its action on the trichlorbenzol, prefacing it with a brief historical sketch of the work of our predecessors.

Koerner * was the first (in 1874) who studied this subject, obtaining on dissolving the symmetrical tribrombenzol with the aid of heat in nitric acid of specific gravity 1.54 the dinitro compound, with a mixture of fuming sulphuric acid and nitric acid the trinitro compound, while all his attempts to obtain the mononitro derivative by direct nitriring failed, owing to the insolubility of the tribrombenzol in weaker acid. In the next year † one of us ‡ working in the laboratory of Berlin found that the fuming nitric acid supplied in that laboratory converted tribrombenzol into the mononitro compound only when boiled with it, and that it was necessary to use a boiling mixture of nitric and (common) sulphuric acids to obtain the dinitro derivative. These observations were confirmed a few years later by Wurster and Beran,§ who obtained only the mononitro compound from the action of a nitric acid of 1.534 specific gravity alone, and the dinitro compound when its action was reinforced by mixture with crystallized fuming sulphuric acid. Even when this mixture was heated with tribrombenzol in sealed tubes to 220° for 48–60 hours, only a very minute quantity of a trinitro compound was formed; which led them to the conclusion that the trinitro derivative mentioned but not described by Koerner could not be obtained.

In taking up again the study of the nitro compounds of symmetrical tribrombenzol we used the nitric acid of specific gravity 1.505–1.51,

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* Gazz. Chim., iv. 422, 425.

† Von Richter (Ber. d. ch. G., 1875, p. 1426) succeeded in obtaining the mononitro compound by boiling glacial acetic acid and tribrombenzol with nitric acid of specific gravity 1.52, but found, in agreement with Koerner, that an acid of 1.54 boiled with tribrombenzol converted it into the dinitro compound.

‡ Jackson, Ber. d. ch. G., 1875, p. 1172.

§ Ber. d. ch. G., 1879, p. 1821.

which had acted on trichlorbenzol in the way already described, and found that this acid converted the tribrombenzol, even when the mixture was carefully cooled, direct into tribromdinitrobenzol, no mononitro compound being formed; and further, that by the action of a mixture of this nitric acid with fuming sulphuric acid on tribromdinitrobenzol the tribromtrinitrobenzol, melting point 285°, was formed without difficulty in open vessels. We therefore confirm completely the results of Koerner, so far as they apply to the di and trinitro compounds, in opposition to those obtained by one of us, and by Wurster and Beran; and, to make the comparison more striking, we have used for these experiments tribrombenzol made from some tribromaniline prepared in Berlin by one of us during his previous experiments. To sum up the whole case in a few words, it appears that our nitric acid of specific gravity 1.505–1.51 is much more efficient in its action than the commercial fuming nitric acid used in the laboratories of St. Petersburg * (1.52), Berlin,† and Munich ‡ (1.534); and we are inclined to ascribe the high specific gravities of these commercial acids in part to the presence of lower oxides of nitrogen, while the specific gravity of our acid was due probably exclusively to HNO_3, since it was prepared in our laboratory directly from nitre and sulphuric acid, not pushing the reaction beyond the formation of acid potassic sulphate. This explanation is based upon the observation of Kolb,§ that the specific gravity of nitric acid is raised by the solution of nitric dioxide in it; and although we cannot submit it to direct experimental proof, since commercial fuming nitric acid is not to be had in this country, yet the following examination of a nitric acid similar to that used in foreign laboratories makes it exceedingly probable that this explanation is correct. This acid was prepared by distilling common nitric acid twice with an excess of sulphuric acid; it had a decided yellow color, and a specific gravity of 1.535 at 15° (the temperature at which all our determinations were made), but converted tribrombenzol into tribrommononitrobenzol only, when acting in the cold, although it gave the dinitro compound when boiled with it. It was therefore less efficient than our acid of specific gravity 1.51, but more so than the foreign acids mentioned above. The analyses of this acid and of our acid of 1.51 specific gravity yielded the following results, which are given in tabular form to facilitate comparison.

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* Beilstein and Kurbatow.

† Jackson.

‡ Wurster and Beran.

§ Ann. Chim. Phys., ser. 4, x. 137.

	Per Cent NO_2.	Per Cent HNO_3.	H_2O by Difference.
Acid of 1.535 sp. gr.	5.0	93.38	1.62
Acid of 1.51 sp. gr.	0.5	96.92 *	2.58

The nitric dioxide was determined in the usual way by treatment of the diluted acid with a standard solution of potassic permanganate. The results are not absolutely accurate, as observed by Feldhaus.† because of the loss of nitric dioxide in transferring the acid from the weighing or measuring tube to the beaker, but are nearly enough so for our purpose. The nitric acid was determined by neutralization with ammonic hydrate, and weighing the ammonic nitrate dried at 120°. It contained no ammonic nitrite. The estimated amount of nitric acid corresponding to the nitric dioxide found has been subtracted, so that the number given represents the percentage of free HNO_3 in the acid. These results show that the acid with the higher specific gravity contains the smaller amount of HNO_3, and therefore that the determination of the specific gravity is not a trustworthy way of finding the strength of nitric acid, unless the sample examined is free from lower oxides of nitrogen.

After the foregoing account of our work was already written we received a paper by Nietzki and Hagenbach,‡ in which a similar experience is described; for they found that with commercial fuming nitric acid a mononitro compound alone could be obtained from diacetylmetaphenylenediamine, whereas they obtained the dinitro compound by using "pure monohydrate," which, they say, can be prepared most easily by distilling fuming nitric acid with twice the quantity of sulphuric acid, and which had a specific gravity of 1.533 at 15°. It is to be observed, however, that our experiment with an acid prepared in a similar way shows that even this acid is not so pure as that made direct from nitre and sulphuric acid.

Preparation of Symmetrical Trichlorbenzol.

We have tried all of the three different processes known for making trichloraniline, viz.: 1st. By the direct action of chlorine on aniline

* This number is higher than that given by Kolb as corresponding to this specific gravity (1.51), which is 94 per cent. The difference may be due to the presence of amines in the ammonia used by us; but we have not studied this point more carefully, as we are not interested in the absolute determination of the amount of HNO_3 in this acid, but only in the relative amounts of HNO_3 in these two nitric acids, which are given accurately by our numbers, since they were obtained under exactly parallel conditions.

† Zeitschr. Anal. Chem , i. 426. ‡ Ber. d. ch. G., 1887, p. 333.

dissolved in glacial acetic acid, — a method which gives the trichloraniline more quickly than any of the others, but which we discarded on account of the very small yield obtained. 2d. According to Beilstein and Kurbatow,* by the formation of chloracetanilid from chlorine and acetanilid, and converting this, after the removal of the acetyl, into trichloraniline by treatment with chlorine in a glacial acetic acid solution. We may be allowed to remark, in regard to this method, that we were unable to make acetanilid in glacial acetic acid solution take up more than one atom of chlorine, an excess of chlorine passing through the solution unaltered after monochloracetanilid had been formed, whereas Beilstein and Kurbatow obtained the dichloracetanilid in this way; we have not thought the point of sufficient importance, however, to devote to it the time necessary to determine the cause of this difference. This method gives good results, but does not lead to them so quickly and easily as the *third*, which consists in making dichloracetanilid according to Witt,† that is, acting on acetanilid in a warm acetic acid solution with a solution of bleaching-powder. The dichloracetanilid was then converted into the trichloraniline, as in the second method.

The method, therefore, which we finally adopted, and should recommend as the best, is the following: 5 parts of acetanilid are dissolved in 20 parts of glacial acetic acid and 100 of water, and heated to boiling; then, after removing the lamp, a 10 per cent solution of bleaching-powder is added, until a viscous precipitate is formed, the temperature being kept above 70°. The precipitate is then treated with ammonic hydrate, and crystallized from alcohol. The yield of dichloracetanilid is nearly quantitative. The dichloracetanilid is next converted into dichloraniline by heating it on the water-bath with strong sulphuric acid, the dichloraniline dissolved in glacial acetic acid, and chlorine passed through the solution until two parts of the dichloraniline have gained one part of chlorine; the product is then rendered alkaline with a large excess of sodic hydrate, and distilled with steam; the solid which distils over, after crystallization from dilute alcohol, is pure trichloraniline, but the yield is far from satisfactory, a large quantity of tarry impurity being formed during the treatment of the free base with chlorine. The trichloraniline is con-

* Ann. Chem., clxxxii. 95.

† Ber. d. ch. G., 1875, p. 1226. Bender, Ber. d. ch. G., 1886, p. 2272, has obtained $C_6H_5NClCOCH_3$ by the action of bleaching powder on a *cold* acetic acid solution of acetanilid.

verted into trichlorbenzol by the method of Bässmann;* that is, it is dissolved in alcohol of 95 per cent by heat, and the calculated amount of a hot concentrated aqueous solution of potassic nitrite added, and then dilute sulphuric acid, little by little, until the reaction is strongly acid; the mixture is then warmed gently on the water-bath until the reaction comes to an end, and the trichlorbenzol purified by crystallization from alcohol. The yield is good, 8 grm. of the trichloraniline giving 5 grm. of trichlorbenzol; that is, 67 per cent of the theoretical amount.

Trichlordinitrobenzol, $C_6HCl_3(NO_2)_2$.

The symmetrical trichlorbenzol was dissolved in nitric acid† of specific gravity 1.505 at the ordinary temperature; the same result was also obtained if the beaker in which the reaction took place was kept cool by immersion in cold water. When the trichlorbenzol was completely dissolved, the product was precipitated by pouring it into cold water or snow, and purified by crystallization from hot alcohol until it showed the constant melting point 129°.5, when it was dried at 100° and analyzed.

0.2694 grm. of the substance gave 24.4 c.c. of nitrogen at 24° temperature and 766.5 mm. pressure.

0.2102 grm. of substance gave, according to the method of Carius, 0.3322 grm. of argentic chloride.

	Calculated for $C_6HCl_3(NO_2)_2$.	Found.
Nitrogen	10.31	10.24
Chlorine	39.22	39.07

Properties. — It forms thick, long white prisms, when crystallized from alcohol, which melt at 129°.5, and are soluble in cold alcohol, much more freely in hot, very easily soluble in benzol, chloroform, carbonic disulphide, or acetone, soluble in ether, or in glacial acetic acid, still more soluble in hot glacial acetic acid.

In order to obtain trichlormononitrobenzol, a nitric acid diluted until it shows the specific gravity 1.46 must be boiled with trichlorbenzol until complete solution takes place. After precipitation with

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* Ann. Chem., cxci. 206.

† The nitric acid was prepared by distilling nitre with sulphuric acid in the proportions of one molecule of each. See page 374, for a discussion of this point.

water and recrystallization from alcohol, the product of such a preparation showed the melting point 68°, that given by Beilstein and Kurbatow. Ordinary strong nitric acid of specific gravity 1.4 has no action on trichlorbenzol, whether hot or cold.

The constitution of the trichlordinitrobenzol follows from the fact that it is made from symmetrical trichlorbenzol, and is

$$H : Cl : NO_2 : Cl : NO_2 : Cl = 1 : 2 : 3 : 4 : 5 : 6.$$

Trichlortrinitrobenzol, $C_6Cl_3(NO_2)_3$.

This substance was made by boiling in a flask, for half an hour or somewhat more, trichlordinitrobenzol with a mixture of fuming sulphuric acid and nitric acid of specific gravity 1.505, prepared direct from nitre and sulphuric acid.* The substance goes completely into solution while hot, but a considerable quantity separates out as it cools. The whole is then precipitated with snow, and treated with hot alcohol, when an insoluble residue containing sulphur is left behind; this is probably a sulphone, but was formed in such small quantities that we did not try to study it. The hot alcoholic solution on cooling deposits the trichlortrinitrobenzol, which is purified by crystallization from boiling alcohol until it shows the constant melting point 187°. The substance was dried at 100° and analyzed, with the following results.

0.1656 grm. of substance gave 18.8 c.c. of nitrogen at a temperature of 18° and 750 mm. pressure.

0.1486 grm. of substance gave, acording to the method of Carius, 0.2034 grm. of argentic chloride.

	Calculated for $C_6Cl_3(NO_2)_3$.	Found.
Nitrogen	13.27	12.94
Chlorine	33.64	33.83

Properties. — The trichlortrinitrobenzol is obtained by crystallization from alcohol in rather thick good-sized needles of a white color, with a slight yellowish tinge, melting point 187°, very nearly insoluble in water, but not completely so, less soluble in alcohol than trichlordinitrobenzol, easily soluble in ether, benzol, chloroform, acetone, glacial acetic acid, or carbonic disulphide. Alcohol is the best solvent for it.

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* See page 374.

The constitution of the trichlortrinitrobenzol, since it is made from the symmetrical trichlorbenzol, is also symmetrical, —

$$Cl : NO_2 : Cl : NO_2 : Cl : NO_2 = 1 : 2 : 3 : 4 : 5 : 6.$$

The description of the tribromtrinitrobenzol, as well as of some of the derivatives of this very reactive substance, will be postponed until another paper.

XX.

OBSERVATIONS OF VARIABLE STARS IN 1886.

By Edward C. Pickering.

Communicated March 9, 1887.

The present publication is the fourth in a series of annual statements relating to variable stars, which was begun in 1884. In the fifth statement, to be published in 1888, it is proposed to review the entire period since the discovery of each variable star, giving the number of observations made by each observer during each year, so far as this information can be obtained. All persons who have any facts of this kind at command are urgently requested to communicate them to the Observatory of Harvard College, so that the proposed publication may be as complete as possible.

Some difficulty has been experienced in preparing the present report, from the circumstance that variable stars are occasionally designated only by letters and constellations, without their numbers in any published catalogue or their places for a given date. The recommendation made in previous reports is accordingly here renewed, that the place of each star should always be given when there is no other means of identification than the name. The number in a designated catalogue, such as that printed with these reports, will of course be a sufficient substitute for the place.

In view of the extended publication proposed for next year, the present report may be made comparatively brief. The names of the observers, their methods of observation, and the abbreviations by which they are designated in Tables I. and II. are mainly the same as in the report for last year; Messrs. Backhouse, Dunér, Eadie, Espin, Gore, Hagen, Knott, Parkhurst, Safarik, and Zaiser, being designated as before by B., D., Ee., En., G., Hn., K., P., Sk., and Zr., while M. denotes the work of the meridian photometer. An eyepiece magnifying 90 times has often been employed in Mr. Parkhurst's observations, in addition to the powers of 56 and 150 mentioned last year. Father Hagen has begun a systematic search for variables of the fourth class in a great circle whose pole is $12^h\ 40^m$, $+28°$, and has examined the DM. chart No. 32 in accordance with suggestions given in "Variable Stars of Short Period." See these Proceedings, XVI. 277, 281. He suspects the following stars to be variable: DM. $+55°$ 2587, $+44°$ 3368, $+44°$ 3402. Dr. Hartwig has not made any statement with regard to his observations in 1886. Professor Safarik has been prevented by illness from making a complete statement of his work, but has sent a list containing a large number of observations, which are entered as usual in Tables I. and II. Statements have also been received from some observers who have not contributed to previous reports. The additional abbreviations thus required in Tables I. and II. are explained in the following paragraphs.

B_1. These observations were made by Mr. Joseph Baxendell, at Birkdale, Southport, England. The telescope used in the observations is an achromatic refractor of 6 inches' aperture, made by Cooke and Sons, of York; and the magnitudes of the variables are determined by comparisons with neighboring stars whose magnitudes have been determined by the method of limiting apertures.

B_2. These observations were made by Mr. Joseph Baxendell, Jr. The place, instrument, and method of observation were the same as described under the heading B_1.

Eq. These observations were made with the equatorial telescope of the Observatory of Harvard College. The aperture and focal length of the instrument are respectively 15 and 279 inches. The magnifying power employed was ordinarily 103. The observers were Messrs. Arthur Searle and O. C. Wendell. The observations consist in measurements, made with the wedge photometer, of the comparison stars known to have been employed by previous observers; but when the variable stars themselves were visible, they were incidentally compared with others by estimate, according to the method of Argelander, and were also observed with the wedge. The work will be continued during the coming year, and it is desired to make it include as many as possible of the comparison stars which have been employed by any observer. The list now in use is chiefly derived from the published work of Argelander, Schönfeld, and Oudemans. Observers are requested to send lists of the comparison stars not included in these publications which they have themselves employed, or which have been employed to their knowledge by others. It is very desirable that not only the places of these stars, but also their designations in the

Durchmusterung, when they occur in that catalogue, should be entered in the lists thus sent.

Sn. These observations were made by Mr. T. S. H. Shearmen, of Brantford, Canada. The instruments employed were an opera-glass and a two-inch refractor. Each variable was compared with stars differing little from it in brightness. Many suspected variables have been photographed.

Table I. indicates the progress of observation for stars included in Table I. of previous reports. Other stars, whether known or suspected to be variable, are included in Table II. All the columns of Table I. except the last are repeated from the statement of the previous year. The first column of the left-hand pages gives a provisional number for designating the star. This number is taken from Schönfeld's Catalogue when the star occurs there; in other cases, a letter is added to the number. The second column contains numbers from the Photometric Catalogue called Harvard Photometry, and published in Volume XIV. of the Annals of the Harvard College Observatory. The following columns contain the usual designation of the star, its right ascension and declination for 1875, magnitude at maximum and minimum, and period in days.

The first column of the right-hand page repeats the number to be used for the provisional designation of the star. The second gives the class to which the star belongs, upon the system of classification employed in the Proceedings of the American Academy of Arts and Sciences, XVI. 257. Upon this system, Class I. includes temporary stars; Class II., stars undergoing large variations in periods of several months; Class III., irregularly variable stars, undergoing but slight changes in brightness; Class IV., variable stars of short period, like β *Lyræ* or δ *Cephei;* Class V., Algol stars, or those which at regular intervals undergo sudden diminutions of light, lasting for a few hours only. The third column gives the name of the discoverer, and the fourth column the date.

The last column contains the number of nights on which each star was observed by the astronomer whose designation is attached to the number. The abbreviations employed have been explained above.

Table I. is followed by a series of remarks containing observed dates of maximum and minimum, and other information derived from the observers with regard to particular stars.

Table II. indicates the progress of observation of stars suspected or known to be variable, but not included in Table I. for reasons explained in previous reports. The provisional numbers given in the first column for many of the stars refer to Mr. Chandler's unpublished catalogue, as in previous years. The second and third columns give the right ascensions and declinations of the stars for 1875. The fourth column gives the number of observations made by each observer, as in the last column of Table I. The abbreviations are likewise the same. The letters in the last column refer to the remarks on page 395.

TABLE I. — Variable Stars.

No.	H.P.	Name.	R. A. 1875.	Dec. 1875.	Max.	Min.	Per.
			h. m. s.	° ′	m.	m.	d.
0*a*	—	Ceti	0 15 26	—20 45.1	5.2	7.0	—
1	51	T Cassiopeiæ	16 29	+55 5.9	6.5 — 7.0	11 — 11.2	436
2	54	R Andromedæ	17 28	+37 53.0	5.6 — 8.6	<12.8	404.7
3	—	S Ceti	17 42	—10 1.3	7.0 — 8.0	<10.7	323.6
4	—	B Cassiopeiæ	17 52	+63 27.2	>1	?	—
5	—	T Piscium	25 31	+13 54.6	9.5 — 10.2	10.5 — 11.0	Irr.
6	94	α Cassiopeiæ	33 25	+55 51.1	2.2	2.8	Irr.
6*a*	—	U Cephei	51 18	+81 12.1	7.0	9.5	2.5
7	—	S Cassiopeiæ	1 10 30	+71 57 2	6.7 — 8.5	<13	615
8	—	S Piscium	11 2	+ 8 16.3	8.8 — 9.3	<13	406.6
8*a*	—	Piscium	16 22	+12 12.7	10	14	—
8*b*	—	Ceti	19 31	— 4 36.6	6.5	7.8	—
8*c*	—	R Sculptoris	21 13	—33 11.5	5¾	7¾	207
9	—	R Piscium	24 12	+ 2 14.1	7.4 — 8.3	<12.5	345
10	—	S Arietis	57 55	+11 55.5	9.1 — 9.8	<13	288.8
11	—	R Arietis	2 9 1	+24 28.4	7.6 — 8.5	11.9 — 12.7	186.2
12	370	*o* Ceti	13 1	— 3 32.7	1.7 — 5.0	8 — 9	331.3
13	—	S Persei	13 54	+58 0.8	8.5 ?	<9.7	—
14	—	R Ceti	19 39	— 0 44.6	7.9 — 8.7	<12.8	167.1
15	—	T Arietis	41 22	+16 59.3	7.9 — 8.2	9.4 — 9.7	324
16	489	ρ Persei	57 10	+38 21.3	3.4	4.2	Irr.
17	496	β Persei	3 0 2	+40 28.4	2.2	3.7	2.9
18	—	R Persei	22 6	+35 14.3	8.1 — 9.2	12.5	208.8
19	657	λ Tauri	53 45	+12 8.2	3.4	4.2	4.0
20	—	T Tauri	4 14 43	+19 14.3	9.2 — 11.5	12.8 — <	Irr.
21	—	R Tauri	21 27	+ 9 52.9	7.4 — 9.0	<13	325.6
22	—	S Tauri	22 22	+ 9 40.1	9.9	<13	378
22*a*	—	Doradus	35 19	—62 19.4	5½	6¾	—
23	—	V Tauri	44 48	+17 19.6	8.3 — 9.0	<12.8	168.6
24	—	R Orionis	52 13	+ 7 56.3	8.7 — 8.9	<13	378.8
25	877	ε Aurigæ	53 0	+43 38.2	3.0	4.5	Irr.
26	880	R Leporis	53 55	—14 59.7	6 — 7	8.5 ?	437.8
27	—	R Aurigæ	5 7 12	+53 26.6	6.5 — 7.4	12.5 — 12.7	465
27*a*	—	S Aurigæ	18 52	+34 2.3	9.4	<13	—
28	—	S Orionis	22 50	— 4 47.5	8.3 ?	<12.3	—
29	1005	δ Orionis	25 37	— 0 23.6	2.2 ?	2.7	Irr.
29*a*	—	Orionis	29 42	— 5 33.5	10	13	—
30	1091	α Orionis	48 24	+ 7 23.3	1	1.4	Irr.
31	1160	η Geminorum	6 7 20	+22 22.4	3.2	3.7 — 4.2	229.1
31*a*	—	Monocerotis	16 26	— 2 8.1	7	<10	—
32	1205	T Monocerotis	18 29	+ 7 9.1	6.2	7.6	26.8
33	—	R Monocerotis	32 21	+ 8 50.7	9.5	11.5	Irr.
34	1256	S Monocerotis	34 6	+10 0.5	4.9	5.4	3.4
35	—	R Lyncis	50 59	+55 30.2	9 ?	<12.3	—
36	1334	ζ Geminorum	56 41	+20 45.1	3.7	4.5	10.2
37	—	R Geminorum	59 49	+22 53.8	6.6 — 7.3	<12.3	371.0
38	—	R Canis min.	7 1 50	+10 13.1	7.2 — 7.9	9.5 — 10.0	335.0
38*a*	—	Puppis	9 43	—44 26.2	3½	<6	135
38*b*	—	V Geminorum	16 10	+13 21.8	8.5	12 — 13½	276
38*c*	1417	U Monocerotis	24 50	— 9 31.0	6.0	7.2	46.0
39	—	S Canis min.	25 56	+ 8 35.0	7.2 — 8.0	<11	332.2
40	—	T Canis min.	27 3	+12 0.6	9.1 — 9.7	<13	335.2
40*a*	—	Canis min.	34 34	+ 8 40.2	8½	13.5	405
41	—	S Geminorum	35 32	+23 44.6	8.2 — 8.7	<13	294.2

TABLE I. — VARIABLE STARS.

No.	Class.	Discoverer.	Date.	Observations, 1886.
0*a*	—	Chandler	1881	3 M.
1	II.	Krüger	1870	8 B_1. 8 Ee. 2 Eq. 9 M. 30 Sk.
2	II.	Argelander	1858	3 Ee. 2 Eq. 3 M. 9 P. 10 Sk.
3	II.	Borelly	1872	9 Ee. 4 Eq. 3 M. 12 P.
4	I.	Tycho Brahe	1572	3 M.
5	II.	Luther	1855	12 Ee. 3 Eq. 4 M. 4 P.
6	III.	Birt	1831	10 M. 1 Sn.
6*a*	V.	Ceraski	1880	1 B_1. 2 B_2. 12 Hn. 1 M.
7	II.	Argelander	1861	2 B_1. 27 B_2. 17 Ee. 2 Eq. 2 G. 6 M. 11 P. 32 Sk.
8	II.	Hind	1851	10 Ee. 2 Eq. 3 M. 6 P.
8*a*	—	Peters	1880	13 P.
8*b*	—	Gould	1874?	2 M.
8*c*	II.	Gould	1872?	—
9	II.	Hind	1850	2 Eq. 3 M. 8 P.
10	II.	Peters	1865	1 Eq. 4 M. 11 P.
11	II.	Argelander	1857	14 B_1. 3 Eq. 9 Hn. 14 P. 2 Sk.
12	II.	Fabricius	1596	50 B. 3 B_1. 22 G. 12 K. 21 Sk. 5 Sn.
13	II.	Krüger	1873	2 Eq. 5 Hn. 1 P. 30 Sk.
14	II.	Argelander	1866	3 Eq. 13 P. 10 Sk.
15	II.	Auwers	1870	3 Eq. 17 Hn. 26 Sk.
16	II.?	Schmidt	1854	1 G.
17	V.	Montanari	1669	—
18	II.	Schönfeld	1861	10 B_1. 3 Eq. 6 Hn. 7 P. 5 Sk.
19	V.	Baxendell	1848	1 B. 9 Zr.
20	—	Hind	1861	8 B_1. 3 Eq. 3 K. 12 P. 2 Sk.
21	II.	Hind	1849	3 Eq. 10 P. 3 Sk.
22	II.	Oudemans	1855	6 Ee. 3 Eq. 11 P. 3 Sk.
22*a*	—	Gould	1874?	—
23	II.	Auwers	1871	3 Eq. 18 P. 12 Sk.
24	II.	Hind	1848	3 Eq. 1 K. 3 Sk.
25	III.	Fritsch	1821	—
26	II.	Schmidt	1855	8 B_1. 2 Eq. 1 K. 17 Sk.
27	II.	At Bonn	1862	2 En. 2 Eq. 4 G. 4 Hn. 1 P. 3 Sk.
27*a*	II.	Dunér	1881	19 D. 4 Eq. 11 P.
28	II.	Webb	1870	9 B_1. 19 Ee. 3 En. 2 Eq. 8 K. 1 P. 24 Sk.
29	III.	J. Herschel	1834	—
29*a*	—	Bond	1863	17 Ee. 1 P.
30	III.	J. Herschel	1836	11 Zr.
31	II.?	Schmidt	1866	2 B.
31*a*	—	Schönfeld	1883	6 P.
32	IV.	Gould	1871	—
33	II.	Schmidt	1861	2 Eq. 1 Sk.
34	IV.	Winnecke	1867	—
35	II.	Krüger	1874	3 Eq. 19 P. 21 Sk.
36	IV.	Schmidt	1844	5 M. 18 Zr.
37	II.	Hind	1848	3 Eq. 2 K. 16 P. 8 Sk.
38	II.	At Bonn	1854	3 Eq. 15 Hn. 1 K. 25 Sk.
38*a*	II.	Gould	1872	—
38*b*	II.	Baxendell	1880	24 B_1. 3 Eq. 6 K.
38*c*	II.?	Gould	1873	11 En. 3 G.
39	II.	Hind	1856	1 B_1. 1 Ee. 3 Eq. 3 K. 19 Sk.
40	II.	Schönfeld	1865	2 Eq.
40*a*	II.	Baxendell	1879	21 B_1. 1 Ee. 1 Eq. 5 K.
41	II.	Hind	1848	2 B_1. 1 Eq. 10 P. 20 Sk.

TABLE I. — *Continued.*

No.	H.P.	Name.	R. A. 1875.	Dec. 1875.	Max.	Min.	Per.
			h. m. s.	° ′	m.	m.	d.
42	—	T Geminorum	7 41 48	+24 2.7	8.1 — 8.7	<13	288.1
42*a*	—	S Puppis	43 6	—47 8.3	7¼	9	—
43	—	U Geminorum	47 41	+22 19.7	8.9 — 9.7	13.1	Irr.
43*a*	—	Puppis	55 0	—12 32	8½	<14	310
44	—	R Cancri	8 9 40	+12 6.5	6.2 — 8.3	<11.7	354.4
45	—	V Cancri	14 36	+17 40.9	6.8 — 7.2	<12	272
46	—	U Cancri	28 37	+19 19.5	8.2 — 10.4	<13	305.7
47	—	S Cancri	36 48	+19 29.0	8.2	9.8	9.5
48	—	S Hydræ	47 3	+ 3 32.4	7.5 — 8.5	<12.2	256.4
49	—	T Cancri	49 32	+20 19.7	8.2 — 8.5	9.3 — 10.5	484.2
50	—	T Hydræ	49 35	— 8 39.8	7.0 — 8.1	<12.5	289.4
50*a*	—	R Carinæ	9 29 6	—62 14.2	4.4	9.3	313
51	—	R Leonis min.	38 4	+35 5.2	6.1 — 7.5	<11.0	374.7
52	1752	R Leonis	40 50	+12 0.5	5.2 — 6.4	9.4 — 10 0	312.6
52*a*	—	l Carinæ	41 49	—61 55.9	3.7	5.2	31.2
52*b*	—	Leonis	53 3	+21 51.6	8½	8.6<13	280 ?
52*c*	—	Antliæ	10 4 22	—37 7.1	6½	<8	—
52*d*	—	Carinæ	5 23	—60 56.3	6¼	9	—
52*e*	—	U Leonis	17 21	+14 38.1	9½	Inv.	—
52*f*	1869	Hydræ	31 22	—12 44.1	4½	6	—
53	1880	R Ursæ maj.	35 47	+69 25.9	6.0 — 8.1	12	303.4
54	—	η Argus	40 13	—59 1.6	>1	6.3	Irr.
54*a*	—	T Carinæ	50 18	—59 51.2	6.2	6.9	—
55	—	R Crateris	54 25	—17 39.2	>8	<9	—
56	—	S Leonis	11 4 23	+ 6 8.5	9.0 — 9.7	<13	187.6
57	—	T Leonis	32 2	+ 4 3.9	10 ?	<13	—
58	—	X Virginis	55 27	+ 9 46.1	7.8 ?	<10	—
59	—	R Comæ	57 51	+19 28.8	7.4 — 8.0	<13	363
60	—	T Virginis	12 8 12	— 5 20.4	8.0 — 8.8	<13	337
61	—	R Corvi	13 10	—18 33.5	6.8 — 7.3	<11.5	318.6
61*a*	—	Virginis	27 26	— 3 43.8	8	14	210±
62	—	T Ursæ maj.	30 42	+60 10.6	7.0 — 8.3	12.2	255.6
63	2147	R Virginis	32 10	+ 7 40.6	6.5 — 7.5	10.0 — 10.9	145.7
63*a*	—	R Muscæ	34 28	—68 43.3	6.6	7.3	0.9
64	—	S Ursæ maj.	38 28	+61 46.7	7.7 — 8.2	10.2 — 11.1	224.8
65	—	U Virginis	44 46	+ 6 14 0	7.7 — 8.1	12.2 — 12.8	207.4
66	—	W Virginis	13 19 35	— 2 43.4	8.7 — 9.2	9.8 — 10.4	17.3
67	—	V Virginis	21 21	— 2 31.4	8.0 — 9.0	<13	251
68	2275	R Hydræ	22 53	—22 38.0	4.0 — 5.5	10 ?	469.3
69	2289	S Virginis	26 29	— 6 33.0	5.7 — 7.8	12.5	374 0
69*a*	—	Virginis	14 3 37	—12 42.7	9	14	—
69*b*	—	R Centauri	7 35	—59 19.8	6	10	—
70	—	T Bootis	8 14	+19 39.1	9.7 ?	<13	—
71	—	S Bootis	18 41	+54 22.7	8.1 — 8.5	13.2	272.4
72	—	R Camelopardi	27 8	+84 23.8	7.9 — 8.6	12 ?	266.2
73	2445	R Bootis	31 41	+27 16.9	5.9 — 7.5	11.3 — 12.2	223.0
73*a*	2459	Bootis	37 56	+27 3.6	5.2	6 1	370 ?
73*b*	—	Bootis	48 33	+18 12.1	9.1	12.0 — 13.6	173.8
74	2506	δ Libræ	54 18	— 8 1.2	4.9	6.1	2.3
74*a*	—	Libræ	15 3 37	—19 33.9	10	<13.5	700±
74*b*	—	R Triang. Austr.	8 37	—66 2.1	6.6	8.0	3.4
75	—	U Coronæ	13 6	+32 6.4	7.6	8.8	3.5
76	—	S Libræ	14 13	—19 56 1	8.0	12.5 ?	—
77	—	S Serpentis	15 48	+14 45.9	7.6 — 8.6	12.5 ?	361.0

TABLE I. — *Continued.*

No.	Class.	Discoverer.	Date.	Observations, 1886.
42	II.	Hind	1848	11 P. 32 Sk.
42*a*	—	Gould	1874?	—
43	II.?	Hind	1855	18 B_1. 26 B_2. 3 Eq. 21 K. 9 P. 45 Sk.
43*a*	II.	Pickering	1881	—
44	II.	Schmidt	1829	1 Ee.
45	II.	Auwers	1870	2 Eq. 12 P. 20 Sk.
46	II.	Chacornac	1853	12 Hn. 5 Sk.
47	V.	Hind	1848	3 Ee. 64 Hn.
48	II.	Hind	1848	6 Sk.
49	II.	Hind	1850	2 En. 2 Eq. 11 P. 19 Sk.
50	II.	Hind	1851	—
50*a*	II.	Gould	1871	—
51	II.	Schönfeld	1863	1 B_1. 2 M. 22 P. 16 Sk.
52	II.	Koch	1782	11 B_1. 2 M. 1 En. 22 Sk. 2 Sn.
52*a*	—	Gould	1871	—
52*b*	II.	Becker	1882	—
52*c*	—	Gould	1872	—
52*d*	—	Gould	1871	—
52*e*	—	Peters	1876	1 Eq. 1 M.
52*f*	—	Gould	1871	3 D. 9 Zr.
53	II.	Pogson	1853	2 B_1. 20 B_2. 5 Eq. 12 K. 4 M. 21 Sk.
54	II.?	Burchell	1827	—
54*a*	—	Thome	1872	—
55	II.	Winnecke	1861	1 B_1. 1 Hn. 2 M. 17 Sk.
56	II.	Chacornac	1856	—
57	II.	Peters	1865	2 M. 5 Sk.
58	II.	Peters	1871	1 Ee. 1 Eq. 2 M.
59	II	Schönfeld	1856	1 Eq. 1 K. 1 M. 13 P. 1 Sk.
60	II.	Boguslawski	1849	12 Sk.
61	II.	Karlinski	1867	3 Eq. 2 Sk.
61*a*	II.	Henry	—	—
62	II.	Hencke	1856	6 B_1. 27 B_2. 22 Sk.
63	II.	Harding	1809	1 Eq. 10 G.
63*a*	IV.	Gould	1871	—
64	II.	Pogson	1853	22 B_2. 12 K. 8 Sk.
65	II.	Harding	1831	1 Ee. 16 Sk.
66	II.?	Schönfeld	1866	—
67	II.	Goldschmidt	1857	8 P. 3 Sk.
68	II.	Maraldi	1704	9 Sk.
69	II.	Hind	1852	1 Eq. 1 K. 1 Sk.
69*a*	II.	Palisa	1880	1 Eq. 8 P.
69*b*	—	Gould	1871	—
70	I.?	Baxendell	1860	3 M. 22 Sk.
71	II.	At Bonn	1860	3 B_1. 24 B_2. 5 Ee. 20 Hn. 9 P. 10 Sk.
72	II.	Hencke	1858	5 B_1. 29 Ee. 11 P. 36 Sk.
73	II.	At Bonn	1858	7 B_1. 1 Eq. 35 Sk.
73*a*	—	Schmidt	1867	1 G. 10 Zr.
73*b*	II.	Baxendell	1880	11 B_1. 2 Eq.
74	V.	Schmidt	1859	14 Zr.
74*a*	II.	Palisa	1878	1 Eq.
74*b*	IV.?	Gould	1871	—
75	V.	Winnecke	1869	15 Hn.
76	II.	Borelly	1872	1 Eq. 5 P. 5 Sk.
77	II.	Harding	1828	10 Ee. 11 Hn. 2 P. 4 Sk.

TABLE I. — *Continued.*

No.	H.P.	Name.	R. A. 1875.	Dec. 1875.	Max.	Min.	Per.
			h. m. s.	° ′	m.	m.	d.
78	2553	S Coronæ	15 16 18	+31 49.1	6.1 — 7.8	11.9 — 12 5	361.0
78*a*	—	Libræ	34 46	—20 46.5	9	<14	—
79	2639	R Coronæ	43 25	+28 32 5	5.8	13.0	Irr.
80	2647	R Serpentis	44 56	+15 30.8	5.6 — 7.6	<11	357.6
80*a*	—	V Coronæ	45 4	+39 57.0	7.7	12	360.0
81	—	R Libræ	46 32	—15 51.7	9.2 — 10.0	<13	723
82	2678	T Coronæ	54 16	+26 16.5	2.0	9.5	—
83	—	R Herculis	16 0 37	+18 42.5	8.0 — 9.0	<13	319.0
83*a*	—	W Scorpii	4 28	—19 48.6	10	<13	224 3
84	—	T Scorpii	9 36	—22 39.9	7	<10	—
85	—	R Scorpii	10 12	—22 38.2	9 ? — 10.5	<12.5	223
86	—	S Scorpii	10 13	—22 35.2	9.1 — 10.5	<12 5	176.9
86*a*	—	Ophiuchi	14 40	— 7 24.0	9.0	<13.5	326
87	—	U Scorpii	15 16	—17 35.3	9 ?	<12	—
87*a*	—	Ophiuchi	19 46	—12 8.5	7.5	10.5	365
88	—	U Herculis	20 16	+19 10.8	6.6 — 7.7	11.4 — 11.6	408.3
89	2772	g Herculis	24 32	+42 9.6	5	6 2	Irr.
90	—	T Ophiuchi	26 35	—15 51.8	10	<12.5	—
91	—	S Ophiuchi	27 4	—16 53.7	8.3 — 9.0	<12.5	233.8
91*a*	—	W Herculis	30 48	+37 35.6	8.0	<14.5	289
91*b*	—	Ursæ min.	31 40	+72 31.9	8.6	10.5	180 ?
91*c*	—	R Draconis	32 22	+67 0.7	7.2	13<	245.9
92	2828	S Herculis	46 13	+15 9.2	5.9 — 6.8	11.5 — 12.2	303
93	2839	Ophiuchi	52 30	—12 42.0	5.5	12.5	—
93*a*	—	V Herculis	53 41	+35 15.5	9.0	11.7	—
94	—	R Ophiuchi	17 0 36	—15 55.5	7.6 — 8.1	<12	302.4
95	2879	α Herculis	8 57	+14 32.1	3.1	3.9	Irr.
95*a*	2883	U Ophiuchi	10 12	+ 1 21.0	6.1	6.8	0.9
96	2890	u Herculis	12 42	+33 14.1	4.6	5.4	38.5
97	—	Serpentarii	23 9	—21 22.4	>1	?	—
98	2972	X Sagittarii	39 41	—27 46.8	4	6	7.0
99	3035	W Sagittarii	57 2	—29 35.1	5	6.5	7.6
100	—	T Herculis	18 4 22	+31 0.1	7.2 — 8.3	11.4 — 12.1	165.1
101	—	T Serpentis	22 43	+ 6 13.1	9.1 — 10.0	<12.8	342.3
102	—	V Sagittarii	24 4	—18 20.9	7.5?	9.5 ?	—
103	—	U Sagittarii	24 32	—19 12.7	7.0	8.3	6.7
104	—	T Aquilæ	39 45	+ 8 36.9	8.8	9.5	Irr.
105	3176	R Scuti	40 49	— 5 50 2	4.7 — 5.7	6.0 — 8.5	71.1
105*a*	—	κ Pavonis	44 3	—67 23.2	4.0	5.5	9.1
106	3193	β Lyræ	45 28	+33 13.0	3.4	4.5	12.9
107	3224	R Lyræ	51 32	+43 47.1	4.3	4.6	46.0
108	—	S Coron. Aust.	52 43	—37 7.2	9.8	11 5 ?	6.1
109	—	R Coron. Aust.	53 29	—37 7.2	10.5 — 11.5	<12.5	31
110	—	R Aquilæ	19 0 21	+ 8 2.6	6.4 — 7.4	10.9 — 11.2	345.1
111	—	T Sagittarii	9 1	—17 11.2	7 6 — 8.1	<11	381
112	—	R Sagittarii	9 21	—19 31.5	7.0 — 7.2	<12	270.0
113	—	S Sagittarii	12 7	—19 15.1	9.7 — 10.4	<12.7	230
114	3395	R Cygni	33 28	+49 55.1	5.9 — 8.0	13	425.3
115	—	11 Vulpeculæ	42 26	+27 0.5	3	?	—
116	—	S Vulpeculæ	43 16	+26 58.7	8.4 — 8.2	9.0 — 9.5	67 5
117	3434	χ Cygni	45 46	+32 36.0	4.0 — 6.0	12.8	406.5
118	3436	η Aquilæ	46 6	+ 0 41.2	3.5	4.7	7.2
119	—	S Cygni	20 2 53	+57 37.6	8.8 — 9.5	<13	322.8
120	—	R Capricorni	4 17	—14 38.2	8.8 — 9.7	<13	347

TABLE I. — *Continued.*

No.	Class.	Discoverer.	Date.	Observations, 1886.
78	II.	Hencke	1860	12 B_1. 1 Eq. 1 G. 12 Hn. 6 K. 11 P. 27 Sk.
78*a*	—	Peters	1878	8 P.
79	II.?	Pigott	1795	1 B_1. 1 En. 2 Eq. 3 G. 13 Ee. 15 P. 23 Sk.
80	II.	Harding	1826	1 Eq. 6 Ee. 9 P.
80*a*	II.	Dunér	1878	20 D. 2 Eq. 7 Ee. 13 P. 26 Sk.
81	II.	Pogson	1858	2 K.
82	I.	Birmingham	1866	17 B. 1 Eq. 8 Hn. 1 K. 3 M. 11 Sk.
83	II.	At Bonn	1855	9 Ee. 1 Eq. 7 Hn. 9 P. 11 Sk.
83*a*	II.	J. Palisa	1877	8 P.
84	I.	Auwers	1860	3 M. 8 P.
85	II.	Chacornac	1853	8 K. 8 P.
86	II.	Chacornac	1854	1 K. 8 P.
86*a*	II.	Schönfeld	1881	2 Eq.
87	I.?	Pogson	1863	—
87*a*	—	Dunér	1881	7 D. 1 Eq.
88	II.	Hencke	1860	5 B_1. 1 Eq. 34 Sk.
89	III.	Baxendell	1857	10 Sk.
90	II.	Pogson	1860	3 Eq.
91	II.	Pogson	1854	3 Eq.
91*a*	—	Dunér	1880	14 D. 13 Ee. 1 Eq. 6 Hn. 11 P.
91*b*	II.	Pickering	1881	5 B_1. 22 Ee. 1 K. 2 P. 69 Sk.
91*c*	II.	Geelmuyden	1876	7 B_1. 26 Sk.
92	II.	At Bonn	1856	7 B_1. 1 Eq. 6 Hn. 11 P.
93	I.	Hind	1848	6 M.
93*a*	II.	Baxendell	1880	8 Ee. 2 Eq. 10 P.
94	II.	Pogson	1853	1 Eq.
95	III.	W. Herschel	1795	14 Zr.
95*a*	V.	Sawyer	1881	—
96	III.	Schmidt	1869?	10 Zr.
97	I.	Fabricius	1604	4 M.
98	IV.	Schmidt	1866	—
99	IV.	Schmidt	1866	—
100	II.	At Bonn	1857	11 B_1. 6 Hn. 3 P. 20 Sk.
101	II.	Baxendell	1860	3 B_1. 5 Ee. 2 Eq. 12 Sk.
102	II.	Quirling	1865	2 Eq.
103	IV.	Schmidt	1866	2 Eq.
104	II.	Winnecke	1860	1 Eq. 1 M.
105	II.	Pigott	1795	5 G. 2 M.
105*a*	IV.	Thome	1872	—
106	IV.	Goodricke	1784	16 G. 19 Zr.
107	II.?	Baxendell	1856	—
108	IV ?	Schmidt	1866	2 Eq.
109	II.?	Schmidt	1866	2 Eq.
110	II.	At Bonn	1856	8 Ee. 2 Eq. 6 G. 39 Sk.
111	II.	Pogson	1863	2 Eq. 4 P. 17 Sk.
112	II.	Pogson	1858	2 Eq. 8 P. 10 Sk.
113	II.	Pogson	1860	2 Eq. 8 P. 9 Sk.
114	II.	Pogson	1852	17 B_1. 4 Hn. 1 K. 15 P. 13 Sk.
115	I.	Anthelm	1670	—
116	II.	Hind	1861	10 B_1. 4 Hn.
117	II.	Kirch	1686	13 B_1. 3 G. 15 P. 6 Sk.
118	IV.	Pigott	1784	3 G. 9 Zr.
119	II.	At Bonn	1860	4 B_1. 2 Eq. 8 K. 19 P. 20 Sk.
120	II.	Hind	1848	2 Eq. 4 P.

TABLE I. — *Continued.*

No.	H.P.	Name.	R. A. 1875.	Dec. 1875.	Max.	Min.	Per.
			h. m. s	° ′	m.	m.	d.
121	—	S Aquilæ	20 5 52	+15 14.9	8.9 — 9.9	10.7 — 11.8	147.2
122	—	R Sagittæ	8 22	+16 21.0	8.5 — 8.7	9.8 — 10.4	70.4
123	—	R Delphini	8 53	+ 8 42.7	7.6 — 8.5	12.8	284.0
124	3547	P Cygni	13 11	+37 38.7	3 — 5	<6	—
125	—	U Cygni	15 44	+47 30.1	7.8 ?	9.8 ?	—
126	3557	R Cephei	19 52	+88 45.0	5 ?	10 ?	—
126*a*	—	— Cygni	37 17	+47 41.8	8	12	423
127	—	S Delphini	37 19	+16 38.4	8.4 — 8.6	10.4 — 11.1	275.6
128	—	T Delphini	39 34	+15 56.7	8.2 — 8.9	<13	331.4
129	—	U Capricorni	41 11	—15 14.4	10.2 — 10.8	<13	203.5
130	3654	T Cygni	42 12	+33 55.0	5.5 ?	6 ?	—
131	—	T Aquarii	43 20	— 5 36.5	6.7 — 7.0	12.4 — 12.7	203.2
132	—	R Vulpeculæ	58 49	+23 19.5	7.5 — 8.5	12.5 — 13.0	137.5
132*a*	—	Capricorni	21 0 19	—24 25.5	9½	14	—
132*b*	—	T Cephei	7 52	+67 58.9	5.6	9.5	382
133	—	T Capricorni	15 6	—15 41.4	8.9 — 9.7	<13	269.4
134	—	S Cephei	36 45	+78 3.6	7.4 — 8.5	11.5	485
134*a*	—	Nova Cygni	37 2	+42 18.2			—
135	3845	μ Cephei	39 41	+58 12.4	4 ?	5 ?	Irr.
136	—	T Pegasi	22 2 48	+11 55.7	8.8 — 9.3	<12.5	367.5
137	3981	δ Cephei	24 32	+57 46.6	3.7	4.9	5.4
137*a*	—	Lacertæ	37 43	+41 43.0	8.6	<13.5	315
138	—	S Aquarii	50 25	—21 0.6	7.7 — 9.1	<11.5	279.4
139	4078	β Pegasi	57 45	+27 24.2	2.2	2.7	Irr.
140	—	R Pegasi	23 0 22	+ 9 52.1	6.9 — 7.7	12 ?	382.0
141	—	S Pegasi	14 14	+ 8 14.2	7.6	<12.2	—
142	4193	R Aquarii	37 21	—15 58.7	5.8 — 8.5	11 ?	388.0
143	4234	R Cassiopeiæ	52 4	+50 41.5	4.8 — 6.8	<12	425.9

Remarks.

27. Spectrum of type III. En.

27*a*. Max. 1886, March 7; magn. 9.5. In middle of May, magn. 10.5; October 27, magn. 8.7. Variation irregular, or law very complicated. D.

43. Max. 1886, December 1. K.

63. Max. 1886, April 9. G

64. Max. 1886, August 10; magn. 7.7. Min. 1886, Dec. 2; magn. 13.1. K.

80*a*. Period 357^{d}.03. Magn. at max. 7.2; at min. 10.3. D.

85. Max. 1886, July 28; magn. 9.8. K.

87*a*. Period 309 days (uncertain). Magn. at max. 7.1; at min. 9.6. D.

TABLE I. — *Continued.*

No.	Class.	Discoverer.	Date.	Observations, 1886.
121	II.	Baxendell	1863	29 B_1. 18 Ee. 19 K.
122	II.?	Baxendell	1859	29 B_1. 24 Ee. 3 Hn.
123	II.	Hencke	1859	2 Eq. 2 Hn. 1 P. 34 Sk.
124	I.	Janson	1600	11 Sk. 11 Zr.
125	II.	Knott	1871	16 B_1. 17 Ee. 14 En. 1 Eq. 17 G. 11 K.
126	II.?	Pogson	1856	6 B_2. 16 Ee. 13 Sk. [39 Sk.
126*a*	II.	Birmingham	1881	18 B_1. 5 En. 9 K. 12 P. 37 Sk.
127	II.	Baxendell	1860	15 B_1. 22 Ee. 2 Eq. 10 P. 6 Sk.
128	II.	Baxendell	1863	13 B_1. 10 Ee. 1 Eq. 10 K. 7 P. 12 Sk.
129	II.	Pogson	1858	2 Eq. 5 P.
130	—	Schmidt	1864	—
131	II.	Goldschmidt	1861	2 Eq. 19 P.
132	II.	At Bonn	1858	12 Ee. 1 Eq. 15 K. 1 M. 4 P.
132*a*	—	Peters	1867	5 P.
132*b*	II.?	Ceraski	1878	17 Ee. 2 Eq. 21 K. 3 M. 52 Sk.
133	II.	Hind	1854	2 Eq. 4 P.
134	II.	Hencke	1858	20 Ee. 3 M. 56 Sk.
134*a*	I.	Schmidt	1876	4 M.
135	III.?	Hind	1848	70 G. 3 M. 31 Sk. 28 Zr.
136	II.	Hind	1863	3 M. 15 P.
137	IV.	Goodricke	1784	11 G. 28 Zr.
137*a*	—	Deichmüller	1883	2 Eq. 5 M. 9 P.
138	II.	Argelander	1853	2 Eq. 4 M. 7 P. 6 Sk.
139	III.	Schmidt	1847	14 M.
140	II.	Hind	1848	1 Ee. 1 Eq. 12 M.
141	II.	Marth	1864?	1 Eq. 11 M.
142	II.	Harding	1811	2 Eq. 3 M. 6 P. 15 Sk.
143	II.	Pogson	1853	6 B_1. 3 D. 7 Ee. 7 G. 10 M. 1 P. 31 Sk.

91*a*. Period $281^d.2$. Magn. at max. 8.0; at min. 11.5. D.

91*b*. 1886, December 1, magn. 9.1; ruddy. K.

121. Max. 1886, October 4?, magn. 9.2. Min. 1886, July 7?, magn. 11.0; also December 2; magn. 10.75.

125. Max. 1886, September 19. G. — Max. 1886, August 17 ±; magn. 7.9. K.

132. Min. 1886, July 5; magn. 13.6. K.

132*b*. Max. 1886, March 26 ±; magn. 6.2. Min. 1886, October 16; magn. 9.6. K.

135. No well marked max. in 1886. Near min. 1886, August 22 to 28, September 16 to 30, October 1 and 16, and November 1. G.

TABLE II.—ADDITIONAL STARS.

No.	R. A. 1875.	Dec. 1875.	Observations, 1886.	Rem.
	h. m.	° ′		
—	0 35.9	+40 37	4 En. 1 P.	
9	37.8	+ 6 37	14 P.	
—	1 4.4	+ 8 53	1 G.	
21	6.2	+80 53	4 M.	
23	7.7	+34 57	3 M.	
25	15.0	+ 9 2	6 P.	
—	16.4	+ 6 45	3 M.	
31	19.5	— 4 37	5 M.	
37	25.7	— 7 22	4 M.	
—	28.2	+11 55	11 G. 2 M.	A.
43	33.5	—29 40	4 M.	
45	39.1	+ 7 56	5 M.	
47	47.8	+ 8 10	2 B. 1 G. 5 M.	
—	48.9	+22 58	6 G.	
57	2 0.8	— 9 11	4 M.	
59	10.4	+58 22	4 M.	
61	15.2	+54 47	1 G. 4 M.	
63	19.0	+ 9 56	4 M.	
—	19.7	+81 5	6 G.	B.
—	31.9	+49 1	1 G.	
—	52.5	+80 59	7 G.	C.
73	3 37.6	+ 9 0	3 P.	
77	41.8	— 0 17	2 M.	
83	46.9	— 0 52	1 M.	
87	57.8	+23 38	3 P.	
93	4 14.6	+19 31	25 Sk.	
117	5 1 4	— 8 49	4 M.	
123	5.3	+ 0 22	2 M.	
—	5.6	—12 0	1 G.	
—	5.9	—12 2	5 En. 5 Sn.	
129	6.6	— 0 15	3 M.	
135	23.0	— 0 9	4 M.	
—	23.4	— 1 12	5 G.	D.
139	23.8	— 1 8	3 P.	
143	27.4	+21 52	3 M. 4 P.	
145	28.3	+10 10	9 G.	E.
151	29.3	— 3 20	2 M.	
—	35.8	+ 2 18	2 G.	
—	42.5	+37 16	1 G.	
—	48.4	+20 9	14 B_1. 16 B_2. 19 D. 26 Ee. 36 G. 5 Hn. 21 M. 39 P. 22 Sn.	F.
—	56.1	+42 59	8 G.	G.
159	6 10.6	+ 5 8	4 M.	
161	11.2	— 1 32	4 M.	
165	27.9	—27 51	1 G. 1 M.	H.
—	45.1	—27 11	1 G.	I.
—	7 22.0	—11 18	3 G.	J.
177	23.0	— 1 39	3 M.	
179	24.8	— 9 31	3 M.	
—	35.0	+ 3 55	2 G.	
199	55.0	—12 32	3 M.	
205	8 2.4	+19 48	5 P.	
—	48.3	+17 42	1 G.	
—	9 1.2	+15 13	3 M.	

TABLE II. — *Continued.*

No.	R. A. 1875.	Dec. 1875.	Observations, 1886.	Rem.
	h. m.	° ′		
—	9 14.6	+14 52	3 M.	
229	20.1	+14 50	3 M.	
—	21.4	— 8 7	1 G.	
243	30.4	+15 48	3 M.	
—	40.8	+ 7 13	6 G. 3 M.	K.
—	53.2	+ 3 59	2 G.	
—	10 5.3	+13 13	4 M.	
—	11.6	+13 21	3 M.	
—	31.4	—12 30	6 En.	
293	45.5	—20 35	4 M.	
294	47.2	+14 23	11 P.	
303	11 10.0	— 3 22	3 M.	
—	54.5	—18 58	19 Sn.	
311	12 7.5	+ 0 17	4 M.	
315	10.7	+80 49	5 M.	
—	14.1	—21 31	18 Sn.	
—	18.8	+ 1 28	1 G. 2 Sn.	
—	18.8	—10 55	1 G.	
327	24.0	+ 5 6	1 M.	
331	26.9	—19 56	1 M.	
—	32.0	+ 2 33	1 G.	
337	32.7	+17 12	4 M.	
345	37.0	—13 10	1 G.	
—	40.7	+ 6 38	3 G.	
348	44.6	+82 23	1 M.	
361	13 24.0	— 8 55	1 M.	
375	47.8	+11 41	3 M.	
381	56.4	— 1 47	3 M.	
383	58.2	— 8 36	11 P.	
—	14 8.1	+13 33	17 Sn.	
—	8.7	+10 41	18 Sn.	
—	13.3	+ 0 58	2 G.	
—	15.5	— 1 25	8 B.	
—	18.3	+16 53	8 B_1.	
—	24.7	+39 25	22 D. 4 G.	L.
—	29.5	+37 11	1 G.	
407	42.7	+ 6 29	14 Hn.	
—	43.6	+ 8 30	2 G.	
413	45.4	—11 49	3 M.	
429	15 10.7	— 3 43	3 M.	
—	13.0	+27 18	9 G.	M.
437	29.0	—20 45	9 P.	
—	30.7	+15 31	4 G.	
441	30.8	—15 46	5 P.	
—	33.5	+36 39	3 G.	
447	36.5	—10 31	3 M.	
451	39.2	—20 44	8 P.	
—	49.4	—17 57	3 M.	
459	16 1.2	—21 11	9 P.	
—	3.3	+ 1 9	1 G.	
465	9.1	+11 50	3 M.	
471	22.4	—19 14	3 P.	
479	31.7	+72 32	4 M.	
483	44.7	— 5 58	3 M.	

TABLE II. — *Continued.*

No.	R. A. 1875.	Dec. 1875.	Observations, 1886.	Rem.
	h. m.	° ′		
491	16 53.2	— 4 2	3 M.	
503	17 37.6	—18 36	3 M.	
509	18 2.7	+28 44	11 B. 27 Hn.	
517	28.0	+36 54	3 M.	
—	32.4	+ 8 43	17 En. 3 M.	
521	43.1	— 8 3	3 M.	
—	50.0	+ 4 3	9 Zr.	
529	52.8	+14 12	2 M.	
—	55.3	+31 58	1 Sn.	
535	57.7	— 5 52	3 M.	
—	19 3.4	+23 59	8 G.	N.
—	7.6	+ 5 18	3 G.	
—	9 3	+56 39	7 G.	O.
—	16.1	+17 25	12 En.	
545	23.9	+ 2 39	2 G.	
549	27.1	+17 28	11 Ee. 3 M.	
—	28.4	—25 0	2 Sn.	
—	32.3	—23 42	8 Sn.	
—	32.6	—23 43	8 Sn.	
555	35.3	+12 53	11 Ee. 3 G. 3 M.	P.
—	50.3	+16 17	55 En. 71 G. 3 M. 39 Sn.	Q.
—	55.0	—28 3	3 Sn.	
—	20 5.7	+47 29	19 En. 7 M.	
—	6.1	+44 39	- Hn.	
567	7.8	—22 21	9 P.	
—	10.7	+44 39	- Hn.	
—	12 4	+39 59	15 G.	R.
—	21.7	—18 13	3 M.	
—	24.3	+39 34	15 En. 3 M.	S.
—	39.7	+17 38	35 G.	T.
—	41.6	+ 5 32	2 G.	
—	46.1	+27 47	49 G. 55 Sn.	U.
—	49.2	+27 35	5 Sn.	
—	21 0.2	—16 15	3 M.	
601	1.4	—21 51	8 P.	
—	9.6	+59 36	3 G.	V.
—	22.4	+55 58	- Hn	
—	31.3	+44 49	77 G.	W.
—	36.8	+34 56	6 G.	X.
—	40.0	— 2 47	3 En. 1 G.	
613	45.2	+ 6 4	2 M.	
615	56.5	—17 14	7 P.	
—	22 31.7	+57 47	18 M.	
—	47.5	+ 1 11	1 G.	
631	23 1.7	— 7 1	3 M.	
635	14 8	+55 26	4 M.	
645	33.3	— 1 26	3 M.	
—	39.9	+ 2 47	6 En. 4 G.	Y.
651	51.5	— 9 39	12 P.	
653	54.9	+59 40	9 M.	
—	58.1	—11 12	2 G.	

Remarks.

A. Only slight variation observed. G.
B. Below magn. 8 in all observations. G.
C. Variation of about half a magnitude observed. G.
D. Only slight variation. G.
E. T *Orionis.* Only small variation observed. G.
F. U *Orionis.* Discovered by Gore in 1885.
G. Variation of three or four steps observed. G.
H. Invisible with binocular, March 5, 1886. G.
I. Estimated magn. 7.4, March 5, 1886. G.
J. No variation detected. G.
K. Below magn. 8 in March and April, 1886. It lies south following DM. +7° 2181. G.
L. V *Bootis.* Period 266^{d}.5. Magn. at max. 6.7; at min. 9.5. D.
M. Certainly variable to some extent. G.
N. Only slight variation observed. G.
O. Slight variation. G.
P. Magn. 7.5 or 7.6 September 3, 6, and 22. G.
Q. S (10) *Sagittæ.* Maxima, 1886, July 19; August 30; September 7, 15; October 1, 10, 27; November 4, 30; December 16, 25. Minima, June 12; August 8; October 7, 24; November 1, 10; December 4. G.
R. No variation observed. G.
S. Practically invariable. Spectrum of type IV. En.
T. Min. August 29 ±. G.
U. T *Vulpeculæ.* Near max. 1886, September 14, 27; October 10; November 10, 15; December 16, 24. Min. 1886, August 29. G.
V. Estimated magn. 7.3, 1886, September 2 and 8. G.
W. W *Cygni.* Max. 1886, May 19, August 28 ±. Min. 1886, Feb. 14 ±. G.
X. Only slight variation observed. G.
Y. Nearly equal to κ on September 15. En. Near max. September 15. G.

Professor Safarik has made 12 observations of the minor planet Vesta, in continuation of his interesting researches upon the light of asteroids, mentioned at the close of the report made last year.

XXI.

CONTRIBUTIONS TO AMERICAN BOTANY.

By Sereno Watson.

Communicated April 13, 1887.

1. *List of Plants collected by Dr. Edward Palmer in the State of Jalisco, Mexico, in* 1886.

Dr. Palmer's collection of the last year was made at certain limited localities within the State of Jalisco, Mexico, at no great distance from Guadalajara, the capital. These localities as indicated by him were as follows: — Guadalajara, in N. lat. 20° 41′, about 270 miles north of west of the city of Mexico, at an altitude of 5,167 feet; Rio Blanco, the principal station, at which fully one half of the species were collected, ten miles west by north of Guadalajara, a valley with a range of low mountains on the east called the Cerro de San Estevan, which are broken by narrow valleys and deep cañons, and covered with a scattered growth of pines and scrub oaks; "Barranca," a cañon nine miles east by north from Guadalajara, with towering rocky sides, where is the hacienda of Señor Portillo, and a ferry over the Rio Grande known as the Paso de Ybarra; Tequila, twenty miles northwest of Guadalajara, in a deep volcanic depression surrounded by more or less barren mountains; and Chapala, thirty miles southeast of Guadalajara, on the lake of the same name, among low barren mountains.

Of these points Tequila proves to have been the richest comparatively in novelties, after which come Barranca and Rio Blanco, Guadalajara being the poorest though still yielding nearly ten per cent of new species. The whole collection includes about 675 species.

The dates of the collections are, at Guadalajara, July to October; at Rio Blanco, June to October; at Barranca, June; at Tequila, August 25th to September 5th; and at Chapala, October 27th to November 3d.

The determinations of the *Gamopetalæ*, with the descriptions and notes upon them, are as given by Dr. Gray. The *Juncaceæ* and *Cyperaceæ* have been named by Dr. N. L. Britton, and the *Gramineæ* by Dr. George Vasey. Professor D. C. Eaton has elaborated the *Filices*.

Clematis grossa, Benth. Guadalajara; October. (690.)

Ranunculus Hookeri, Schlecht., var. (?) with more abundant hairs throughout, spreading upon the pedicels instead of appressed, and with more numerous carpels in oblong-ovate heads. Rio Blanco; June. (24.) — From the failure to identify Schlechtendal's species with any earlier named one of the Mexican flora his name is still retained.

Delphinium ——? A low species, the specimen insufficient for identification. Rio Blanco; October. (672.)

Anona (Cherimoliæ) longiflora. A low shrub (3 feet high), the young branches, pedicels, and petioles densely soft-pubescent: leaves ovate-elliptical, rounded at base, acutish or obtuse, 2 to 4 inches long, softly pubescent (densely so when young), becoming nearly glabrous above: flowers pubescent, densely so at base; sepals deltoid-ovate, 2½ lines long; outer petals linear-oblong, nearly 2 inches long, convex at base, glabrous within, "whitish cream-color with a black base," the inner wanting or minute: fruit globose-ovate, 1½ inches long, covered with flat reticulations: seeds smooth and shining. Rio Blanco, in ravines; June. (55.) — Bourgeau's 2482, from Orizaba, in herb. Gray, appears to be the same as to the sterile leafy branch, but the flowering stem is *A. Cherimolia*, and probably belongs with his n. 2481, from the same locality.

Nymphæa gracilis, Zucc.? Rootstock very short and premorse: flowers white, 3 inches broad, "moderately fragrant": stamens with a short and rather thick appendage, a line long or less: capsule 8 lines in diameter. Guadalajara; July. (283.) — The appendages of the stamens are shorter and less acuminate than they are described by Zuccarini, and than are those of 5 Bourgeau, so named.

Casearea corymbosa, HBK. This species is referred to *C. nitida*, Jacq., by Grisebach and by Eichler. Palmer's plant is a shrub 3 to 5 feet high, the leaves not shining, narrowly oblong, and obtuse at both ends; sepals 6 or 7; stamens 6; fruit oblong-ovate, 6 to 8 lines long, dark orange; seed with adherent crimson aril, and the outer portion of the albumen abundantly resiniferous. Barranca. (103, 104.)

POLYGALA AMERICANA, Mill. Two feet high or less; outer petals purple, the inner cream-color. Barranca, in exposed places. (417.)

POLYGALA LEPTOCAULIS, Torr. & Gray. Very like *P. gracilis*, the seed slightly larger, more pubescent, and with a minute unappendaged aril. Guadalajara, among grass in a swampy bottom; September. (447.)

POLYGALA BERLANDIERI, Watson. Guadalajara, in sandy bottoms; September. (470.)

POLYGALA GLOCHIDATA, HBK. Flowers lilac. Rio Blanco, among grass in the shade of rocks; September. (546.)

POLYGALA LONGICAULIS, HBK., var. (?) with less laciniate crests, each half of the double crest consisting of two unequal segments, the anterior oblong-ovate, the posterior narrow and acuminate; otherwise the specimens differ little from the Brazilian species. Rio Blanco, on exposed hills, among grass; September. (553.) — The hairs upon the seeds of this and the allied species are erect, instead of retrorse as described, becoming divergent when wet, especially those near the summit.

POLYGALA CONFERTA, Bennett. Rio Blanco, in low places; September. (571.) — The specimens seem to accord with the description of this species. They are also the same as 3249 Bourgeau, in herb. Gray, which is referred by Mr. Bennett to *P. cruciata*.

POLYGALA GRACILLIMA. Annual, very slender, glabrous, the stems (3 to 5 inches high) simple or branched above: leaves scattered, very small, the basal petiolate, ovate or oblong-ovate, a line long, the upper linear, acute, glandular-punctate, 1 to 1½ lines long: flowers very small, white, nearly sessile in dense slender spikes half an inch long or less; bracts lanceolate, acuminate, glanduliferous: outer sepals minute; wings unguiculate, oblong-ovate, exceeding the keel; crests comparatively broad, entire: capsule broadly elliptical, substipitate: seeds oblong (immature). Rio Blanco, among grass; October. (756.)

POLYGALA ——? Flowering specimens of an herbaceous perennial allied to *P. Americana*, erect, 1½ feet high, simple or branched above, pubescent throughout with spreading hairs: leaves linear-lanceolate, very acute, cuneate at base, prominently nerved and veined beneath, ciliate, very shortly petiolate, 6 to 15 lines long: flowers in a loose elongated raceme, on slender pedicels (2 lines long), creamy white, 2½ to 3 lines long: ovary orbicular, densely pubescent. Rio Blanco, under bushes; September. (735.)

ARENARIA ALSINOIDES, Willd., a rough form. Rio Blanco, in shaded spots, among rocks; June. (42.)

Drymaria villosa, Schlecht. Rio Blanco, in wet shaded places; August. (748.)

Malva parviflora, Linn. Rio Blanco, in moist bottoms; June. (48.)

Malvastrum spicatum, Gray. Chapala, on hillsides among underbrush. (707.)

Anoda incarnata, HBK. The specimens agree nearly with the description of this species, which is known only from plants cultivated in gardens at the city of Mexico. The leaves, however, are not canescent beneath, and the carpels are ten instead of twelve. Rio Blanco, in a cañon; September. (604.)

Sida diffusa, HBK. Guadalajara, hillsides and dry bottoms; August. (257.)

Modiola multifida, Moench. Rio Blanco; June. (56.)

Kosteletzkya paniculata, Benth. Five feet high, very hirsute, the panicled flowers with purplish accrescent calyx and large yellow corolla. Rio Blanco, in a deep ravine among bushes; August. (328.)

Gossypium Barbadense, Linn. A cultivated plant, four years old, the seed from the "Laguna desert cotton country" in Coahuila. Rio Blanco; June. (10.)

Bombax Palmeri. A tree, 15 to 20 feet high, with a short stout trunk (2 or 3 feet in diameter), very scaly bark, and widely spreading branches: leaves 3–5-foliolate, densely tomentose beneath (as also the petiole, 2 or 3 lines long), loosely stellate-pubescent above, the leaflets on very short densely pubescent petiolules, obovate or oblong-obovate, 5 to 7 inches long by 3 to 5 wide, the two lower (of five) smaller and suborbicular: pedicel stout, an inch long: calyx truncate, glabrous, ½ inch long: capsule glabrous, narrowly oblong, 5 or 6 inches long by 1½ thick: seeds oblong-ovate, 3 lines long. Barranca, on mountain sides. (134.)

Physodium corymbosum, Presl. A large widely spreading shrub. Barranca, at the base of the mountains. (86.)

Melochia hirsuta, Cav., var. serrata, Schauer; fide Gray. Guadalajara, among grass; July. (287.)

Melochia pyramidata, Linn. Tequila, among bananas. (371.)

Guazuma tomentosa, HBK. A shrub, 10 feet high. Barranca. (91.)

Ayenia glabra. A shrub, 3 or 4 feet high, glabrous throughout or very slightly puberulent: leaves ovate-lanceolate, long-acuminate, cordate at base, coarsely serrate, 3 or 4 inches long on petioles a half-inch to an inch long: peduncles fascicled, 2–4-flowered, with the slender pedicels equalling or shorter than the petioles: flowers dark brown, the narrowly acuminate sepals 1 to 1½ lines long; blade of petals suborbicular, deeply 2-lobed: stamineal tube broadly funnelform; anthers 3-celled: fruit unknown. Tequila, in a deep barranca. (382.)

Buettneria Carthaginensis, Jacq. Tequila. (385.)

Triumfetta semitriloba, Linn. Chapala, on hill-tops, among underbrush. (711.)

Triumfetta brevipes. A shrub, 3 to 5 feet high, densely stellate-pubescent throughout, the upper surface of the leaves more loosely so: leaves on petioles 1 to 3 lines long, oblong-lanceolate, acuminate, subcordate at base, unequally serrate, 2 to 4 inches long by 1 to 1½ wide: flowers nearly sessile in short axillary corymbs; sepals densely tomentose, shortly apiculate, 4 or 5 lines long; petals a little shorter, yellow, obovate, the claw somewhat pubescent and strongly ciliate with stellately branched hairs: stamens 25 or 30: style exserted: fruit 3 or 4 lines long, pubescent, hooked-echinate, 2-celled, 2-seeded. Rio Blanco, in shaded ravines; August. (323.)

Triumfetta Palmeri. A shrub, 4 feet high, somewhat hirsutely pubescent throughout with stellate hairs: leaves nearly sessile, lanceolate, shortly acuminate or acute, rounded at base, serrate, greener and hispid with short scattered hairs above, 2 or 3 inches long by ½ to 1 wide: flowers shortly pedicelled in short axillary corymbs; sepals densely tomentose, apiculate, 4 to 6 lines long; petals yellow, a third shorter, linear, acuminate, pubescent within at the base: stamens about 15; anthers purple: style equalling the stamens: fruit 2½ lines long, tomentose, strongly echinate, 2-celled, 2-seeded. Rio Blanco; August. (330.)

Triumfetta insignis. Stout, branching from a woody (?) base, 3 feet high, coarsely stellate-pubescent throughout and somewhat hirsute: leaves rhombic-ovate, on stout petioles (3 to 5 lines long), acutish, slightly cordate at base, serrate with short blunt teeth, 4 to 6 inches long by 3 or 4 broad, those of the subpaniculate inflorescence oblong: floral bracts linear, acuminate, 3 to 6 lines long; pedicels very short: calyx densely pubescent, an inch long, appendaged at the apex; petals orange, equalling the calyx, oblanceolate, pubescent at base: stamens numerous, as long as the petals, subtended by a thin disk above the conspicuous glands: style exserted: fruit dehiscing loculicidally, 5-valved (valves 3 lines long), 5-seeded, densely covered with straight rigidly plumose and spinulosely apiculate setæ 4 or 5 lines long. Rio Blanco; July. (152.) — A remarkable species on account of the size of its flowers (opening at night) and the ready dehiscence of the fruit. Schumann (in Fl. Bras. fasc. 98. 132) agrees with Grisebach in the statement that the fruit is indehiscent in all the species of the genus. In the East Indian *T. pilosa*, however, it dehisces as readily as in the present species.

PROCKIA CRUCIS, Linn. Barranca. (109.)

BUNCHOSIA PALMERI. A small tree, 12 feet high, with dense green foliage, the branches glabrous: leaves oblong-obovate, acute, cuneate at base, without glands, glabrous above, loosely pubescent beneath, 4 inches long by 2 wide, on petioles 3 or 4 lines long: racemes 2 or 3 in the axils (distinct or on a very short peduncle) and in a short terminal panicle, 2 or 3 inches long, somewhat appressed-pubescent; pedicels (1 or 2 lines long) jointed at the base: calyx 10-glandular, the broad obtuse lobes glabrous; petals yellow, concave, 3 or 4 lines long: anthers unappendaged: ovary glabrous, 2-celled, the styles coherent but with the carpels easily separable: fruit unknown. Tequila. (389.)

BUNCHOSIA (MALACMÆA) GUADALAJARENSIS. A small tree, 9 to 12 feet high, usually with several stems, the bark gray and scaly, the young branches subtomentose: leaves ovate-elliptical to ovate- or oblong-lanceolate, shortly acuminate, acute at base, the petiole 3 to 5 lines long, tomentose beneath, nearly glabrous above, without glands, 4 or 5 inches long by 2 or 3 broad; petioles 3 to 5 lines long; stipules very small and caducous: raceme short-pedunculate, contracted and much shorter than the leaf; pedicels 6 lines long, bibracteate in the middle: calyx 10-glandular, pubescent; petals yellow, 4 lines long: stamens and ovary glabrous; styles 3, wholly distinct: drupe red, depressed-globose, 3-pyrenous, 6 to 8 lines in diameter. Guadalajara; September. (490.) — Known as "Manzanito." The wood is white and close-grained. The fruit resembles that of the hawthorn, and yields an indifferent wine.

GALPHIMIA HUMBOLDTIANA, Bartl. (*G. glandulosa*, HBK. Nov. Gen. & Spec. 5. 172, t. 452, and var. *oblongifolia*, DC. Prodr. 1. 582, and Moç. & Sesse, Calq. Dess. t. 139, with shorter and obtuser leaves.) An upright shrub, 3 or 4 feet high, the short racemes wholly in flower. Rio Blanco, in a deep cañon; October. (684.) — This was also collected by Dr. Lay on Beechey's voyage.

GALPHIMIA GLAUCA, Cav. A more slender shrub, 4 feet high, with more slender and attenuated racemes, the flowering more prolonged. Barranca. (97.) — The same as 865 Coulter and 13 Hartweg. Much that has been referred to this species appears to belong to *G. gracilis*, Bartl., with lanceolate acute leaves and acute sepals, — including 2149 Berlandier, 130 Ervendberg, 1065 Palmer (1878–79), and the *G. glauca* of the West Indies.

Heteropterys Portillana. A tall climber, the branches dotted with numerous white tubercles and sparingly appressed-pubescent or glabrate: leaves thin, oblong-ovate or -lanceolate, shortly and acutely acuminate, mostly rounded at base, 2 to 4 inches long and 1 to $1\frac{3}{4}$ broad, slightly appressed-hairy, becoming glabrous on both sides, biglandular on the lowest lateral veins; petioles (3 lines long) pubescent, often with 2 stipitate glands; panicles axillary and terminal, exceeding the leaves, the dense appressed pubescence ferruginous; pedicels mostly umbellate, 4 to 6 lines long, jointed below the middle: calyx rather thinly pubescent or glabrate; petals salmon-color without, scarlet within, oblong, sagittate or truncate at base with a broad claw, $2\frac{1}{2}$ lines long: ovary densely pubescent. Barranca. (112.)

Tetrapterys Mexicana, Hook. & Arn. Barranca. (101.)

Gaudichaudia mollis, Benth. In respect to flowers and foliage identical with Hartweg's specimen. The fruit now collected is peculiar in this genus, the marginal wings of the 2 or usually 3 carpels being scarcely at all developed. Rio Blanco; July. (153.)

Oxalis latifolia, HBK. Flowers rose-color. Rio Blanco, in rich wet bottoms; June. (67.)

Oxalis decaphylla, HBK. Flowers rose-color. Rio Blanco; June. (68.)

Oxalis Hernandezii, DC. Flowers white. Rio Blanco, in similar localities; June. (69.)

Bursera bipinnata, Engler. A compact tree, 12 feet high. (99.)

Bursera Kerberi, Engler. A tree with few branches, about 16 feet high and a foot in diameter, covered with loose bronzy papyraceous bark. Tequila. (423.)

Bursera Palmeri. Near *B. cuneata*, a shrub, 5 feet high, with numerous stiff lateral branches: leaves densely tomentose beneath, more loosely pubescent above; leaflets 3 to 5 pairs, lanceolate, acute or shortly acuminate, rounded (the terminal cuneate) at base, acutely serrate, somewhat rugose above, the lateral veins prominent beneath, 1 or 2 inches long, the winged internodes of the rhachis 1 to 4 lines broad: peduncles very short or none; pedicels 2 to 4 lines long: fruit ovate, acute, glabrous, 4 lines long; nutlet orange, often tipped with black when mature. Rio Blanco, in deep cañons; September. (609.) — Differing from *B. cuneata* especially in its acuter leaflets, rounded at base and more pubescent above, and in the much more contracted inflorescence.

Ximenia parviflora, Benth. Fruit globose, yellow, 4 lines long, edible. Guadalajara, on hillsides; July. (272.)

Wimmeria concolor, Cham. & Schlecht.? A small shrub, in flower, probably belonging to this species, with leaves smaller and obtuser than in *W. discolor*, and more lanceolate than in *W. confusa*. Tequila, on hillsides. (368.)

Karwinskia Humboldtiana, Zucc. A small shrub, called "Margarita." A decoction of the leaves and stems is used as a febrifuge. Guadalajara; September. (438.)

Rhamnus (Frangula) Palmeri. A shrub, 4 feet high, tomentose throughout: leaves broadly elliptical to ovate, rounded or emarginate above, subcordate at base, finely serrate, densely tomentose especially beneath, greener above, $2\frac{1}{2}$ to 4 inches long by $1\frac{1}{2}$ to $2\frac{1}{2}$ broad, on very short petioles: flowers umbellate on a very short axillary peduncle, the pedicels 3 or 4 lines long: calyx tomentose, $1\frac{1}{2}$ lines long, the acute lobes twice longer than the petals: fruit depressed-obovate, 3-lobed, 3 lines long. Tequila, on hillsides. (363.)

Vitis Caribæa, DC. "Intensely white"; fruit ripening early in July. Rio Blanco; June. (25.)

Serjania ——? Flowering specimens only, with the habit of *S. racemosa*, but the pedicels longer (1 to $1\frac{1}{2}$ lines) and the flowers rather smaller. Tequila, in a deep barranca. (381.)

Spondias Mexicana. A widely spreading tree, with short crooked limbs and body, the young branches and petioles puberulent: rhachis of the leaves 3 to 6 inches long; leaflets 4 to 6 pairs, distinctly petiolulate, sparingly pubescent both sides or glabrate above, becoming somewhat coriaceous and shining, entire or obscurely crenulate toward the apex, oblong-ovate or -obovate, acute, cuneate at base, the terminal oblanceolate and sharply acuminate, $1\frac{1}{2}$ to 2 inches long by an inch wide or less: fruit pale greenish yellow, 15 lines long, the endocarp very foraminate. Tequila. (408.) — Differing much from *S. lutea* in the foliage. The plum-like fruits, called "Ciruela," are eaten and made into sweetmeats, and the juice is put into "attole."

Trifolium goniocarpum, Lojacono. (*T. amabile*, var. *longifoliolum*, Hemsl.) Flowers white. Guadalajara, in rich moist bottoms; July. (236.) — This may stand as a good species. Lojacono's *T. amabile*, however, as to the Californian specimen which he describes, is *T. Breweri*, while his *T. Hemsleyi* is typical *T. amabile*, HBK., or nearly so. His *T. Potosanum* is *T. Mexicanum*, Hemsl.

Dalea lasiostachys, Benth. A slender form with very small narrow leaflets. Rio Blanco, on moist hillsides; June. (26.)

Dalea pectinata, Kunth. Usually with a single stem, 4 or 5 feet high; flowers purple with a white centre. Rio Blanco; July. (145.)

Dalea Lemmoni, Parry. Guadalajara and Rio Blanco, trailing among grass and bushes in low sandy places; September. (477, 497, 573.)

Dalea nigra, Mart. & Gal. A form with the rather broad spikes sessile or very nearly so; flowers blue. Rio Blanco, in grassy bottoms; September. (550.)

Dalea sericea, Lag. Rio Blanco, in deep ravines; October. (666.)

Dalea gracillima. Trailing, glabrous throughout, the very slender stems several feet in length with numerous almost filiform branchlets: leaves delicate, on the stems 9 lines long, on the branchlets 6 lines or less; leaflets 6 to 10 pairs, narrowly oblanceolate, ½ to 2 lines long: racemes terminal on filiform peduncles, 2–5-flowered, the pedicels approximate: calyx turbinate-campanulate, about a line long, the broad lobes acute; petals purple, 3 lines long. Guadalajara; September. (461.) — Near *D. diffusa*.

Dalea revoluta. Annual (?), glabrous throughout; stems herbaceous, erect (1 to 2 feet high), slender, simple or sparingly branched above: leaves 1 to 1½ inches long; leaflets about 10 pairs, linear-revolute, densely punctate, 2 or 3 lines long: spikes on elongated peduncles, dense, cylindrical, an inch long; bracts ovate and long-acuminate, puberulent, ciliate at base, densely punctate, persistent: calyx cylindric-campanulate, thin and pale, finely pubescent, the lanceolate acuminate teeth as long as the tube; corolla white, or the banner purplish. Guadalajara, among bushes; September. (496.) — With the habit of *D. pectinata*.

Indigofera sphærocarpa, Gray. Rio Blanco, among underbrush on the side of a cañon; September. (596.)

Indigofera Palmeri. A shrub, 4 to 6 feet high, the branchlets subtomentose: leaflets 2 to 5 pairs, oblong-elliptical, obtuse or acute, usually acute at base, 5 to 8 lines long, appressed-pubescent, the pubescence upon the rhachis, as upon the peduncles and pods, somewhat loose and spreading: racemes sessile, shorter than the leaves: calyx-lobes acute, about equalling the short tube: pods straight or slightly curved, scattered, about an inch long. Tequila. (392.)

Brongniartia inconstans. A glabrous shrub, about 3 feet high:

stipules large (an inch long or less), foliaceous, semicordate or obliquely reniform-ovate, distinct or often connate by the upper margins; leaves 1–5-foliolate, or the single leaflet sometimes connate with the stipules; leaflets ovate or broadly elliptical, abruptly acute, rounded or subcordate at base, coriaceous, prominently reticulated and concolorous both sides, $\frac{3}{4}$ to $1\frac{1}{2}$ inches long; stipules small, rigid and spinose: peduncles axillary, 1 or 2 inches long, 1–4-flowered; bracts foliaceous: corolla 9 to 12 lines long, twice longer than the calyx, yellowish brown turning to purple in drying: pods 2 inches long by 9 lines wide, 2–4-seeded. Tequila, in rich bottoms among the hills. (411.)

Tephrosia talpa. Stout, erect, densely covered throughout with a soft gray subtomentose pubescence, more straight and silky upon the leaves, especially beneath: stipules elongated (5 or 6 lines long), linear; leaflets 6 to 8 pairs, oblong or the lower elliptical, rounded at both ends, 1 to $1\frac{1}{2}$ inches long by 4 to 8 lines broad: racemes terminal, 4 to 6 inches long; flowers nearly sessile, somewhat fascicled: calyx-lobes broad, acuminate, exceeding the tube; corolla rose-color, 8 lines long: pods spreading, very densely tomentose, $1\frac{1}{2}$ to 2 inches long by 3 lines broad, about 6-seeded. Rio Blanco, on hillsides under pines, growing in clumps; July. (161.)

Tephrosia toxicaria, Pers. (*T. Schiedeana*, Schlecht.) Guadalajara and Rio Blanco, among underbrush on the sides of deep cañons; August. (220 in part, 322.)

Tephrosia affinis, Watson. About 2 feet high: leaflets 4 to 8 pairs: pods 2 inches long by 3 lines broad. Rio Blanco, in deep cañons; August and September. (220 in part, 594.)

Tephrosia leptostachya, DC. Chapala, on grassy hillsides. (704.)

Diphysa suberosa. A low shrub, 3 or 4 feet high, with very thick corky bark, the branchlets occasionally spinose, glabrous throughout: leaflets 3 to 5 pairs, somewhat scattered on the slender rhachis, oblong-obovate, acute or obtuse or sometimes retuse, often apiculate, acute or acutish at base, 6 lines long by 2 to 4 broad: peduncles slender, 3 to 5 lines long, 2–3-flowered; pedicels very slender, 6 to 12 lines long; bracts ovate, short-acuminate: calyx 4 lines and yellow corolla 6 lines long: pods nearly sessile, $1\frac{1}{2}$ to 3 inches long. Barranca. (123.) — "Palo santo." The powder of the bark is used as a remedy for catarrh. Distinguished from described species by its entire smoothness, acuter leaflets, elongated pedicels, and nearly sessile pods.

Sesbania longifolia, DC.? A tree, 15 to 18 feet high and 6 inches in diameter, with smooth bark, resembling the mesquite but more compact: leaflets 8 to 12 pairs, narrowly oblong-lanceolate, petiolulate, acute at both ends and apiculate, 6 to 15 lines long: racemes 10–20-flowered, the pedicels ½ to 1 inch long; flowers bright yellow: pods linear, strongly torulose, 4–8-seeded, 2 to 4 inches long not including the elongated stipe (1 to 1½ inches long), 3 lines broad. Guadalajara; July. (237.) — Referred with doubt to Ortega's imperfectly described species.

NISSOLIA CONFERTIFLORA, Watson. Pod pubescent, on a short stipe about twice the length of the calyx, 1–3-jointed, the upper joint dilated into a broad wing 4 to 6 lines long. Tequila. (388.)

BRYA (?) AMORPHOIDES. A small unarmed shrub, 3 feet high, with numerous leafy branchlets, pubescent with short spreading hairs: leaflets 20 to 35 pairs, crowded upon a rhachis 1½ to 3 inches long, sessile, oblong, obtuse at both ends with a long excurrent costa, 3 lines long by 1 broad, subappressed-pubescent beneath, glabrate above: flowers very shortly pedicellate and somewhat fascicled in narrow axillary and terminal panicles shorter than the leaves: calyx glabrous, 6 lines long, subtended by a pair of small ovate bractlets, the teeth nearly equal, obtuse, ciliate; corolla brown, 2 lines long, the very broad banner reflexed and glabrous, the claws of the spatulate wings and strongly curved keel prominently auricled: stamineal tube cleft above and readily separating into two equal phalanges; filaments equal: ovary pubescent, 2-ovuled, stipitate, with slight indication of constriction in the middle. Tequila, in deep barranca. (414.) — The absence of fruit renders the determination of this plant somewhat doubtful. The habit is that of *Brya ebenus* (with a general resemblance to that of *Amorpha microphylla*), and the characters of the flowers are those of the genus.

ÆSCHYNOMENE AMERICANA, Linn. Gaudalajara, in grassy bottoms; September. (491.)

ZORNIA DIPHYLLA, Pers. Same locality. (495.)

DESMODIUM STROBILACEUM, Schlecht. A procumbent or prostrate form, with short ascending branches: pods 5–8-jointed, 8 to 10 lines long by 1½ broad, densely covered with short hooked hairs, as also the pedicels and axis of the raceme. Rio Blanco; August. (312.)

DESMODIUM ORBICULARE, Schlecht. A diffuse shrub, 4 or 5 feet high. Tequila. (398.)

DESMODIUM (CHALARIUM) JALISCANUM. Suffrutescent (?), 3 feet high, slender, appressed-pubescent throughout, without hooked hairs: leaflets lanceolate, acute, rounded at base, 1½ to 2 inches long by 8 or 10 lines wide, the rhachis an inch long: racemes in axillary and terminal panicles somewhat exceeding the leaves; bracts 2 lines long; pedicels half as long: calyx villous, deeply and acutely lobed; corolla $2\frac{1}{2}$ lines long: pods glabrous, stipitate, subsecund, erect, 4–6-jointed, 6 to 9 lines long, the joints nearly orbicular with a narrow junction. Rio Blanco, on the high sides of a cañon; October. (667.)

Clitoria (Neurocarpum) triflora. Stems herbaceous, erect, a foot high, somewhat subappressed-pubescent: leaflets 3, narrowly oblong, obtuse, rounded or subcordate at base, glabrous or slightly pubescent on the veins beneath, $1\frac{1}{2}$ to 4 inches long by 4 to 6 lines wide, the petiole and rhachis $1\frac{1}{2}$ to 3 inches long; stipules and stipels narrowly subulate, 2 to 5 lines long: peduncles $\frac{1}{2}$ to 1 inch long, 1–5-flowered; bracts like the stipules: calyx $\frac{1}{2}$ inch long, the upper teeth united to the middle; corolla an inch long, dark purple and lilac, the banner finely pubescent: pods glabrous, the valves ecostate, $1\frac{1}{2}$ inches long: seeds globose to oblong-cylindric. Rio Blanco; July. (159.) — Much resembling *C. Guianensis*, but with elongated petioles and rhachis, the leaflets broader at base, the smaller flowers usually more numerous, and the pod not at all costate.

Clitoria (?) sericea. With the habit of the last, a span high, in rounded clumps, hoary pubescent: leaves simple, narrowly oblong, 2 or 3 inches long by 6 to 9 lines wide, acute, obtuse at base, densely white-silky beneath, greener and less silky above; petiole about a line long; stipules and bracts narrowly subulate, 3 to 5 lines long: raceme terminal, pedunculate, few-flowered; pedicels 3 or 4 lines long: calyx-tube shorter than the narrow long-acuminate distinct teeth: pod pubescent, $1\frac{1}{4}$ to 2 inches long by 3 lines broad, the valves ecostate: seeds flattened. Rio Blanco, on grassy hillsides; August. (321.) — Flowers unknown; calyx-tube (remaining at the base of the pods) short for the genus.

Cologania pulchella, HBK. Tequila, borders of ravines. (379.)

Erythrina coralloides, DC. Two feet high. Rio Blanco, in shaded places among rocks; June. (17.)

Canavalia villosa, Benth. Rio Blanco, a tall climber among trees and bushes; July. (162.)

Phaseolus heterophyllus, Willd. Guadalajara, in sandy grassy bottoms, often rooting at the joints; September. (614.)

Pachyrrhizus angulatus, Rich. Rio Blanco; August. (318.) — "Jicama."

Rhynchosia phaseoloides, DC. Racemes much elongated. Guadalajara, among low bushes; August. (269.)

RHYNCHOSIA MINIMA, DC. Flowers yellow. Tequila, climbing over low bushes. (390.)

RHYNCHOSIA NIGROPUNCTATA. Stems twining, pubescent with short spreading hairs: lateral leaflets obliquely and the terminal triangularly ovate, very acutely short-acuminate, minutely pubescent and ciliate, the veins beneath somewhat hairy, finely punctate beneath with black dots, the larger leaflets 2 inches long by 1½ wide: racemes exceeding the leaves (3 to 5 inches), few-flowered: calyx-lobes narrow, long-acuminate; petals yellow within, brownish outside, 5 lines long: pods nearly an inch long, sparsely hairy: seeds dark-colored. Tequila, on the borders of ravines. (402.) — Also 35 Ervendberg, from near Tantoyuca, doubtfully referred to *R. Caribæa*, which the species much resembles in habit.

ERIOSEMA PULCHELLUM, G. Don. Rio Blanco, on hillsides; June. (60.)

ERIOSEMA PALMERI. Stems clustered, erect, rather stout, 6 inches high, simple or branched, leafy, hirsute and glandular-pubescent: lower leaves simple, round-ovate or broadly elliptical, the rest trifoliolate, the leaflets elliptical to broad-oblong, obtuse or acute, rounded or subcordate at base, loosely rufous-hirsute and ciliate, nearly concolorous both sides, reticulated beneath and sprinkled with yellow resinous dots; stipules distinct, 3 lines long, exceeding the petioles: peduncles shorter than the leaves; flowers rather numerous in a short dense raceme: corolla 6 or 7 lines long, exceeding the long-acuminate hirsute calyx-teeth: pods hirsute, about 6 lines long by 3 wide. Guadalajara, in rich, grassy bottoms; August. (264.) — Near *E. simplicifolium*, differing chiefly in its distinct stipules, 3-foliolate leaves, and more numerous flowers.

ERIOSEMA GRANDIFLORUM, Seem. A bushy plant, 3 or 4 feet high. Guadalajara, on hillsides; September. (464.)

ERIOSEMA DIFFUSUM, G. Don. Of compact habit, 2 feet high. Rio Blanco, at base of hills; October. (654.)

CASSIA ABSUS, Linn. Stamens only 3, in the flowers examined. Tequila, roadsides in the shade. (412.)

CASSIA ROTUNDIFOLIA, Pers. Tequila, along roads, in meadows and ravines. (395.)

CASSIA NICTITANS, Linn. Guadalajara, by roadsides and in ravines; September. (460.)

CASSIA (CHAMÆCRISTA) PALMERI. Stems procumbent, from a branching woody caudex, a span long, pubescent and somewhat hirsute: leaflets 6 to 8 pairs, narrowly oblong, nearly glabrous, very shortly ciliate, concolorous and strongly veined on both sides, 2 to 2½ lines long; petiole and rhachis hirsute; stipules narrowly lanceolate, ciliate; gland stipitate: pedicels exceeding the leaves (an inch long, or more); flowers large (6 to 8 lines): pods pubescent, an inch long by 2 lines broad. Rio Blanco; June. (29.) — Near *C. Wrightii.*

MIMOSA FASCICULATA, Benth. Compact shrub, very thorny, 4 feet high; pods 1½ inches long by 2 lines wide, long-acuminate, pubescent and densely covered with rigid setæ and occasional curved spines. Guadalajara; September. (449.)

MIMOSA ALBIDA, Humb. & Bonpl. Very bushy, 5 feet high, with numerous heads of pink flowers. Guadalajara, in fences and on embankments; October. (693.)

MIMOSA FLORIBUNDA, Willd. Bushy, 2 feet high. Chapala, in ravines. (705.)

MIMOSA (MODESTÆ) TEQUILANA. Annual, erect and branching, a foot high, hirsute throughout with spreading hairs, and armed with infrastipular and scattered recurved prickles: petioles slender, 1 to 1½ inches long; pinnæ a single pair; leaflets 1 or 2 pairs, oblong-obovate, about an inch long, glabrous above, strigose beneath and long-ciliate: peduncles axillary, 3 or 4 lines long; bracts linear, striate, hirsute and ciliate, equalling the flowers: calyx wanting; corolla scarious, 4-toothed. Tequila, in ravines among grass and weeds. (378.)

SCHRANKIA ACULEATA, Willd. Rio Blanco, on gravelly hills among bushes; July. (164.)

SCHRANKIA DISTACHYA, DC. A large shrubby plant with long pendent branches; agreeing well with Moç. & Sesse's figure. Guadalajara; July. (267.)

LEUCÆNA ESCULENTA, Benth. A tree, 20 feet high and a foot in diameter, with white flowers; cultivated under the name of "guage." Guadalajara; October. (634.)

LEUCÆNA MACROPHYLLA, Benth.? A shrub, in flower only; pinnæ and acute leaflets two pairs each; flowers white. Rio Blanco, on grassy hillsides among underbrush; August. (320.) — Also, probably, as a small tree, 10 feet high, the narrower acuminate leaflets in 3 pairs in the upper pinnæ. Tequila. (354.)

ACACIA FILICINA, Willd. Rio Blanco; October. (603, 647.)

ACACIA TEQUILANA. Glabrous throughout, unarmed, the stem 6 feet high, with few lateral branches: leaves large (rhachis 6 to 8 inches long), without glands; pinnæ 5 pairs; leaflets 5 to 10 pairs, thick, orbicular to very broadly elliptical (5 to 7 lines long), obtuse or retuse, subcordate and but slightly oblique at base, reticulately veined:

heads in a large loose panicle, few-flowered, the flowers shortly pedicellate, glabrous: petals greenish, a line long: stamens very numerous, white. Tequila, on the sides of ravines. (539.) — Stipules wanting in the specimens; fruit unknown. A peculiar species, belonging to the *A. Rœmeriana* or perhaps to the *A. grandistipula* group.

Lysiloma Acapulcensis, Benth. A shrub, 12 feet high, with white fragrant flowers. Rio Blanco, in deep ravines; June. (31.)

Lysiloma (?), sp. A small tree, 2 or 3 inches in diameter, with slender branches, puberulent: stipules narrowly semicordate to lanceolate, acuminate, pubescent, 2 or 3 lines long; pinnæ 8 to 10 pairs; leaflets about 40 pairs, linear-oblong, 1 to 2½ lines long, glabrous: peduncles slender, an inch long or more; heads small: calyx puberulent; corolla cleft to the middle: stamens white. Barranca. (88). — As the fruit is wanting the species may belong to *Pithecolobium*, near *P. parvifolium*. Except in its finer and closer pubescence it much resembles a species collected by Mr. Pringle in the Rincon Mountains, Arizona, doubtfully referred to *Pithecolobium*.

Calliandra humilis, Benth. Rather unusually hirsute; stamens white, becoming pinkish. Rio Blanco, on hill-tops under pines. (174.)

Calliandra tetragona, Benth. A large shrub with many stems, about 12 feet high, with an abundance of white bloom; cultivated, and known as "Potosina." Guadalajara; October. (635.)

Calliandra (Racemosæ) nitida. A small shrub, 2 feet high, subtomentose-pubescent: stipules short, lanceolate; pinnæ 7 to 10 pairs; leaflets 15 to 25 pairs, loosely tomentose both sides, somewhat ferruginous beneath, dark gray and becoming glabrous and shining above, oblong, subfalcate, obtuse or obtusish, a line long: peduncles fascicled in the axils of short bracts, an inch long or more, few-flowered: calyx very short; corolla 3 or 4 lines long, narrowly tubular, cleft nearly to the middle, appressed-pubescent, reddish: stamens red, an inch long. Rio Blanco, in deep ravines; July. (178.)

Calliandra (Racemosæ) Palmeri. Suffruticose, with rarely more than a single stout flowering stem 3 to 5 feet high, hoary with a rather dense spreading pubescence: leaves large; pinnæ about 15 pairs; leaflets 40 to 60 pairs, narrowly oblong, subfalcate, acute, about 3 lines long, loosely pubescent beneath, glabrous dark gray and shining above: heads few-flowered, racemose on very short peduncles (a line, becoming 2 or 3 lines long in fruit): calyx and corolla thick and firm, white-sericeous, the campanulate repandly toothed calyx 3 or 4 lines long; corolla cleft nearly to the base, 7 to 9 lines long: stamens nearly 3 inches long: pods densely subtomentose-pubescent, 4 or 5 inches long (with the elongated stipe) by 5 lines broad. Guadalajara, on hillsides among underbrush; August. (279.) — Closely allied to *C. Houstoni* and *C. grandiflora*, differing from both in the white pubescence, more numerous pinnæ and leaflets, and larger flowers, and from *C. grandiflora* also in its shorter peduncles and acute subfalcate leaflets.

PITHECOLOBIUM DULCE, Benth. Barranca. (102.) — In fruit only, but apparently differing from the ordinary form only in the mostly crimson (instead of white) pulpy aril, which is an article of food and trade under the name of "guamuchel."

PRUNUS SALICIFOLIA, HBK. (*P. Capuli*, Cav. *P. Capollin*, DC.) A tree, 25 to 30 feet high and a foot in diameter, fruiting abundantly, the fruit nearly as large as the Black Tartarian cherry, and ripe at Guadalajara early in May: leaves lanceolate or oblong-lanceolate, acuminate or often long-acuminate, frequently more or less attenuate at base, the blade often 3 or 4 inches long. Rio Blanco; June. (22.) — There appears to be no distinction between the Mexican and Peruvian species, for which the name here adopted is the oldest, unless an earlier citation than Sprengel can be found for *P. Capuli*, Cav. The form (var. ACUTIFOLIA) from more northern Mexico and extending into Arizona, New Mexico, and western Texas, having smaller leaves (rarely 3 inches long), which are acute or rarely subacuminate, may be distinct.

CRATÆGUS PUBESCENS, Steud. Twenty feet high; fruit yellow with black dots, and often a red blush on one side. Guadalajara; September. (465.) — "Tejocote"; a jelly is made from the fruit, resembling that from the quince.

SEDUM GUADALAJARANA. Perennial, with numerous slender somewhat woody branching stems from a branching tuberiferous rootstock, a foot high or less, puberulent: leaves numerous, very narrowly linear, clasping, glabrous, glaucous, 3 lines long or less: flowers in simple or rarely forked short terminal racemes, shortly pedicellate: sepals linear-subulate, acuminate; petals white, linear, acuminate, $1\frac{1}{2}$ lines long; scales rounded, thickened and glandular above: stamens and pistils equalling the sepals. Rio Blanco, on mountain sides upon shaded rocks; July. (170.) — Near *S. Bourgæi*, Hemsl.

SEDUM CHAPALENSE. Stems stout, about a span high, paniculately branched above, glabrous: leaves pubescent, those on sterile shoots rosulate, obovate or ovate, acutish, 6 lines long: flowers sessile upon the simple or once-forked circinate branches: calyx-lobes slightly pubescent, oblong-ovate, acutish; petals white, oblong-ovate, acute, 2 lines long: stamens 10; scales obsolete: pistils equalling the petals. Chapala. (726.)

Myrtus Arayan, HBK.? A cultivated tree, 25 feet high, bearing a greenish yellow fruit (half an inch in diameter, containing a bony 2-celled and 2-seeded nutlet) upon pedicels 6 to 9 lines long. Tequila. (407.) — Cultivated for ornament and for its fruit, under the same popular name that is given to the original species in Peru, and agreeing closely with it (as described) in its characters, excepting the color of the fruit. It is noted by Palmer as reported to be a native of the Pacific coast, and is probably therefore the *M. communis* of Hook. & Arn. in the Botany of Beechey's voyage. In foliage it closely resembles *Eugenia Schiedeana*, Schlecht. (*Myrtus? Capuli*, Cham. & Schlecht.), which however has very short pedicels. The fruit has a rich spicy subacid flavor, and is said by Palmer to be sold in a dried state throughout Mexico and used for making a refreshing drink.

Cuphea Llavea, Llav. & Lex. Rio Blanco, in ravines. (62.)

Cuphea Tolucana, Peyr.? Guadalajara, in moist shady places among grass; August. (299.) — The same as Bourgeau's 611 and 2829, referred by Koehne to *C. Wrightii*, from which species it differs in its much more scabrous pubescence, its larger flowers (calyx 4 or 5 lines long) on shorter pedicels ($\frac{1}{2}$ to rarely $1\frac{1}{2}$ lines long), and 1 to 3 of its longer stamens slightly exceeding the calyx-tube. Like the nearly allied *C. Palmeri* (which has a peculiar pubescence without purplish hairs upon the stem and petioles, and the leaves only slightly scabrous) it has a broad ascending disk instead of the peculiar compressed helicoid one of *C. Wrightii*. The only specimens of *C. Wrightii* in herb. Gray are from New Mexico, Arizona, and Sonora.

Cuphea Palmeri, Watson. Tequila, in ravines among grass. (380.)

Cuphea procumbens, Cav. Guadalajara, in rich grassy bottoms; September. (428.)

Cuphea (Melvilla) viridostoma. Apparently perennial; stems herbaceous, decumbent, a foot long, glandular-pubescent: leaves sessile or nearly so, narrowly lanceolate to linear, $1\frac{1}{2}$ inches long or less, scabrous, sparingly hirsute above and ciliate; upper floral leaves bract-like: peduncles mostly solitary in the axils, simple or forked, 3 to 10 lines long: calyx narrow (9 to 12 lines long) with a long spur, scarlet with more or less of yellow and a greenish throat, the green teeth nearly equal and hispid; tube pubescent within: stamens 11, slightly pubescent, 4 to 6 a little exserted: ovary pubescent; style glabrous; disk thick and pyramidal, projecting into the spur: seeds about eight. Rio Blanco, among grass; July. (148, but by error 145 in Cambridge set.)

CUPHEA (MELVILLA) RETROSCABRA. Perennial; stems herbaceous, erect, a foot high or more, retrorsely scabrous as also the pedicels and under side of the leaves, with some spreading glandular hairs: leaves sessile (the middle ternate), lowermost ovate, the rest lanceolate, rounded or subcordate at base, acute, an inch long or less, finely scabrous above, the floral bract like: peduncles simple or forked, axillary, 2 to 10 lines long: calyx purplish, subglandular-pubescent, 9 lines long, glabrous within; spur $1\frac{1}{2}$ lines long; teeth subequal, naked: petals 6, unequal, pinkish white: stamens 11, glabrous, three slightly exserted: disk large, thick, somewhat 2-lobed above, reflexed: ovary and style glabrous: seeds 7. Rio Blanco, in moist grassy spots; July. (175.) — Near *C. heterophylla*, Benth.

LOPEZIA PUMILA, Bonpl.? Tall specimens which may be referable to this species, similar to 640 Schaffner. Guadalajara, in wet land formerly a garden; September. (487.)

GRONOVIA SCANDENS, Linn. Tequila. (393.)

MENTZELIA HISPIDA, Willd. Rio Blanco, in rocky barranca; September. (600.)

TURNERA PALMERI. Perennial, very villous throughout; stems several, herbaceous, 2 to 4 inches high: leaves oblong-ovate, obtuse, cuneate at base, eglandular, coarsely serrate, mostly crowded at the top of the stem: pedicels solitary in the axils, wholly adnate to the petiole; bractlets linear, 4 lines long: calyx 7 lines long, the lobes twice longer than the tube; petals bright orange, obovate, 6 or 8 lines long, glabrous: stamens on the base of the calyx, slightly exceeding the tube: capsule villous, 3 lines long: seeds subreniform, finely pitted, a line long, the unilateral aril reaching to the apex. Rio Blanco; June. (37.) — Much resembling *T. acaulis*, Griseb., in habit.

TURNERA ULMIFOLIA, Linn., var. SURINAMENSIS, Urban. Flowers lilac. Tequila, on grassy hillsides. (403.)

SECHIOPSIS TRIQUETRA, Naud. Chapala. (728.)

SICYOS DEPPEI, Don. The form named by Naudin *S. Bourgeanus*. Guadalajara, covering bushes, fences, and old buildings; October. (631.)

APODANTHERA ASPERA, Cogn. Closely resembling *A. undulata*, but the pubescence less dense and more strigose, and the peduncle of the male inflorescence apparently only 2-flowered. The peduncle of the pistillate flower is 3 inches long or more, much exceeding that of *A. undulata*, and of *A. aspera* as described. Fruit oblong, $2\frac{1}{2}$ inches long by 1½ broad, somewhat ribbed longitudinally and verrucose. Guadalajara, in grassy bottoms; August. (281.)

MELOTHRIA SCABRA, Naud.? Prostrate and rooting at the joints, fruit an inch long, "resembling little watermelons." Rio Blanco; July. (179.) — The fruit ("sandellitas") is pickled and also eaten raw.

CUCURBITA FICIFOLIA, Bouché. (*C. melanosperma*, Al. Br.) The specimens correspond closely with the description of this species (hitherto known only as cultivated in European gardens and conjectured to be from the East Indies) excepting in the shape of the leaves, which have the lobes (often short) and sinuses acute instead of rounded. Guadalajara, cultivated; September. (620.) — The fruit, called "cidra cayote" or "chila cayote," is about a foot in length, resembling a watermelon in appearance, with a hard outer shell, the contents white and fibrous, and seeds black. It keeps for many months without decay. A preserve is made of the inner fibrous portion. The name "cayote," given to this and other cucurbitaceous species in Mexico, may be the equivalent of the "chayote" of Cervantes and the "chayotli" of Hernandez.

BEGONIA (KNESEBECKIA) BICOLOR. Monœcious, glabrous throughout, the herbaceous simple stem (1½ to 2 feet high) from a very short rootstock covered with fibrous roots: leaves thick, only the lower with a very short petiole, the lowermost reniform, obscurely lobed and with blunt teeth, the rest semiorbicular in outline (2 to 6 inches broad), palmately and unequally 5-lobed, irregularly and acutely toothed, all green above and whitish beneath, mostly bulbiferous in the axils; stipules semicordate, sparingly toothed: flowers dark rose-color, in a terminal bracteate raceme; pedicels bibracteolate in the middle, the lower 1½ inches long: perianth-segments of male flowers 4, the outer oblong-obovate, 6 lines long, the inner suborbicular, 8 lines long; of pistillate flowers 5, 6 lines long: capsule 6 or 8 lines long, the rather narrow truncate wings nearly equal. Guadalajara; August. (282.) — "Callules" or "agritos." The succulent stems are eaten by the natives to assuage thirst, and a decoction is used as a carminative.

BEGONIA (KNESEBECKIA) PORTILLANA. Monœcious. stem erect from a very short rootstock, a foot high, glabrous, purplish: leaves thin, equalling or the upper exceeding the petioles, subreniform-cordate in outline with a closed sinus (the smaller uppermost not cordate), 3 inches long by 4 broad, with few scattered hairs above and on the veins beneath and villous at the summit of the petiole, laciniately many-lobed and doubly toothed, the teeth setosely tipped; stipules small, setosely toothed: cymes bracteate, few-flowered, glabrous; flowers white, on slender bibracteolate pedicels, the perianth-segments (4 in the male, 5 in the female flowers) 3 or 4 lines long: capsule 4 or 5 lines long, with one broad truncate wing. Barranca, among shady rocks. (143.)

Eryngium Carlinæ, Delar. Guadalajara, very common; September. (458.) — "Yerba del zapo"; used as an abortifacient.

Eryngium cymosum, Delar.? Often 5 feet high, the radical leaves 2 feet long by 4 or 5 lines broad, the rigid spinose teeth (4 to 9 lines long) usually with a slender tooth at the base: involucral bracts (8 to 12) very rigid and spinose, 1 or 2 inches long, entire; floral bract strongly 3-nerved, two of the nerves marginal, equalling the white flowers. Rio Blanco, in grassy ravines; October. (681.)

Arracacia decumbens, Benth. & Hook. Rio Blanco, in moist bottoms; June. (51.) — An examination of the material at hand has brought me unwillingly to the conclusion adopted by Bentham & Hooker, that this genus should be considered a polymorphous one, embracing *Pentacrypta*, *Velæa*, and *Deweya*. *Eulophus*, moreover, appears to be separated only by its smaller obsoletely ribbed fruit with numerous irregular vittæ. I perceive no combination of characters — blunt or attenuate fruit, prominent or depressed stylophore, entire or bifid or divided carpophore, more or less thickened ribs, vittæ solitary or several in the intervals, a terete and involute seed or sulcate between the ribs and deeply channelled on the face, together with differences of habit — by which the species can be very satisfactorily grouped into two or three genera. The more recent species of *Deweya* (*D. Kelloggii*, *D. Hartwegi*, and *D. vestita*) should therefore be referred, with the original *D. arguta*, to *Arracacia*.

Eulophus peucedanoides, Benth. & Hook. Rio Blanco, on moist hillsides; June. (40.)

Apium leptophyllum, F. Muell. Barranca, in moist shade. (94.)

Cicuta (?) linearifolia. Stem stout, fistulous, 10 feet high, glabrous: leaves large, sessile upon a dilated sheathing base, twice ternate and quinate (uppermost simply ternate), the divisions linear, 3 to 6 inches long, simple or hastately lobed at base, acute and acutely serrate: peduncles somewhat in threes; involucres and involucels of several linear long-acuminate bracts; rays about 20, an inch long or more; pedicels short: flowers "brick-red": immature fruit oblong-ovate, with thickened ribs, depressed stylopodium, and somewhat dorsally compressed seed. Guadalajara, on a hilltop among shrubs; August. (275.) — Fruit too immature for more than a conjecture as to the genus, but the plant is undescribed among Mexican umbellates.

BOUVARDIA LINEARIS, HBK.* Rio Blanco, on hillsides among grass; September. (544.)

BOUVARDIA VERSICOLOR, Ker, Bot. Reg. t. 245, var. GRACILIFLORA. (*B. triflora*, HBK. Nov. Gen. & Spec. 3. 386, t. 288. *Anotis longiflora*, Benth. Pl. Hartw. 23. *Houstonia triflora*, Gray, Proc. Am. Acad. 4. 313; Hemsl. Biol. Centr.-Am. Bot. 2. 30.) Rio Blanco; July. (154[1].) Tequila, a depauperate form in the crevices of rocks. (369.) Chapala, among underbrush. (708.) — The seeds are finely winged, and it must belong to *Bouvardia*. The only specimen in the Kew herbarium which answers to *B. versicolor*, Bot. Reg. t. 245 (1817), is one cultivated in the Montpellier garden in 1831, in Bentham's herbarium, without fruit. All the numerous other specimens have the slender corolla as figured by Kunth, and of these the calyx-lobes vary in length and pubescence. If all are of one species, as it seems, the name *B. versicolor* is the older and better.

BOUVARDIA SCABRA, Hook. & Arn. Rio Blanco, hillsides and ravines; October. (663.)

HAMELIA VERSICOLOR, Gray, *n. sp.* *H. nodosæ*, Mart. & Gal., fortasse peraffinis, glabra; foliis plerumque ternis cæterum iis *H. chrysanthæ* similibus; cyma corymbiformi laxa, ramis vix spiciformi-scorpioideis; calycis dentibus minimis; corolla semipollicari tubulosa sursum parum ampliata aurantiaca demum sanguinea, dentibus rotundatis staminibusque sæpius 7; antheris inclusis vix apiculatis; baccis globosis rubris 4-locularibus. — Barranca. (125.) A compact shrub, 5 feet high, with numerous orange flowers changing to crimson; berries crimson.

CHIOCOCCA RACEMOSA, Linn. Tequila. (383.)

CRUSEA RUBRA, Cham. & Schlecht.? A long-petioled and rather small-flowered form; same as a cultivated specimen in herb. Kew, figured in "The Botanist, t. 82." Flowers rose-color. Tequila, in the barranca. (416.)

CRUSEA CALOCEPHALA, DC. Prodr. 4. 567, ex char. Like narrow-leaved *C. rubra*, but much smaller-flowered. Flowers rose-color. Guadalajara, in ravines; September. (462.) — The same as 1525 Bourgeau, and in other collections.

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* The determinations and descriptions of the following *Gamopetalæ* are by Dr. ASA GRAY, including results of recent comparisons made by him at the Kew herbarium and at Paris.

SPERMACOCE ——? Rio Blanco, in moist places; June. (32.)

SPERMACOCE (DIPHRAGMUS) ASPERIFOLIA, Mart. & Gal., ex char. (*Diphragmus scaber*, Presl.) Tequila, by roadsides. (397.) — This is certainly Presl's plant, which, like Palmer's, was in fruit only. It is most probably, from the description, *S. asperifolia*, Mart. & Gal., of which only flowering specimens are described, but it should be compared with Galeotti's no. 2626, which is not found at Kew. Probably *Diphragmus* may well be retained as a section. The fruit separates completely into its two carpels, splitting the broad septum in two; each part of it then separates as an oval valve, opening almost the whole ventral face of the carpel, and is for a time hinged at base.

SPERMACOCE HÆNKEANA, Hemsl. (*Borreria*, DC.) Very like *S. podocephala* (*Borreria*, DC.), ex char., but it has four equal and herbaceous calyx-teeth. Rio Blanco, on hills among pines; October. (743.)

MITRACARPUS BREVIFLORUS, Gray. Guadalajara, by roadsides; September. (453.) — Rio Blanco, sides of overhanging rocks; October. (653.)

RICHARDIA SCABRA, Linn. Rio Blanco, in moist places; June. (34.)

GALIUM ——? Rio Blanco, in shady ravines; September. (753.)

VALERIANA APIIFOLIA, Gray, *n. sp.* *V. ceratophyllæ* sat affinis, ut videtur perennis radicibus fibrosis; caule gracili folioso; foliis 3–5-sectis partitisve, segmentis laciniato-paucilobatis vel pinnatifidis, lobis sublinearibus parvis. — Rio Blanco, along shaded water-courses; September. (564.) Fruit not seen. It is the same as 2947 Bourgeau, from Orizaba, and was collected there previously by Sallé and by F. Mueller.

VALERIANA PALMERI, Gray, *n. sp.* Herbacea e radice annua (?) erecta: caule ultra bipedali inferne retrorsum hirsuto superne cum panicula longe nuda laxiflora glaberrimo; foliis inferioribus oblongis basi in petiolum marginatum brevem attenuatis, imis subintegerrimis, sequentibus repando-dentatis vel lyrato-pinnatifidis, superioribus dissitis parvulis sessilibus pinnati- (3–5-) sectis, bractealibus filiformibus vel subulatis minimis. — Rio Blanco, on the river bank; September. (754.)

VERNONIA SERRATULOIDES, HBK. Nov. Gen. & Spec. 4. 26, t. 316. Rio Blanco, on sides of cañons; September. (605.)

VERNONIA FOLIOSA, Schultz Bip. (*Monosis foliosa*, Benth. Pl. Hartw. 133.) Rio Blanco, among rocks; October. (678.)

BOLANOSA COULTERI, Gray, Pl. Wright. 1. 82. Rio Blanco, on rocky hillsides; September. (587.) A very interesting rediscovery.

Bolanos, where Coulter collected scanty specimens, is not very far north of Palmer's station. The paleæ of the receptacle are mostly wanting in the centre of the head.

ELEPHANTOPUS (DISTREPTUS) SPICATUS, Juss. Barranca, in exposed level places. (87.)

PIQUERIA TRINERVIA, Cass. Rio Blanco, in shady ravines; August. (313.) — Used as a febrifuge.

AGERATUM CORYMBOSUM, Zucc. Chapala. (715.) — Also the form answering to *Cœlestina ageratoides*, DC. Guadalajara, on hillsides among underbrush; August. (289, and a white-flowered state, 290.) Also another form, at Tequila, on stony hillsides. (351.)

AGERATUM CONYZOIDES, Linn., var. MEXICANUM, DC. Guadalajara, in wet bottoms; September. (437.)

STEVIA TRIFIDA, Lag. Nov. Gen. & Spec. 27. Barranca, among shaded rocks. (95.) — The name takes precedence of *S. microphylla*, HBK., and *S. multifida*, DC., founded on different states of the species. It appears to be an annual.

STEVIA SUBPUBESCENS, Lag. Gen. & Spec. 28? A shrub, 3 to 6 feet high, white-flowered. Guadalajara; July. (224.) — Also Rio Blanco, on the shaded sides of rocky hills, with a strong Anthoxanthum-like odor; October. (673.) — The specimens, on the whole, accord better with the character and details given by Lagasca than does Hartweg's 137, which must be of a different species. The heads in Palmer's plant are much larger, the pubescence more decided and cinereous, especially of the leaves, which are rather long-petioled and when opposite with abruptly dilated base, answering better to the "folia petiolis connatis longiora."

STEVIA SERRATA, Cav. Same as Hartweg's 136 (*S. canescens*, HBK.?). Rio Blanco, on grassy hillsides; August. (319.)

STEVIA CANESCENS, HBK., var. (?) with short and broad leaves. Probably an extreme form of *S. serrata*. Rio Blanco; August. (309.)

STEVIA LINOIDES, Schultz Bip. in Linnæa, 29. 284. Less pubescent than the var. *grisea* of the Batopilas collection, and quite like Schultz's specimen; but the achenes are all 5-awned. Rio Blanco, on hillsides among oaks and pines; August. (316.) — Also in grassy bottoms; September. (534.)

STEVIA GLANDULOSA, Hook. & Arn. Bot. Beechey, 296. Tequila, on hillsides. (357.)

STEVIA LAXIFLORA, DC. Guadalajara, hillsides and grassy bottoms; September. (456.)

STEVIA RHOMBIFOLIA, HBK. Nov. Gen. & Spec. 4. 143. With awns to the pappus as in the original. Rio Blanco, in grassy bottoms; October. (742.) — Also with awnless or occasionally 1-awned pappus. Guadalajara, in ravines; September. (493.)

Stevia phlebophylla, Gray, *n. sp.* E grege *S. lucidæ*, pariter fruticosa et glutinosa, glabra; foliis maxime coriaceis (plerumque 3-pollicaribus) oblongo-lanceolatis ultra medium argute serratis utrinque acutis brevipetiolatis venis adscendentibus venulisque prominulis reticulatis; capitulis numerosissimis dense glomeratis; involucro (lin. 3 longo) pubescente; corolla fere alba, tubo glanduloso, lobis parvulis extus hirtis; pappo coroniformi denticulato latitudine achenii haud altiore. — Rio Blanco, on shaded stony hillsides, "3 or 4 feet high, bloom pinkish white, and leaves shining and very gummy"; October. (679.) It is desirable to know more certainly what *S. lucida*, Lag., was founded on. The plant we take for it has thinnish leaves, with lax venation, somewhat open cymes, nearly glabrous involucre, and is near *S. glutinosa*, but with shorter-petioled leaves. The foliage of the present species is very like that of *S. venosa*, Gray, of Palmer's Batopilas collection, but still more venose, the involucre pubescent and herbaceous, and the pappus different.

Stevia Eupatoria, Willd., which doubtless includes *S. purpurea*, Pers. Guadalajara, in ravines and by old ditches; October. (692.)

Stevia paniculata, Lag., probably. (*S. hyssopifolia*, Sims, Bot. Mag. t. 1861.) The same as 819 Bourgeau, and perhaps 242 Schaffner. Rio Blanco, in shaded ravines; October. (755.) This is also *S. ovata*, Lag., according to specimens cult. in Hort. Paris in 1835.

Piptothrix pubens, Gray, *n. sp.* *P. Palmeri* (Gray, Proc. Amer. Acad. 21. 383) peraffinis, at pube brevi subcinerea; foliis firmioribus parum crenulatis subtus canescentibus; involucri bracteis latioribus; receptaculo fimbrillato. — Rio Blanco, on hillsides; October. (648.) This form tends to confirm the proposed genus, which really cannot well be merged in either *Fleischmannia* or *Eupatorium*, nor with *Decachæta*, DC., and should stand next to them except for the anther-tips, here evident but short and rounded. I fear too much has been made of this character.

Ageratella microphylla, var. Seemanni. (*Ageratum microphyllum*, Schultz Bip. in Seem. Bot. Herald, 298. *Decachæta Seemanni*, Hemsl. Biol. Centr.-Am. Bot. 2. 78, t. 42.) Capitulis paucioribus subspicatis; foliis plerisque cuneato-ovatis obovatisque inciso-dentatis. — Var. Palmeri, capitulis minoribus plerisque pedicellatis in panicula angusta laxiuscula plurimis; foliis angustioribus, secundariis linearibus subintegerrimis nunc spathulatis parum incisis. — Rio Blanco, among rocks in cañons; September. (537.) Paleæ of the pappus only 5, the awns denticulate. Style-branches those of *Eupatorium*, not short and truncate as figured by Hemsley. Anther-tips obscure, if any. This plant is certainly not a congener of De Candolle's *Decachæta*, nor can it well remain in *Ageratum*. It seems to form a good genus, distinguished from *Ageratum* by its cylindraceous several-flowered involucrum of oblong obtuse bracts imbricated in three or four series, the outer successively shorter, and anthers nearly inappendiculate; from *Decachæta* by its slender minutely 5-toothed corolla and 5-paleaceous, not clavellately 10-setose, pappus.

EUPATORIUM LEPTODICTYON, Gray, *n. sp.* *Eximbricata*, *E. stricto* (Gray, Proc. Amer. Acad. 21. 384) peraffine; foliis plerisque alternis rotundatis crebrioribus crenulatis lucidulis magis reticulatis, rete venularum saltem paginæ superioris subtiliter eximie areolata; capitulis paucioribus; involucro 9-floro 9-phyllo floribus dimidio breviore e bracteis oblongis obtusis. — Rio Blanco; July. (154[2].) Seems to be related to *E. calaminthæfolium*, but probably not frutescent.

EUPATORIUM DASYCARPUM, Gray, *n. sp.* *Subimbricata*, subglabrum; caule suborgyali stricto superne corymboso-paniculato; foliis plerisque alternis angusto-lanceolatis utrinque attenuatis subsessilibus scaberulis hinc inde dentatis (majoribus 4–5-pollicaribus), ramealibus linearibus integerrimis; capitulis laxe paniculatis 18–20-floris semipollicaribus; involucro campanulato e bracteis laxe biseriatim imbricatis rigidulis lineari-lanceolatis sensim acutissimis 2–3-nervatis, exterioribus dimidio brevioribus; corollis albis vel ochroleucis; acheniis undique canescenti-hirsutis; pappi setis rigidulis barbellato-denticulatis. — Rio Blanco, on hillsides; September. (545.) The plant has the aspect, inflorescence, and involucre of a *Kuhnia*, or of some *Brickelliæ*. The achenes are strongly pentangular, yet now and then with a secondary nerve on one or two of the faces. The style-branches are remarkably broad, clavate, and seemingly yellowish.

EUPATORIUM TRINERVIUM, Schultz Bip. in Seem. Bot. Herald, 300. Larger and more floribund than Seemann's plant, less "asperulous," and heads at least 40-flowered. Rio Blanco, on hillsides; September. (563.)

EUPATORIUM COLLINUM, DC. Prodr. 5. 164. Shrubby, 5 or 6 feet high; flowers white tinged with lavender. Rio Blanco, in barranca; September. (607.)

EUPATORIUM INCOMPTUM, DC. Prodr. 5. 173. About 5 feet high, the stems below very stout and striate-angled; lower leaves all alternate, 6 inches long, somewhat rhomboidal, or with short hastiform lobes above the cuneate base: pubescence fine and cinereous or fulvous, not at all villous. Rio Blanco, sides of barranca; September. (608.) — The specimens agree with Liebmann's and Bourgeau's.

EUPATORIUM ADENOSPERMUM, Schultz Bip. in Seem. Bot. Herald, 208, var. PLEIANTHIUM, Gray, Proc. Amer. Acad. 15. 26. Rio Blanco, on hillsides; October. (651.)

EUPATORIUM (HEBECLINIUM) —— ? Rio Blanco, in a deep ravine; October. (665.)

EUPATORIUM PYCNOCEPHALUM, Less. (*E. Schiedeanum*, Schrad.) Rio Blanco, bottom of barranca; October. (683.)

EUPATORIUM PULCHELLUM, HBK. Nov. Gen. & Spec. 4. 119, t. 345. Guadalajara, in ravines; October. (691.) — Rio Blanco, with more slender and open corymb; October. (669.)

EUPATORIUM GUADALUPENSE, Spreng. (*E. paniculatum*, Schrad.) Chapala, on shaded hillsides. (712.) — *E. grandidentatum*, DC., must be a synonym of *E. Pazcuarense*, HBK.

BRICKELLIA RETICULATA, Gray, Pl. Wright. 1. 84; a coarser and broader-leaved plant than *B. oliganthes* and *B. polycephala*. Rio Blanco, in ravines; June. (59.)

BRICKELLIA LANATA, Gray, l. c. Guadalajara, on hillsides; September. (450.)

BRICKELLIA CAVANILLESII, Gray, l. c. Guadalajara; September. (485.)

BRICKELLIA CORYMBOSA, Gray, l. c. Rio Blanco, sides of ravines and cañons; September, October. (601, 758.)

BRICKELLIA CUSPIDATA, Gray, *n. sp.* Species insignis ob cuspidem foliorum *Barroeteæ* instar, cum pappo barbellato *B. brachyphyllæ*: subglabra; caulibus gracilibus 2–3-pedalibus apice laxe corymboso-paniculatis; foliis oppositis chartaceo-membranaceis rotundo-ovatis seu ellipticis (vix pollicaribus) triplinerviis venis venulisque prominulis utrinque reticulatis, basi raro subcordata subsessilibus apice obtuso arista tenui e costa excurrente cuspidatis; capitulis circa 10-floris longiuscule pedunculatis pappoque albo molli eximie barbellato *B. brachyphyllæ;* acheniis albo-sericeis. — Rio Blanco, on exposed hillsides; October. (652.) The achenes are terete and thin-walled; in age the delicate walls break up, liberating the ten equal nerves.

HETEROTHECA LEPTOGLOSSA, DC. Prodr. 5. 317; a form of *H. Lamarckii*, Cass. Guadalajara, in rich bottoms; July. (268.) — In these specimens the rays are disposed to be sterile.

APHANOSTEPHUS HUMILIS, Gray, Pl. Wright. 1. 64. Rio Blanco, in moist bottoms; June. (64.)

KEERLIA MEXICANA, Gray, *n. sp.* Hirsuta; caulibus (pedalibus) e radice perenni assurgentibus subsimplicibus pedunculo monocephalo elongato terminatis inferne foliis sat crebris lingulatis membranaceis obsitis: involucro Bellidiformi lato-campanulato e bracteis pluribus lineari-lanceolatis acuminatis æquilongis; ligulis 20–30 linearibus albis; floribus disci totidem fertilibus; receptaculo planiusculo; acheniis obovatis crassis epapposis (maturis fere lin. 2 longis), faciebus unicostatis et subnervatis. — Rio Blanco, on grassy hillsides; July. (146.) This species is intermediate between *Bellis* and *Keerlia*, but the shape and nervation of the achenes and the flat or barely convex receptacle indicate the latter genus, although the involucre is that of the former.

ASTER SPINOSUS, Benth. Rio Blanco, in a deep barranca; October. (650.)

ERIGERON EXILIS, Gray, *n. sp.* *E. hyssopifolii* ut videtur consors, *E. tenello*, DC., haud dissimilis, forte perennis, striguloso-puberulus; caulibus filiformibus rigidulis ultraspithamæis equaliter foliosis; foliis (majoribus pollicaribus) oblanceolato-linearibus integerrimis acutis basi attenuatis subsessilibus: pedunculis solitariis filiformibus; involucro (lin. 2 longo) glabriusculo; ligulis sat numerosis linearibus (lin. 2 longis) albis; pappo simplici. — Rio Blanco, in shady ravines; June. (63.)

ERIGERON DELPHINIFOLIUS, Willd. Rio Blanco, on grassy hillsides; July. (166.)

ERIGERON SCAPOSUS, DC. Guadalajara, in rich grassy bottoms; July. (229.)

ERIGERON (LÆNNECIA) GNAPHALIOIDES, HBK. Nov. Gen. & Spec. 4. 88, t. 331. Rio Blanco, sides of ditches; September. (561.)

BACCHARIS PTERONIOIDES, DC. Prodr. 5. 410. (*B. ramulosa*, Gray.) Rio Blanco; June. (5, 6.) — Used as fuel in burning bricks and pottery; "Tepopote," as also the next.

BACCHARIS HETEROPHYLLA, HBK. Rio Blanco; June. (7, 8.) — Used like the last.

BACCHARIS THESIOIDES, HBK. Rio Blanco, on hillsides; September and October. (536, 744.)

BACCHARIS MUCRONATA, HBK. Rio Blanco, sides of ravines; October. (737.) — *B. Seemanni* is probably the same as *B. squarrosa*, HBK., which is an herbaceous species of the *Arrhenachne* section, with very imbricated involucre.

GNAPHALIUM LEPTOPHYLLUM, DC. Prodr. 5. 226. Rio Blanco, in moist places; July. (155.)

GNAPHALIUM PURPUREUM, Linn. Guadalajara, on shady banks; July. (219.)

GNAPHALIUM SEMIAMPLEXICAULE, DC. Guadalajara; July. (256.)

LAGASCEA ANGUSTIFOLIA, DC. Prodr. 5. 92. Rio Blanco, on tops of hills; October. (643.)

LAGASCEA SUAVEOLENS, HBK. (*L. latifolia*, *L. helianthifolia* &c.) Rio Blanco, in ravines; October. (664.)

GUARDIOLA MEXICANA, Humb. & Bonpl. Pl. Æquin. 1. 144, t. 41. (*G. atriplicifolia*, Gray, Pl. Wright. 1. 111.) Guadalajara, on hill-sides; July. (214.) — The figure is exaggerated in size.

GUARDIOLA TULOCARPUS, Gray, l. c., var. ANGUSTIFOLIA. Tequila, on sides of ravines. (360.) — With much smaller heads than the last species.

MELAMPODIUM HISPIDUM, HBK. Nov. Gen. & Spec. 4. 273, t. 399. Guadalajara, on hills among shrubbery; July. (260.)

MELAMPODIUM SERICEUM, Lag. Nov. Gen. & Spec. 32, var. LONGIPES. Tequila, base of mountains. (391.) — This is the normal form, with peduncles an inch or two long. The specimens of Menzies (var. *brevipes*), from near Guanajuato, seem to be a depauperate state. *M. lanceolatum*, DC., which appears to be a plant of the western coast of Mexico (Manzanilla, Xantus, an annual), is probably a form of *M. Americanum*, Linn.

MELAMPODIUM OVATIFOLIUM, Reich. (*M. divaricatum*, DC.) Chapala. (759.)

TRAGOCERAS ZINNIOIDES, HBK. Nov. Gen. & Spec. 4. 249, t. 385. (*T. Schiedeanus*, Less. in Linnæa, 9. 269; a mere form.) Guadalajara, on grassy hilltops; July. (262.) — The bifurcation of the ligule is variable, and appears to increase with age.

ZINNIA ANGUSTIFOLIA, HBK. (*Z. linearis*, Benth. Pl. Hartw. 17.) Rio Blanco, in rocky ravines; June. (54.) — Leaves very narrowly linear. The broader-leaved *Z. angustifolia* of authors is, I think, the *Z. multiflora* of Kunth, but not of Linnæus.

ZINNIA MARITIMA, HBK. Nov. Gen. & Spec. 4. 251. Tequila, on rocky hillsides. (355.) — The form with oblong or some lanceolate leaves, which Coulter collected at Mazatlan, and of which Schaffner distributed specimens collected by Barcena. Bates, Gregg, and Seemann collected the narrower-leaved form, Hemsley's *Z. bicolor*, the *Mendezia bicolor*, DC. The ligules are bright white, the disk yellow.

ZINNIA PALMERI, Gray, *n. sp.* Ramosissima, bipedalis; ramis gracilibus tenui-pubescentibus; foliis membranaceis ovato-lanceolatis basi subcordata sessilibus glabriusculis (majoribus bipollicaribus); pedunculo folia subæquante filiformi; involucro hæmispherico, bracteis ovalibus adpressis immarginatis; ligulis ovalibus (lin. circiter 4 longis) aurantiacis subtus mox pallidis; paleis receptaculi lanceolatis apice molli sensim attenuatis; acheniis obovatis bidentatis, ala callosa ciliolata, faciebus papillosis. — Tequila, base of hills and roadsides. (386.)

Heliopsis procumbens, Hemsl. Biol. Centr.-Am. Bot. 2. 156. Rio Blanco, in moist shady places; June. (36.)

Jægeria pedunculata, Hook. & Arn. Bot. Beech. 299. Instead of a span, Palmer's specimens are a foot or two high, and 1–7-cephalous. The ligules, 8 or 9 in number, are over two lines long, and the golden yellow heads make the plant showy according to the collector's notes. The root is annual. The outer paleæ much surpass the achenes and fully embrace them; the inner are gradually narrower, smaller, and subulate. Guadalajara, in swamps, in great masses; September. (427.) — The original in herb. Kew is a poor and monocephalous specimen.

Gymnolomia squarrosa, Hemsl. l. c. 2. 163. (*Zalazaria*, Schultz Bip. in Flora, 1864, 217.) Guadalajara; September. (486.) — Rio Blanco, in ravines; October. A smaller form. (741.)

Gymnolomia rudis, Gray, *n. sp.* Herbacea, pilis brevibus aut patentibus aut strigillosa-appressis undique hispida; caulibus subsolitariis 2–3-pedalibus e rhizomate nodoso valido parum ramosis apice laxe oligocephalis; foliis crassiusculis oblongis et sublanceolatis sessilibus plerumque obtusis nunc serrulatis nunc subintegerrimis triplinerviis sæpius tripollicaribus; pedunculis spithamæis nudis; capitulo subgloboso semipollicem diametro; ligulis plurimis oblongis discum convexum haud superantibus; involucri brevis bracteis oblongis adpressis, apice brevi tantum squarroso-patente; receptaculo convexo parum conico. — Rio Blanco, sides of ravines; September. In two forms growing together; one (533) with yellow rays, "rarely shaded with dark brown"; the other (531) "with dark brown rays"; disk in both forms yellow, becoming fuscous. It bears some resemblance to Hemsley's *G. flava*, but the bracts of the involucre much smaller, shorter and closer, and in other respects abundantly different.

Sclerocarpus uniserialis, Hemsl. l. c. 164. Tequila, from the cañon, in the shade of trees. (415.)

Montanoa grandiflora, DC. Prodr. 5. 565. A shrub 12 feet high. Guadalajara; September. (492.)

Montanoa subtruncata, Gray, *n. sp.* Fruticosa, ramis gracilis glabellis; foliis hispidulo-puberulis ovatis acuminatis serrulatis basi lata rotundata vel truncata trinervatis, petiolo gracili prorsus nudo; capitulis (mediocribus) laxe paniculato-cymosis; involucri bracteis subovatis brevibus; paleis receptaculi fere glabris parum mucronatis demum truncatis; ligulis 5 vix semipollicaribus albis. — Rio Blanco, on sides of barranca; September. (599.)

MONTANOA (ERIOCOMA) ——? With the habit of the elder, 10 to 12 feet high, the stems with large pith. Chapala, in waste places and on wooded hillsides. (714.) — From the habitat this is probably one of Koch's species from "Guadalajara" (Wochenschrift. 7. 406, &c.), perhaps *M. triloba*, as it is near *M. xanthiifolia*, and not that species.

IOSTEPHANE HETEROPHYLLA, Hemsl. l. c. 168. Rio Blanco, in damp shaded ravines; August. (327.)

ASPILIA ALBIFLORA, Gray, *n. sp.* Multicaulis e radice perenni, spithamæa, diffusa, striguloso-hispidula; foliis spathulatis subintegerrimis (1–3-pollicaribus) basi in petiolum attenuatis; pedunculis solitariis monocephalis folia haud æquantibus; involucri bracteis exterioribus 5–6 lineari-oblongis subfoliaceis (fere semipollicaribus) interiores totidem membranaceas superantibus; ligulis 4–6 linearibus semipollicaribus albis; acheniis disci pyriformibus parum compressis hirsutis basi utrinque callo carnoso rotundo adnato instructis; pappo cupulato multilaciniato nunc 1–2-aristellato. — Rio Blanco, on shaded hillsides; August. (332.) A congener of *A. Mexicana*, but peculiar.

ASPILIA ANGUSTIFOLIA, Gray, *n. sp.* Scabrido-hispidula; caule 4-pedali paniculato-ramoso; ramis gracilibus patentibus; foliis linearibus integerrimis (1–2-pollicaribus) utrinque acutis brevipetiolatis supra hispidulis subtus subcanescentibus; capitulis subcymosis longiuscule pedunculatis parvulis; involucro brevicampanulato (lin. 3 longo), bracteis ovatis concavis plerumque obtusis imbricatis, exterioribus brevioribus interioribus fere conformibus; ligulis 7–8 oblongis flavis; acheniis clavato-oblongis hispidulis basi utrinque calliferis; pappo cupulato lacero. — Tequila, at base of hills, among underbrush. (361.)

ZEXMENIA PODOCEPHALA, Gray, Syn. Fl. 1². 286, probably. Rio Blanco, in ravines; June. (50.)

ZEXMENIA (OTOPAPPUS) TEQUILANA. Fruticosa, orgyalis, scabrido-puberula, subcinerea; ramis elongatis ad apicem usque æqualiter foliatis; foliis e basi rotundata parumve subcordata ovato-lanceolatis acuminatis denticulatis juxta basim 3–5-nerviis venulosis (4–5-pollicaribus) brevipetiolatis; capitulis in pedunculis axillaribus et terminalibus paucis laxe cymosis brevipedicellatis hemisphæricis (lin. 3–4 latis); involucri bracteis parvulis gradatim imbricatis oblongis adpressis cum apice obtuso parum patulo; ligulis plurimis discum vix superantibus;

acheniis angustis glabris margine interiore sursum in alam paleaceam pappiformam producto; paleolis intermediis sæpius obsoletis. — Tequila, in ravines and along hillsides. (359, a thin-leaved form; 394, with thicker and more pubescent leaves.) The aspect of this plant is essentially that of *Z. scandens*, Hemsl. (which, at Cordoba, where I as well as Bourgeau collected specimens, is not scandent, but very straggling). I suppose that Hemsley's *Otopappus epaleaceus* is a near relative of this, with fewer and much larger heads, and perhaps it may show now and then, as this does, a manifest scarious edge stretching from the pappus-palea on one angle to the tooth on the other. I think that *Otopappus* will not hold out as a genus, and agree with Bentham that it is better to retain the *Salmea curviflora*, R. Br., in that genus. The extension of a wing of the achenium upward into pappus is not uncommon in the related genera.

ZEXMENIA GREGGII, Gray, Pl. Wright. 1. 113. Shrubby, about 10 feet high. Tequila, edges of ravines. (356.) — *Z. ovata*, Hemsl., is *Z. helianthoides* (or the plant of Bates so called), near to this.

ZEXMENIA AUREA, Benth., ex Hemsl. l. c. (*Wedelia* (?) *aurea*, Don, and Bot. Mag. t. 3384.) Rio Blanco, in grassy bottoms; October. (757.) — This has been collected by Schaffner, and we have received it from Schultz Bip. under an unpublished name.

TITHONIA TUBÆFORMIS, Cass. Rio Blanco; September. (560.)

VIGUIERA EXCELSA, Benth., ex Hemsl. (*Tithonia*, DC. Prodr. 5. 585.) Guadalajara; September. (443.) — Rio Blanco, a low form; September. (532.) — "Perennial sunflower."

VIGUIERA TENUIS, Gray, *n. sp.* Consors *V. helianthoidis*, annua, pubescens; caule exili subsimplici; foliis sessilibus subintegerrimis, inferioribus oppositis lanceolatis, summis alternis linearibus; capitulis paucis longe pedunculatis parvis; involucro (lin. 3 longo) villoso-cinereo, bracteis subulatis vix inæqualibus; disco convexo; paleis albo-scariosis mollibus apice mucronato parum rigidulo; ligulis 5–6 (lin. 3 longis) flavis; acheniis brevibus albo-villosissimis; pappo deciduo, e paleis 2 lateralibus lanceolatis longe aristatis (achenio 3-plo longioribus et paleam receptaculi superantibus) cum 2–4 oblongis obtusis vel truncatis fimbriato-ciliatis achenio paullo brevioribus. — Rio Blanco, among shaded rocks; October. (657.) Doubtless the specimens are depauperate; but I cannot identify the species with any other.

VIGUIERA HELIANTHOIDES, HBK. A canescent or cinereous but thin-leaved form, probably passing into *V. canescens*, DC. Rio Blanco, in a deep barranca, abundant; October. (674.)

VIGUIERA QUINQUERADIATA, Gray. Fruticosa, 8–10-pedalis, tomentuloso-pubescens; foliis alternis membranaceis (4–5-pollicaribus) deltoideo- vel subcordato-ovatis basique subito in petiolum gracilem contractis; cymis pleiocephalis laxis; capitulis cylindraceis semipollicaribus; pedunculis tenuibus bracteis tenui-linearibus fulcratis; involucro e bracteis 5–10 erectis disci paleis mollibus inermibus (apice nunc petaloideo-flavidis) dimidio brevioribus; ligulis 5–6 aureis ovalibus; receptaculo planiusculo; acheniis disci angusto-oblongis (lin. 3 longis) villosis paleis 2 lanceolatis aristiformibus brevibus cum intermediis utrinque 3–4 dimidio brevioribus laciniatis coronatis. — Chapala, in ravines and on hillsides. (718.) This is evidently the *Helianthus quinqueradiatus*, Cav. Ic. 3. 36, t. 272, a peculiar but genuine species of Viguiera, for which the name of Cavanilles is to be retained, although the rays are more commonly six. Their fewness and the narrow heads in an ample cyme give the species a peculiar appearance.

VIGUIERA PALMERI, Gray, *n. sp.* Fruticosa, orgyalis, brachiato-ramosa, scabro-hispidula; foliis omnibus oppositis ovato-lanceolatis acuminatis parum denticulatis a basi rotundata fere triplinerviis venulis transversis subtus prominulis reticulatis, petiolo brevissimo; capitulis paucis ad apicem confertis parum pedunculatis globosis vix semipollicem latis; involucro e bracteis appendice lineari vel sublanceolata herbacea reflexa auctis squarroso; ligulis angustis flavis; achenio palea subquadrata coriacea valde complicata incluso subfalcato glabro vel glabriusculo aristis binis subulatis squamellisque intermediis plurimis minimis coronato. — Rio Blanco, sides of ravines; October. (738.)

HELIANTHUS ANNUUS, Linn. Rio Blanco; July. (187.) — "Maiz de Teja"; the seeds have the property of coloring mescal and of deepening the color of wines.

PERYMENIUM CERVANTESII, DC. Prodr. 5. 609. Rio Blanco, on gravelly hillsides; August. (310.) — *P. Mendezii*, DC., is probably a form of this species.

ENCELIA (SIMSIA) SANGUINEA, Hemsl. l. c. 185, var. (?) PALMERI; foliis (superioribus) omnibus integris ovato-lanceolatis basi lata sessilibus; acheniis etiam ovariis glabris calvis. — Often 4 feet high, purple-flowered. Rio Blanco, in thickets on the sides of cañons; September. (602.)

ENCELIA (SIMSIA) MEXICANA, Mart. in DC. Prodr. 5. 578. Guadalajara, in cornfields and fences; October. (622.)

VERBESINA STRICTA, Gray, Proc Amer. Acad. 19. 13. (*Actinomeris*, Hemsl.) Rio Blanco, near streams; July. (163.)

Verbesina virgata, Cav. Ic. 3. 38, t. 275; probably a small form. Rio Blanco, on hills among pines; July. (167.)

Verbesina tetraptera, Gray, Proc. Amer. Acad. 19. 13. Tequila. on rocky hillsides. (377.)

Verbesina sphærocephala, Gray, *n. sp.* Species singularis, fruticosa, ultra-orgyalis, scabrido-puberula; foliis oppositis integerrimis ovali-oblongis acutis (majoribus 4–5-pollicaribus) basi subito contractis subsessilibus secus ramos in alam angustam decurrentibus, summis subpollicaribus capitula globosa brevipedunculata fulcrantibus; involucri pluriserialis bracteis lato-ovalibus apicibus herbaceis squarroso-patentibus; ligulis 10–12 linearibus discum haud superantibus fœmineis; receptaculi convexi paleis mollibus apice obtuso nunc flavido subpetaloide; acheniis glabellis ala circumdata sat magna obovatis biaristatis. — Guadalajara, on the sides of ravines; September. (448.) A true *Verbesina*, but I know no species like it.

Verbesina pinnatifida, Cav. Ic. 1. 67, t. 100. Guadalajara, in hedgerows and ravines; October. (698.)

Verbesina crocata, Less. Guadalajara, river-sides among underbrush; October. (700.) — *V. hypoleuca*, Gray, Proc. Amer. Acad. 15. 37, of Coulter's collection, belongs to *V. mollis*, HBK.

Spilanthes Beccabunga, DC. Prodr. 5. 622. Rio Blanco, in shady wet places; June. (47, in part, the nearly glabrous plant with petioled leaves.) — The rest is probably S. sessilis, Hemsl. Biol. Centr.-Am. Bot. 2. 193, but the flowers are too young to examine.

Salmea grandiceps, Cass. Rio Blanco, on shaded hillsides; September. (528.)

Heterospermum pinnatum, Cav. Guadalajara, on grassy hillsides; September. (440.)

Coreopsis cordylocarpa, Gray, *n. sp.* *Eucoreopsis*, suborgyalis, foliosa, tenui-pubescens; foliis omnibus oppositis petiolatis submembranaceis sæpius quinatisectis, segmentis angusto-lanceolatis trifidis superne laciniato-dentatis; pedunculis subcymosis folia paullo superantibus; involucri bracteis utrisque lineari-subulatis; ligulis circa 10 oblongis integris luteis; acheniis obcompresso-clavatis glabris lævibusque lin. 4 longis apice contracto disco epigyno parvo terminatis calvis. — "A loose-growing plant, with many stems, 5 or 6 feet high, and with orange-yellow flowers"; probably perennial. Rio Blanco; July. (172.)

Coreopsis (Pseudo-Agarista) petrophila, Gray, *n. sp.* Fruticosa, ramosissima, bipedalis, glabra; foliis pinnatipartitis (bipollicaribus), segmentis 5–9 subulato-linearibus inæqualibus, majoribus sæpius trifidis vel 1–2-dentatis; capitulis graciliter breviuscule pedunculatis subcymosis; involucro campanulato (lin. 3–4-longo), bracteis exterioris angustis parvis, interioris oblongis 2–3-plo longioribus; ligulis 5 integerrimis oblongis (lin. 3 longis) flavis, tubulo hispidulo; fl. disci 6–10; acheniis rectis subturgidis obovato-oblongis palea angusto-oblonga nunc apice triloba scariosa parum superatis dorso glabris marginibus intusque longissime villosissimis; pappo ex aristis 2 achenio æquilongis barbellatis. — Rio Blanco, hanging loosely about rocks at the entrance of cañons; September. (530.) This belongs to the Andean frutescent group, the only one known in the northern hemisphere. Of course the rays are neutral, as in all true members of this genus.

Leptosyne Mexicana, Gray, *n. sp.* Perennis; caulibus rigidulis ultrapedalibus superne nudis oligocephalis; foliis filiformi-linearibus integerrimis; involucri exterioris bracteis oblongo-linearibus interioribus subdimidio brevioribus; ligulis 8–10 oblongis (lin. 4 longis); acheniis orbicularibus subcoriaceis fere immarginatis glaberrimis calvis, iis radii omnibus fertilibus. — Rio Blanco, along a rivulet in a grassy bottom; September. (568.) A good *Leptosyne*, although not quite of the typical section. The thickened tips of the style-branches have a subulate appendage.

Cosmos exiguus, Gray, *n. sp.* Glabra; caule filiformi e radice annua pedali 1–5-cephalo; foliis fere filiformibus integerrimis; capitulo paucifloro (florifero lin. 3 longo); bracteis exterioribus lato-subulatis appressis, interioribus oblongis obtusis; paleis receptaculi fructiferis elongatis; floribus atro-purpureis; acheniis (5–6) lineas 8–9 longis aristis 2 brevibus *sursum* hirtello-barbellatis instructis. — Rio Blanco, among grass and rocks; September. (559.) Like other annuals, it probably occurs of larger growth. It must go with *Cosmos*, with which it accords in everything except that the bristles of the pappus-awns are upwardly barbellate. It is also Seemann's no. 1469 from Cerro de Pinal, with some mature (longer) achenes, the awns similarly hispid upwardly.

Cosmos sulphureus, Cav. Ic. 1. 56, t. 79. (606 in the Cambridge set, but a mistake.)

Cosmos bipinnatus, Cav. Guadalajara, in fields, fence-rows, and gardens; September, October. (623, 699.)

Bidens chrysanthemoides, Michx. (*B. helianthoides*, HBK.) Guadalajara, in swamps; July. (239.)

Bidens Palmeri, Gray, *n. sp.* *Psilocarpæa*, e grege *B. angustissimæ* et *B. glaberrimæ* (sp. ignota), prorsus glaberrima, ut videtur perennis; caule pluripedali rigidulo striato-angulato; foliis rigidis pinnati-(5–9-)partitis, segmentis linearibus acutis integerrimis imis quandoque bifidis; pedunculis elongatis monocephalis; involucri exterioris bracteis lineari-lanceolatis acutis patentibus, interioris oblongis obtusis pallidis; ligulis ultra-semipollicaribus ovalibus modice nervosis; acheniis subulatis glabellis semipollicaribus subrostratis; aristis plerumque 4 lineas longis. — Rio Blanco, on hillsides, very common: August. (315.) It should be compared with *B. glaberrima*, DC., of uncertain origin, but probably Mexican, and said to have biaristate achenes, as well as 15–16-nerved ligules.

Bidens heterophylla, Ort. Dec. t. 12. Guadalajara, in swamps; September. (425.) — *B. triplinervia*, HBK., seems to be a form of this species.

Bidens ferulæfolia, DC. Prodr. 5. 603; but no well-grown fruit. With the last. (426.)

Bidens tereticaulis, DC. Prodr. 5. 598. Chapala, on hillsides, reclining among shrubs. (713.)

Chrysanthellum procumbens, Rich. Tequila, in rich grassy bottoms. (364.)

Calea Palmeri, Gray, *n. sp.* *Caleacte.* Parce villoso-hispida; caule simplici (bipedali) herbaceo e caudice nodoso apice nudo oligocephalo; foliis sessilibus lanceolatis parum denticulatis submembranaceis triplinerviis vix venosis (majoribus tripollicaribus); capitulis longiuscule pedunculatis; involucri bracteis laxe biseriatis æquilongis oblongis obtusis; ligulis circ. 8 elongatis albis; pappi paleis inæqualibus subulatis. — Rio Blanco, on grassy hillsides; July. (147.)

Calea peduncularis, HBK. Nov. Gen. & Spec. 4. 295, t. 408, var. longifolia. (*Calydermos longifolius*, Lag.) It has, however, a pappus, while Hartweg's very similar plant has none. Rio Blanco, in low rich bottoms; August. (317.)

Calea Zacatechichi, Schlecht. in Linnæa, 9. 589. Tequila, in narrow bottoms. (352.)—To this no doubt belongs *C. rugosa*, Hemsl. (*Calydermos rugosus*, DC. Prodr. 5. 670).

Calea urticæfolia, DC. Prodr. 5. 674. Rio Blanco, near the head of a rocky cañon; October. (675.)

Tridax procumbens, Linn. Guadalajara, on grassy hillsides; July. (297.)

Tridax balbisioides, Gray, Proc. Amer. Acad. 15. 39. Rio Blanco, at base of rocky hills; September. (569.) — This narrow-leaved form comes much nearer to the original *Galinsoga balbisioides*, HBK. Nov. Gen. & Spec. 4. 253, t. 386, than do the broader-leaved specimens of Palmer's former collection. The yellow ligule, broader than long, is very little lobed.

Galeana hastata, Llav. & Lex. Nov. Veg. 1. 12. (*Unxia pratensis*, HBK. *Chlamysperma pratense*, Less.) Guadalajara, on the tops of hills in low wet places surrounded by bushes; July. (263.) — It is remarkable that this unidentified genus should be found about Guadalajara. I have, however, had a poor specimen of it, since the year 1863, collected by Xantus near Manzanilla on the Pacific coast, and also from another unrecorded source.

Perityle Jaliscana, Gray, *n. sp.* Nana, e caudice lignescente crasso, subpuberula; ramis gracilibus foliosis; foliis omnibus oppositis longe petiolatis deltoideis nunc rhombeo-dilatatis angulato-dentatis; pedunculis subcorymbosis brevibus; involucri bracteis 14 linearibus; ligulis nullis; corollis disci albidis; acheniis lineari-oblongis hirsutis marginibusque filiformibus hirsuto-ciliatis; pappo e setis tenuibus 2 achenio 2–3-plo brevioribus cum corona brevi squamellarum. — Rio Blanco, in the crevices of exposed rocks; September. (554.)

Oxypappus scaber, Benth. Bot. Sulph. 118, t. 42. Rio Blanco, in a depression under pines; October. (644; but in the Cambridge set as 444.)

Schkuhria Hopkirkia, Gray, Pl. Wright. 2. 94, — but the faces of the achenes only slightly nerved. Tequila, in rich grassy bottoms. (365.)

Porophyllum viridiflorum, DC. Prodr. 5. 648. A shrub, 5 or 6 feet high. Rio Blanco; August. (325.)

Porophyllum Seemanni, Schultz Bip. in Seem. Bot. Herald, 308. A narrow-leaved form. Rio Blanco, on hillsides; October. (658.)

Dysodia porophylla, Cav.; DC. Prodr. 5. 649. Guadalajara, in a deep cañon; September. (441, the radiate form.) — Rio Blanco, on hillsides; October. (646, discoid.)

Dysodia tagetiflora, Lag.; Gray, Pl. Wright. 1. 114, and Proc. Amer. Acad. 19. 39. Rio Blanco, grassy bottoms and hillsides, very common; October. (656.)

Tagetes subulata, Llav. & Lex. (*T. multiseta*, DC.) Guadalajara, in sandy bottoms; September. (469.)

Tagetes tenuifolia, Cav. Ic. 2. 54, t. 169. A form with broader leaflets than the type. Rio Blanco, among rocks; September. (574.) — Also a form answering to *T. peduncularia*, Lag. Chapala, by roadsides. (709.)

Pectis diffusa, Hook. & Arn. Bot. Beech. 296? Rio Blanco;

June. (1.) — "Lemoncillo"; a hot decoction is used as a remedy for fever and ague.

PECTIS CANESCENS, HBK. Nov. Gen. & Spec. 4. 263. t. 393. Tequila. (418.)

PECTIS JALISCANA, Hook. & Arn. Bot. Beech. 296? Pappus rather different from that of the original very poor specimen. Rio Blanco, among grass; October. (760.)

ARTEMISIA MEXICANA, Willd. Rio Blanco, sides of cañons; September. (597.)

LIABUM PALMERI, Gray, *n. sp.* Herbacea, 1–2-pedalis e radice tuberoso, floccoso-lanata; foliis basi angusta connatis alte trifidis, segmentis linearibus nunc integris nunc laciniato-3–5-fidis supra mox pube laxo delapso glabratis subtus indumento denso pannoso incanis; caule scapiformi capitula 9–15 racemosa vel paniculata gerente; involucro $\frac{2}{3}$-pollicari glanduloso-pubescente, bracteis subulato-lanceolatis gradatim imbricatis; floribus omnibus hermaphroditis aureis; receptaculo nudo plano; acheniis cano-sericeis; pappo duplici, exteriore e paleis plurimis albis fimbriato-laceris, interiore plurisetoso rigidulo-fusco. — Rio Blanco, on stony ridges; September. (586.) Quite unlike any described species.

LIABUM ANGUSTISSIMUM, Gray, *n. sp.* Prioris soror; caule gracili spithamæo ad pedalem e radice fusiformi, inferne fere aphyllo foliis (quasi?) verticillatis angusto-linearibus integerrimis discoloribus instructo; capitulis 1–2 brevipedunculatis iis *L. Palmeri* subsimilibus. — Guadalajara, in low rich ground in deep ravines; July. (215.) Perhaps an extreme form of the preceding. The specimens are scanty.

ERECHTHITES HIERACIFOLIA, Raf., var. Guadalajara, in low moist bottoms; July. (248.)

SENECIO HERACLEIFOLIUS, Hemsl. l. c. 241. Five or six feet high. Guadalajara, in hedgerows and ravines; October. (697.)

CACALIA TUSSILAGINOIDES, HBK. Nov. Gen. & Spec. 4. 168, ex char.? Leaves not multifid, nor downy beneath. Coulter's no. 426, from Zimapan, accords with the character in the (cauline) leaves; but these too are not downy beneath. Tomentum is commonly deciduous. Rio Blanco, on exposed embankments; July. (168.)—Flowers white.

CACALIA SCHAFFNERI, Gray, Proc. Amer. Acad. 19. 53, or near it; ovaries glabrous and leaves more umbrella-like. Roots fascicled-tuberous. Rio Blanco, in sunny ravines; July. (171.)

CACALIA CORDIFOLIA, HBK. Nov. Gen. & Spec. 4. 168, t. 360. Rio Blanco, ravines and grassy bottoms; September. (576.)

CACALIA RADULÆFOLIA, HBK. Rio Blanco, grassy slopes and bottoms; October. (689.)

CNICUS MEXICANUS, Hemsl. (*Cirsium*, DC.) Guadalajara, in moist bottoms; July. (274.) — "Cardo santo"; the flowers are sometimes used in cheese-making instead of rennet.

PEREZIA WISLIZENI, Gray, Pl. Fendl. 111, and Proc. Amer. Acad. 19. 58, var. MEGACEPHALA. A form with still larger heads than the original, an inch and a half broad; stem leafy up to the involucre. Rio Blanco, on grassy hillsides, rare; October. (655.)

PEREZIA RIGIDA, Gray, Pl. Wright. 1. 127. A less rigid form. Rio Blanco, hillsides and ravines; October. (661.)

PEREZIA VERNONIOIDES, Gray, *n. sp.* Inter species subdiv. * * * conspecti in Proc. Amer. Acad. 19. 58 collocanda: caule ultra-bipedali usque ad apicem folioso hirsutulo apice cum cyma nuda polycephala glabro; foliis oblongis chartaceis basi obtusissima parumve subcordata subsessilibus subtus laxe venoso-reticulatis glabriusculis supra hispidulo-scabris obsolete serrulatis vel denticulatis, majoribus 4-pollicaribus; capitulis lin. 5 longis 9–12-floris; involucro subturbinato, bracteis pluriseriatim gradatim imbricatis chartaceis nitidulis sensim acuminatis, interioribus lanceolatis, extimis brevissimis subulatis; corollis roseis; pappo (immaturo) albo. — Rio Blanco, in shaded grassy bottoms; October. (745.) Seemingly a very distinct species. The heads show no disposition to cast off the involucral bracts; but they are still young.

PYRRHOPAPPUS MULTICAULIS, DC. (*P. pauciflorus*, DC.) Rio Blanco, in moist bottoms; June. (66.)

PINAROPAPPUS ROSEUS, Less. Rio Blanco, near water-courses; June. (30.)

LOBELIA SUBNUDA, Benth. Pl. Hartw. 44. Rio Blanco, on moist shady river banks; June. (43.)

LOBELIA LAXIFLORA, HBK., var. ANGUSTIFOLIA, DC. Rio Blanco; June. (45.) — Also a tomentulose form between *L. ovalifolia* and *L. lanceolata*, Hook. & Arn. Guadalajara; August. (298.)

LOBELIA FENESTRALIS, Cav. Rio Blanco, in rich wet bottoms; August. (339.)

PALMERELLA TENERA, Gray, *n. sp.* Annua, glabra; caule gracili simplici spithamæo; foliis imis oblongis rotundisve minimis, cæteris linearibus subdenticulatis (majoribus fere pollicaribus); corollæ tubo tenui (lin. 3 longo) basi hinc gibboso calycis segmentis 3–4-plo longiore, lobis ligulato-oblongis, tribus emarginato-truncatis cum apiculo medio, fauce ad sinus eorum bituberculatis; ovario capsulaque ovato-lanceolata $\frac{3}{4}$-supera. — Rio Blanco, in shaded rocky places, rare; September. (552.) A very interesting accession to this genus, all the more so because discovered by Dr. Palmer himself. It requires some extension of the generic character, beyond that referred to in Syn. Flora. Suppl. 394. The ovary is almost free, as in several species of *Lobelia;* the gibbosity at the base of the corolla is well marked, and the stamens are very unequally adnate to its tube on the side of the gibbosity, not beyond the middle.

CLETHRA MEXICANA, DC. Prodr. 7. 590. Rio Blanco, in deep gorges; June. (23.)

LENNOA MADREPOROIDES, Llav. & Lex. Rio Blanco, on the roots of various plants; October. (671.) — "Body of plant white; blossoms white at base, then a rim of yellow, and upper part violet."

ANAGALLIS ARVENSIS, Linn. Rio Blanco, in moist bottoms; June. (41.)

SIDEROXYLON PETIOLARE, Gray, *n. sp.* Arbor grandis; foliis novellis cum ramis pube ferruginea indutis, adultis nunc glabratis ovalibus oblongisve 3–4-pollicaribus basi obtusis vel acutiusculis apice sæpius apiculato-acuminatis, venis primariis utrinque 12–15 prominulis, petiolo 2–3-pollicari; floribus in fasciculis confertis numerosis; sepalis 5 rotundatis, interioribus scarioso-membranaceis, extimis sericeo-puberulis; corolla glabra rotata 5-partita, lobis oblongis subcucullatis (lin. 2 longis) stamina 5 paullo superantibus; filamentis lato-subulatis usque ad medium fere adnatis staminodia deltoidea 1–3-setigera sinubus inserta plus duplo excedentibus; bacca eduli ovali-oblonga acutata ultrapollicari; semine ovali albuminoso. — Barranca, large trees, 25 feet high and 2 or 3 in diameter; June. (131, 135, 136.) Under this name are described flowering specimens from two different trees and fruiting specimens from another, all belonging to a true *Sideroxylon.* It is not very likely to be *Lucuma ferruginea* of Hooker & Arnott.

THEVETIA CUNEIFOLIA, A. DC., probably. Fruit a trigonal drupe ($1\frac{1}{4}$ inches long by $1\frac{1}{2}$ broad) with thin flesh, 2-celled, 2-seeded; seed wingless, apparently all embryo. Chapala. (725.) — A stout shrub, 6 to 8 feet high. "Guevo de gato."

STEMMADENIA BIGNONIÆFLORA, Miers, Apocyn. 77, or near it. A shrub, 8 feet high, with bright orange-colored flowers. Barranca. (132.)

PLUMERIA MEXICANA, Lodd. Cab. t. 1024. A small erect tree, 15 to 20 feet high, with numerous very fragrant white flowers. Barranca. (137.)

Trachelospermum stans, Gray, Proc. Amer. Acad. 21. 394. An upright compact shrub, 3 feet high; in fruit only. Chapala. (724.)

Echites (Amblyanthera, J. Muell.) tubiflora, Mart. & Gal., ex char. Flowers yellow, tipped with dark green. Barranca. (98.)

Echites (Amblyanthera?) apocynifolia, Gray, *n. sp.* Subscandens (?) puberula; ramis foliosis; foliis ovato-lanceolatis acutis chartaceo-membranaceis basi subcordata brevissime petiolatis, venis primariis adscendentibus; pedunculis lateralibus folium æquantibus (bipollicaribus) racemifloris; sepalis e basi latiuscula setaceo-subulatis, squamellis brevibus; corolla lutea hypocraterimorpha glabra, tubo (lin. 5 longo) calyce paullo longiore limbo suo subbreviore; disco 5-glanduloso; antheris acuminulatis basi emarginata obtusissima; folliculis juvenilibus gracilibus torulosis. — Rio Blanco, on hillsides; July. (734.) "A small bush." The specimens give the idea that the stems may be disposed to twine; and the habit and short-tubed yellow corollas are not congruous with *Macrosiphonia*, although the foliage is not very unlike that of *M. brachysiphon.*

Philibertia Pavoni, Hemsl. Biol. Centr.-Am. Bot. 2. 319. Without doubt also *Sarcostemma pannosum*, Decaisne, and probably *S. rotundifolium* also. Rio Blanco, on hillsides; August. (340.)

Enslenia ligulata, Benth. Pl. Hartw. 290. Rio Blanco, in ravines; August. (314.)

Roulinia Jacquini, Decaisne. Tequila, in ravines. (384.)

Marsdenia Zimapanica, Hemsl. l. c. 338. Barranca. (115.)

Vincetoxicum astephanoides, Gray, *n. sp.* Frutex volubilis, alte scandens; foliis (cum ramulis puberulis) membranaceis ovato-lanceolatis acuminatis 2–3-pollicaribus, cum petiolo subpollicari umbellam plurifloram breve pedunculatam superante; pedicellis flore sesquilineari 2–3-plo longioribus; corolla alba urceolato-campanulata calycis lobis lato-ovalibus paullo longioribus, lobis ovalibus intus tenuiter arcteque retrorsum villosis; corona staminea fere obsoleta, nempe annulari 5-crenata gynostegio brevissimo accreta vel potius ad crenaturas carnosulas sub antheris singulis omnino aduatas diminuta. — Barranca, in exposed places, climbing high over bushes. (107.) Scanty specimens, in blossom only. There are no corolline appendages, except faint indications of mammæform papillæ, one just below each sinus; and it might be thought that there is no stamineal crown, and that the plant should be an *Astephanus;* but the fleshy thickening under each subsessile anther may rather be taken for a wholly adnate coronal tube.

Asclepias rosea, HBK. Nov. Gen. & Spec. 3. 189. Rio Blanco, in rich moist places; June. (19.)

Asclepias setosa, Benth. Pl. Hartw. 24. Rio Blanco, in moist rich soil; June. (20.) Also on hilltops under pines; October. (740.)

Asclepias Curassavica, Linn. Barranca. (138.) — "Platitaza"; the milky juice is used as a remedy for catarrh.

Asclepias macroura, Gray, *n. sp.* Facie *A. glaucescenti* subsimilis, glaberrima (pedicellis puberulis exceptis); foliis ovali-oblongis basi cordulata sessilibus (poll. 3–5-longis); pedunculis folia superantibus; umbella 8–12-flora; petalis albo-viridulis (fere semipollicaribus) ovalibus; columna vix ulla; cucullis erectis antheras parum excedentibus lato-quadratis submembranaceis albidis intus a basi usque fissis marginibus approximatis, crista costæformi omnino adnata in caudam gracilem sæpe circinatam cucullo ipso subæquilongam excurrente; antherarum alis basi auriculato-productis. — Rio Blanco, on hillsides, in flower only; August. (344.) A striking and apparently tall species. The hoods would be nearly square if flattened out, with the end slightly excised, but are tubular-convolute, their approximate margins perfectly straight and not at all auriculate or appendaged at base; the horn is represented by the long flexuous or involute tail.

Gomphocarpus Palmeri, Gray, *n. sp.* Multicaulis, subpedalis, tomentoso-puberulus mox glabrescens; foliis longo-linearibus sessilibus (majoribus 4-pollicaribus vix ultra lineam latis); umbellis sat longe pedunculatis laxifloris; corolla (lin. 3 longa) cum calyce rubella; cucullis (albis cum linea rubella) lamina linguæformi subcarinata crassiuscula a basi saccata parum dependente subito assurgente antheris adæquante; alis antherarum semiovatis. — Rio Blanco, in rich damp places; June. (21.) Fruit not seen. There is no crest or horn to the hoods, the open-saccate portion of which rises to about the middle of the dorsal portion or lamina, which seems to be, as it were, abruptly assurgent. It is doubtless a congener of *G. hypoleucus*, Gray, and like it only technically distinct from *Asclepias*.

Dictyanthus Pavonii, Decaisne in DC. Prodr. 8. 605. Barranca. (113.)

Dictyanthus stapeliæflorus, Reichenb., ex Walp. Ann. 3. 60, as far as the character goes. Near *D. parviflorus*, Hemsl., but corolla larger and more funnelform, and leaves rather larger and more petioled. The follicles (which were unknown in the genus) are in this echinate. Guadalajara, in ravines; July. (251.)

Gonolobus atratus, Gray, *n. sp.* *G. piloso*, Benth., peraffinis, minus pubescens; foliis (e basi cordata ovato-lanceolatis) longius petiolatis; floribus paullo majoribus; sepalis ovato-lanceolatis acuminatis (nec ovatis acutiusculis); corolla atra diametro sesquipollicari; corona patellari 5-loba margine parum denticulata præter tubercula 5 crassa læviuscula sat dissita quasi introflexa antheris opposita submembranacea. — Rio Blanco, in ravines; August. (334.) "Climbing over large trees; blooms black, with unpleasant smell." The flowers in Coulter's specimens of *G. pilosus* are nearly as large as those of the plant here characterized; but they have the calyx and the crown of Schaffner's n. 650, and of specimens from Guanajuato collected by Dugès. In all these the crown is dense, the whole summit of the lobes thickened and as it were muricately dentate by two or more rows of teeth; so that the two species must be quite distinct.

GONOLOBUS (EUGONOLOBUS) SORORIUS, Gray, *n. sp.* E grege typico, subglaber; caulibus gracilibus bifariam retrorsumque pilosulis; foliis ovato-lanceolatis sinu lato subcordatis sesqui–bipollicaribus petiolo gracili parum longioribus; pedicellis in fasciculo sessili vel brevissime pedunculato perpaucis; sepalis lato-lanceolatis herbaceis (lin. 2–3 longis); corolla cum andrœcio haud visa; ovariis 5-angulatis; folliculis ovatis lævibus (3-pollicaribus), angulis subalatis. — Tequila, on hillsides among bushes. (353.) The fruits of many Mexican species are unknown, and the specimens of this want the corolla and andrœcium. It may therefore belong to some of them; but it is the only known species, except the two typical ones of the Atlantic United States, which has the pentangular follicles which gave name to the genus.

GONOLOBUS (CHTHAMALIA) NUMMULARIUS, Hemsl. l. c. 332. Probably the plant of Née, which is more likely to be of the western or central parts of Mexico; but the leaves (as in Gregg's 784 from hills west of Morelia, in flower) are decidedly cordate and villous-hirsute beneath, as also the stems. No flowers, but mature pods, were collected. These are short-ovate and unarmed. Rio Blanco; September. (565.) — "Talayote."

MELLICHAMPIA* RUBESCENS, Gray, *n. sp.* Herba volubilis, glabra,

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* MELLICHAMPIA, nov gen. *Asclepiadacearum, Roulinicæ* sat affine. Calyx alte 5-partitus, segmentis angustissime linearibus. Corolla in alabastro fusiformi-conica, æstivatione convoluta, per anthesin oblongo-campanulata, alte 5-fida, lobis lineari-loratis superne recurvatis. Corona simplex, ad juncturam corollæ et andrœcii sessilis inserta, tubulosa, scariosa, profunde 5-fida in lacinias e basi ovata sensim caudato-attenuatas corolla paullo breviores. Antheræ corneæ, quadrato-oblongæ, intus sagittatæ, appendicibus scariosis ovatis termi-

ut videtur perennis; foliis oppositis membranaceis ovato- vel oblongo-cordatis; petiolis gracilibus; pedunculis folia æquantibus corymboso-paucifloris; corolla rubella vel rosea semipollicari intus pilosa, corona alba. — Guadalajara, among underbrush in wet ground on hills; August. (280.)

POLYPREMUM PROCUMBENS, Linn. Guadalajara, in grassy sandy bottoms; September. (613.)

SABBATIA PALMERI, Gray, *n. sp.* *S. maculatæ*, Benth., ut videtur proxima; caule stricto subpedali; foliis omnibus sessilibus subpollicaribus, inferioribus spathulatis vel obovatis basi attenuatis, superioribus angusto-linearibus; floribus perpaucis longe pedunculatis 5-meris; calycis lobis filiformibus seu linearibus (semipollicaribus), tubo parum turbinato brevi exangulato; corolla rosea fauce immaculata, lobis spathulato-lanceolatis calycem vix superantibus; stylo bipartito, lobis stigmatiferis clavato-filiformibus; capsula ovali lin. 3 longa. — Rio Blanco, in a deep barranca; October. (668.) The character is contrasted with that of *S. maculata* (*Eustoma*, Pl. Hartw.), which I have not seen.

ERYTHRÆA MADRENSIS, Hemsl. More depauperate. Rio Blanco, on grassy hillsides; October. (746.)

HALENIA PARVIFLORA, Don. Rio Blanco, in a shady ravine under pines; October. (680.)

LIMNANTHEMUM HUMBOLDTIANUM, Griseb. Rio Blanco; July. (181.)

LŒSELIA CILIATA, Linn. Tequila, among bananas. (370.)

LŒSELIA GLANDULOSA, Don. Rio Blanco, in ravines; October. (685.)

WIGANDIA URENS, Cham. Guadalajara; October. (637.)

HYDROLEA SPINOSA, Linn. Guadalajara, in a swampy bottom; September. (432.)

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natæ. Styli ovariis æquilongi. Vertex stigmatis convexus 7-lobulatus; lobulis 5 parvis deorsum in radios corpuscula polliniorum gerentibus circa duos centrales (pseudo-stigmata) paullo majores verticillatis. Folliculi ignoti. — Certainly a very distinct genus, technically more like to *Roulinia* than to any other.* I take pleasure in dedicating it to a valued botanical correspondent, Dr. J. H. Mellichamp, of South Carolina, who has helped us by acute observations upon the Asclepiadeous plants of the Southern Atlantic States, and whose investigations upon *Sarracenia variolaris* and its appliances for enticing ants into its tubular pitchers have long been upon record.

* ROTHROCKIA, Gray, Proc. Amer Acad. 20 295, and Syn. Fl. ed. 2, 2. 401, although referred to the *Cynancheæ*, is ambiguous between that tribe and the *Gonolobeæ*, having very short anthers and oval pollinia; but the former are not at all "transversely dehiscent."

Cordia cana, Mart. & Gal., ex Walp. Rep. 6. 554, but less canescent. A small straight tree, 8 feet high, with roundish top. Barranca. (84.)

Heliotropium limbatum, Benth. Pl. Hartw. 20. Certainly the species of Hartweg's collection, but with finer and closer pubescence. Rio Blanco, on damp hillsides; June. (52.)

Heliotropium inundatum, Swartz. Very narrow-leaved. Guadalajara, in moist bottoms; July. (258.)

Onosmodium strigosum, Don. Rio Blanco, in shady ravines; July. (173.)

Ipomœa stans, Cav. Rio Blanco; August. (324.) — "Espantilobo"; a decoction of the root is used for fever and ague.

Ipomœa longepedunculata, Hemsl. Biol. Centr.-Am. Bot. 2. 389. (*Pharbitis longepedunculata*, Mart. & Gal., by the character, but not a *Pharbitis.*) Rio Blanco; August. (335.) — "Running over grass, rocks, and low plants; the root an oblong tuber; corolla pink, the tube white." The same as Bourgeau's 495, from Pédrégal. *I. Hartwegi*, Benth., is a related species.

Ipomœa læta, Gray, *n. sp.* *Euipomœa*, hispidulo-pubescens; caulibus e caudice crasso ligneo humifusis parumque volubilis; foliis (sesqui–bipollicaribus) pube utrinque strigilloso profunde trifidis, segmentis lateralibus bilobis, medio e basi contracta ovato; pedunculis unifloris folium superantibus apice bibracteato unifloris; pedicello bracteis lanceolatis æquilongis sepalis extus patenti-hispidis ovatis obtusiusculis (exterioribus subpollicaribus) dimidio brevioribus; corolla extus in alabastro pilis longis barbata, tubo per anthesin cylindraceo bipollicari fere albo, limbo amplo (poll. 4 lato) violaceo-purpureo; capsula parvula quadrivalvi glabra; seminibus subglobosis glabris lin. 3 latis. — Rio Blanco, "running among grass and over low plants, very showy"; August. (341.) This fine species may have some name already, but it cannot be *I. superba*. The flower in form and pubescence is much like that of *I. Maireti* (which abounds at Orizaba), but foliage, pubescence, and habit are quite different.

Ipomœa purga, Wender. Tequila, in ravines. (373.)

Ipomœa rhodocalyx, Gray, *n. sp.* Inter *Calonyction* et *Euipomœam*, glaberrima; caule alte scandente pedicellisque omnino lævibus (nec muricatis); foliis cordatis seu oblongo-cordatis integerrimis membranaceis (majoribus 4-pollicaribus cum petiolo $2\frac{1}{2}$-pollicari); pedunculis folium subæquantibus 1-2-floris; calyce in alabastro subvesicario ovato rubente, fructifero pollicari pedicello clavato-incrassato paullo breviore, sepalis ovatis acutiusculis pergamentaceis vel interioribus scariosis capsulam superantibus; corolla "sulphurea" hypocraterimorpha, tubo vix bipollicari usque ad limbum haud sesquipollicem latum cylindraceo; antheris in fauce inclusis; seminibus lævibus. — Tequila, at the base of hills. (421.) This striking species does not agree with the characters of any of those which Martens & Galeotti have referred to *Calonyction*. As flattened in the dried specimens the tube of the corolla is a third of an inch in diameter, while the expanded limb is only an inch and a quarter. The filaments are inserted very low in the tube; the tips of the anthers are on a level with the orifice.

IPOMŒA MEXICANA, Gray, Syn. Fl. 2. 210. Sepals broadly lanceolate. Rio Blanco, among grass; September. (583.)

IPOMŒA PUNCTICULATA, Benth. Bot. Sulph. 136. The puncticulate leaves are well marked; apparently an annual. Chapala, in old fields. (702.)

IPOMŒA MURUCOIDES, Rœm. & Schl., var. GLABRATA. "A large irregular-growing tree, 20 to 30 feet high; the white blooms with a yellow shading at the base of the tube." Chapala, on rocky hillsides. (703.) — Palmer's specimens are glabrous or very early glabrate, even to the calyx; indeed, even the corolla is almost glabrous in the bud. The calyx is short, the leaves acuminate, and the petioles elongated (two to nearly three inches long).

IPOMŒA SIDÆFOLIA, Choisy. Chapala, climbing over walls and hedges. (721.)

IPOMŒA BONA-NOX, Linn. Chapala, covering tall trees and rocks. (727.)

EVOLVULUS LINIFOLIUS. Linn. Rio Blanco; September. (572.)

EVOLVULUS PILOSISSIMUS, Mart. & Gal., ex Walp. Rep. 6. 542, and from the same district. Rio Blanco, in grassy bottoms; July. (750.) — Has been referred to *E. alsinoides*, and may well be one of its manifold forms.

CUSCUTA TINCTORIA, Mart. Rio Blanco; September. (577, in Cambridge set as 579.)

CYPHOMANDRA BETACEA, Sendt. Guadalajara; September. (636.) — The tree-tomato; "Verengena."

CESTRUM LANATUM, Mart. & Gal. A shrub, 8 to 12 feet high. In fruit only. Barranca. (120.) — "Fruit black, yielding a stable dye."

BELLINIA UMBELLATA, Rœm. & Schult. (*Saracha umbellata*, Don, and with many other synonyms.) Rio Blanco; June. (3.) — "Jaltomate."

CAPSICUM BACCATUM, Linn. Several cultivated forms. Guadalajara; September. (638, Chili piquin"; 639; 640; 642, "Mirasol.")

SOLANUM NIGRUM, Linn. Rio Blanco; June. (11.) — "Mora"; the fruit is used in the treatment of erysipelas and sores generally.

SOLANUM TORVUM, Swartz, — probably a form; no prickles seen. A shrubby plant, with white flowers. Barranca, in shade. (106.)

SOLANUM REFRACTUM, Hook. & Arn. Bot. Beech. 304. "With long stems hanging upon other plants; leaves upon the ends of the branches very different from those below," being pinnatifid, some deeply so, while many of the lower are entire. It evidently climbs by means of the short refracted prickles. Calyx often 6–8-toothed; white corolla-lobes and stamens 5 to 8; fruit globose, an inch and a half in diameter or more. Barranca. (108.) — *S. bicorne*, and var. *angustifolium*, Dunal in DC. Prodr. 13. 232, are evidently forms of this.

SOLANUM PILIFERUM, Benth. Pl. Hartw. 68. Doubtless also *S. Andrieuxii*, Dunal, l. c. 165. Rio Blanco, in shaded ravines; July. (186.) — "Flowers open only at night, the corolla either light or dark drab with some brown lines; fruit egg-shaped, greenish yellow, with an apple-like odor and pleasant taste. It is much eaten, is sold in the markets, and a preserve is made of it."

SOLANUM TEQUILENSE, Gray, *n. sp.* *Leptostemonum*, crebiter ochraceo-tomentosum; caule (toto herbaceo?) valido aculeis subulato-acicularibus rectis (lin. 3–4 longis) crebris horrido; foliis ovalibus pinnatifido-dentatis vel sinuatis basi cordulatis utrinque subæqualiter pannosis, majoribus 10–18-pollicaribus, costa venisque primariis parce aculeatis; pedunculis unifloris subfasciculatis petiolo brevi haud longioribus mox recurvatis; calyce 5-fido inermi (lobis ovatis obtusis) cum corolla 5-partita (lobis ovato-lanceolatis subsemipollicaribus intus albis) extus creberrime pannoso-tomentoso; bacca globosa rubra pilis stellatis subpungentibus tecta calyce vix accreto stipata. — Tequila, along rocks and fences among the hills. (424.) A remarkable species, of the type of *S. scabridum*, which I do not find described.

SOLANUM ——? Probably a very narrow-leaved variety of *S. Jamesii*, Torr., or of *S. appendiculatum*, Schlecht. Rio Blanco, near a small stream; September. (611.) — "Flowers white; tubers white, firm, and nutty in flavor."

SOLANUM CALLICARPEÆFOLIUM, Linn. Guadalajara, on hillsides; September. (625.)

NICOTIANA PLUMBAGINIFOLIA, Viv. Barranca, in the shade of rocks. (110.)

NICOTIANA TABACUM, Linn. Rio Blanco, "long cultivated by the common people"; August. (347.) — With this is mixed a hybrid of *N. paniculata* with *N. Tabacum*.

PHYSALIS ÆQUATA, Jacq. f., — may pass for forms.* Rio Blanco: June. (1, 2.) — "Tomate."

PHYSALIS FŒTENS, Poir.? Guadalajara, in exposed sandy places and shady ravines; September. (472.) — Fruit not edible.

PHYSALIS NICANDRIOIDES, Schlecht. in Linnæa, 9. 311. Rio Blanco; September. (582.) — "Tomato de Perro; exceedingly gummy, and used for the toothache."

PHYSALIS ——? Guadalajara, in shady ravines; September. (473.)

CALCEOLARIA MEXICANA, Benth. Pl. Hartw. 47. Guadalajara, cultivated; September. (624.)

RUSSELLIA SARMENTOSA, Jacq. Barranca, among underbrush. (126.) — Also Rio Blanco, a variety 4 or 5 feet high, on hillsides; September. (540.)

ILYSANTHES GRANDIFLORA, Benth.; Gray, Syn. Fl. 2. 283. Rio Blanco, on grassy river bank; June. (46.)

ESCOBEDIA LINEARIS, Schlecht. Rio Blanco, in deep barranca; October. (670.)

BUCHNERA PILOSA, Benth. Rio Blanco, on grassy hillsides; August. (308.)

BUCHNERA DISTICHA, HBK., ex Gray, Proc. Amer. Acad. 19. 94. "Flower nearly white." Rio Blanco, grassy base of hills; September. (547.)

BUCHNERA MEXICANA, Hemsl. Biol. Centr.-Am. Bot. 2. 457; Gray, l. c. Rio Blanco, grassy base of hills; October. (739.)

LAMOUROUXIA CORDATA, Cham. & Schlecht. Rio Blanco, among rocks; September. (578.)

CASTILLEIA CANESCENS, Benth. (a var. of *C. tenuiflora*). Guadalajara, on hillsides; July. (265.)

CASTILLEIA ARVENSIS, Cham. & Schlecht. Rio Blanco, in corn-fields; September. (575.)

UTRICULARIA DENTICULATA, Benj. in Linnæa, 20. 492, ex char.

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* Dr. Palmer remarks in regard to this determination that the two forms when growing appear very different; the first, low and compact, with flowers so small as scarcely to be seen, and an abundance of fruit; the second, of large and loose growth, with much larger flowers and less abundant fruit, which is also less esteemed. [S. W.]

Flowers white with the upper portion light lilac. Guadalajara, in wet bottoms; September. (446.)

Pinguicula crenatiloba, DC.; Moç. & Sesse, Calques, t. 1071, fig. 3; not of Hemsley, at least not the *P. lilacina* of Seem. Bot. Herald. Flowers white. Rio Blanco; September. (570.)

Achimenes coccinea, Pers. Rio Blanco, in deep ravines; July. (169.)

Isoloma ——? Near to *I. Deppeanum*, Hemsl., to which apparently more than one species has been referred. Rio Blanco, among shaded rocks; September. (169.)

Tecoma mollis, HBK. Nov. Gen. & Spec. 3. 144. About 6 feet high. Rio Blanco, on side of barranca; September. (606.)

Calophanes Palmeri, Gray, *n. sp.* Hirto-puberula, herbacea; caulibus simplicibus strictis pedalibus æqualiter foliosis apice 1–2-floris; foliis ovatis seu ovato-oblongis basi rotundata arcte sessilibus (majoribus vix ultrapollicaribus acutiusculis, imis parvulis rotundatis); corolla purpurea, tubo gracili subpollicari sepala angustissime linearia glabella bis superante in faucem late obconicam abrupte ampliato, lobis ovato-rotundis; staminibus 5 fere æqualibus; antheris oblongo-sagittatis (loculis basi divergentibus parum apiculatis) filamentis æqualiter dissitis paullo longioribus; ovarii loculis biovulatis. — Rio Blanco, in ravines among shaded rocks; July. (160.) Fruit not seen; the flowers being scanty, only one flower-bud was dissected, so that it is uncertain whether the pentandrous character is normal. *Pentstemonacanthus* of Brazil is so characterized, and Bentham remarks that only in that plant had an *Acanthacea* with five stamens been observed.

Ruellia pilosa, Pav., fide Nees in DC. Prodr. 11. 127. Corolla "royal purple with white throat." Guadalajara, on hillsides; July. (218.) — Probably only Mexican, and not from "Peru."

Lantana involucrata, Linn. Barranca; in flower. (100.) Tequila, in ravines; in fruit. (399.)

Lantana Camara, Linn. Guadalajara; July. (221.)

Lantana horrida, HBK. Guadalajara; July. (252, 259.) — Probably only a form of *L. Camara.*

Lantana hispida, HBK.? Tequila, in ravines. (400.)

Lantana velutina, Mart. & Gal. A shrub, 5 to 8 feet high; fruit bluish green. Tequila. (401.)

Lippia geminata, HBK. Rio Blanco; June and October. (33, 686.) — "Yerbe buena cimarona."

Lippia purpurea, Jacq. Guadalajara, on hillsides; July. (266.)

BOUCHEA EHRENBERGII, Cham. Guadalajara, in wet places on hilltops; July. (261.)

PRIVA HISPIDA, Juss. Guadalajara, on sides of ravines; September. (500.)

VERBENA CILIATA, Benth. Rio Blanco; June. (35.)

DURANTA PLUMIERI, Jacq. Guadalajara, cultivated. (736.)

VITEX MOLLIS, HBK. Barranca. (129.) Tequila. (422.) — The black-brown fruit, known as "ahuilote," is much eaten by the natives.

HYPTIS ALBIDA, HBK. Nov. Gen. & Spec. 3. 129. Rio Blanco, on hillsides; July. (150.)

HYPTIS STELLULATA, Benth. Lab. 129, and DC. Prodr. 12. 128. Rio Blanco; August. (326.)

HYPTIS MACROCEPHALA, Mart. & Gal., ex Benth. l. c. (probably), var. VILLOSA, bracteis capituli oblongo-spathulatis 3-nervatis; calycis dentibus tubo suo sublongioribus. — Guadalajara, in wet bottoms; September. (436.)

HYPTIS POLYSTACHYA, HBK. l. c. 121. Rio Blanco, along creeks and ravines, 6 to 8 feet high; September. (538.)

HYPTIS SPICATA, Poit. Chapala, hedges and hillsides. (717.)

MENTHA ROTUNDIFOLIA, Linn. Guadalajara, in rich wet places; July. (235.) — "Vervena."

CUNILA LONGIFLORA, Gray, *n. sp.* Corollis (lin. 4 longis) albis calyce brevidentato quadruplo longioribus: cæt. *C. polyanthæ*, Benth. — Rio Blanco, in a deep barranca; October. (649.) The stems are said to be frutescent ("a compact shrub"), but so far as the specimens of a foot and a half long show, they are herbaceous and slender. *C. secunda*, Watson, collected by Dugés, must be a form of *C. polyantha*, from the original of which the present plant differs principally in its elongated corollas.

MICROMERIA XALAPENSIS, Benth. Guadalajara, in damp shaded places; September. (618.)

SALVIA VERONICÆFOLIA, Gray, *n. sp.* *Calophace, Brachyanthæ;* e basi suffrutescente multicaulis, pilis longis patentissimis plerumque glandula parva terminatis undique molliter hirsutissima; ramis caulibusve pedalibus laxis; foliis membranaceis ovatis subserratis basi lata subsessilibus semipollicaribus; racemo spiciformi interrupto gracili, verticillastris 4–6-floris, foliis floralibus lato-ovatis viridibus pedicellos breves superantibus subpersistentibus; calyce ad medium usque bilabiato ringente herbaceo ut caulis pilosissimo, labio postico tridenticulato, antico bipartito, lobis deltoideis acutis; corolla parum semipollicari violacea glabra, tubo subventricoso incluso labio antico amplo paullo breviore; connectivis antice deflexis oblongo-lanceolatis læviter connatis medio loculum cassum gerentibus; stylo apice incrassato postice saltem villosissimo, lobo postico subulato anticum deltoideum triplo superante. — Rio Blanco, on moist hillsides; June. (28.) Near Schaffner's 678, an unnamed species.

SALVIA ANGUSTIFOLIA, Cav. Rio Blanco, in bottoms; June. (53.) Guadalajara, edge of a swamp; July. (226.)

SALVIA GLECHOMÆFOLIA, HBK. Nov. Gen. & Spec. 2. 270, t. 141. A rather narrow-leaved variety. Rio Blanco, on hillsides; June. (61.)

SALVIA AMARISSIMA, Ort. (*S. nepetoides*, HBK. l. c., t. 150.) Rio Blanco, at base of hills; July. (183.)

SALVIA KEERLII, Benth., ex char. Barranca, in shade. (118.) — The same as 1073 Coulter, referred to *S. Drummondii*, but not the Texan plant.

SALVIA SESSILIFOLIA, Gray, *n. sp.* Inter *Fulgentes* notabilis foliis sessilibus oblongo-ovatis e basi rotundata vix cordulata parce serratis subacutis tenuiter venulosis, majoribus sesquipollicaribus, floralibus semipollicaribus ovato-lanceolatis parum nervatis ciliatis persistentibus; verticillastris remotis paucifloris; calyce (semipollicari pedicellis triplo longiore) turbinato-campanulato 10-nervato, lobis ovatis, postico integro obtuso, anticis mucronato-acuminatis; corolla sanguinea pollicari, tubo ventricoso e calyce vix exserto, labio antico trilobato (lobo medio bifido) posticum magis purpurascenti-pubescens superante; stylo superne villosissimo: planta herbacea debilis, pilis patentibus hirsuta, caule bipedali. — Rio Blanco, bottom of ravine; July. (184.) By the characters this cannot be *S. glumacea*, HBK., nor *S. lineata*, Benth.

SALVIA ALBIFLORA, Mart. & Gal., var. CÆRULESCENS, Gray, of Palmer's Batopilas collection. It needs comparison. Guadalajara, a tall plant, in ravines and by shaded roadsides; September. (488.) Rio Blanco, a foot and a half high, on sides of cañons; September. (598.)

SALVIA PRIVOIDES, Benth. Guadalajara, by fences; September. (498.)

SALVIA HELIANTHEMIFOLIA, Benth., var. Tenuissime puberula; foliis semipollicaribus, thyrso racemiformi virgato nunc ramoso; calycibus cæsio-cæruleis cano-puberulis paullo angustioribus. — Rio Blanco, among rocks; September. (556.) Hardly of the same species with 729 Parry & Palmer, referred here, but without doubt the species of Bentham.

Salvia Hispanica, Linn. Rio Blanco, in moist shady places; October. (659) — "Chia." A pure Mexican species.

Salvia purpurea, Cav. Ic. t. 166, var. pubens, foliis venosissimis ut in ic. Jacquini, sed subtus mollissime supra minutim pubescentibus. — Rio Blanco, in deep ravines and on shaded hillsides; October. (662.)

Scutellaria rumicifolia, Benth. Barranca, on stream banks. (6.)

Stachys agraria, Cham. & Schlecht., var. calyce fere glabro. — Rio Blanco; June. (49.) Barranca. (119.) Guadalajara; September. (612.)

Stachys Drummondii, Benth. A slender form. Guadalajara, in wet bottoms; July. (228.)

Boerhaavia erecta, Linn.? Barranca. (121.) — Too young for determination.

Amarantus leucospermus. (*A. leucocarpus*, Watson, Proc. Amer. Acad. 10. 347.) Yellow and red forms. Guadalajara; October. (694, 695.) — "Aglegria"; cultivated among corn or by itself; the seeds are parched, sprinkled with honey while hot, and made into cakes. Opportunity is here taken to correct the name which was first carelessly given to the species.

Amarantus chlorostachys, Willd. Guadalajara, by old fences and in waste places; October. (626, 629, 630.)

Amarantus Palmeri, Watson. Same localities. (627, female; 628, male.) — With stouter spikes than in the usual form.

Guilleminea illecebroides, HBK. Guadalajara, in sandy bottoms; September. (471.)

Gomphrena decumbens, Jacq. Guadalajara, in grassy bottoms; July. (238.)

Gomphrena nitida, Rothr. Rio Blanco, along fences and roadsides; September. (549.)

Iresine celosioides, Linn. Barranca. (92.)

Iresine canescens, Humb. & Bonpl. A compact shrub, 5 or 6 feet high. Chapala, on mountain sides. (716.) — The same as Mexican specimens, so named, collected by Bourgeau, Parry & Palmer, and others. The original of the species, from New Grenada, is described as a woody twiner.

Petiveria alliacea, Linn. Barranca, in moist shade. (89.)

Antigonon flavescens. Finely pubescent: leaves subtriangular-ovate, truncate at base with the angles acute or rounded, the petiole usually margined: racemes axillary or in a terminal panicle, sessile, short (1 or 2, sometimes in fruit 3 or 4, inches long), the pedicels 1 or 2 (becoming 3) lines long: sepals yellowish white, cordate at base, 3 narrowly ovate and acutish, 2 oblong and obtuse, at length greenish, shorter than the fruit (5 lines long) and scarcely enclosing it: anthers reddish brown. Chapala, among hills. (722.) — Differing from the various forms of *A. leptopus* in the color of the sepals, which are also in fruit much narrower and shorter.

Aristolochia (Gymnolobus) longecaudata. Finely pubescent throughout; stems herbaceous from a stout elongated root, trailing: leaves oblong-hastate, acute, with a deep sinus between the rounded basal lobes, 1 to 1½ inches long; petioles ½ inch long or less: peduncles axillary, 1 to 3 lines long, with a sessile cordate-lanceolate bract: ovary linear, 3 lines long: calyx pubescent, slightly dilated for 4 lines below the broad nearly straight half-longer upper portion of the tube (partially closed at base by a glabrous funnelform diaphragm), enlarging upward, and terminated by a long-attenuate lamina (2 inches long): stamens 5: lobes of the style attenuate and pubescent above: capsule oblong, an inch long, attenuate at base. Guadalajara, in moist bottoms; August. (278.) — Near *A. longiflora* and *A. brevipes*. Lamina dark brown with a band of yellow at base dotted with black.

Aristolochia Palmeri. Of the same section, somewhat puberulent or finely pubescent throughout, the several span-long stems erect from a fusiform root: leaves linear-hastate, long-acuminate, 2 or 3 inches long, truncate at base, the narrow divaricate lobes obtuse; petioles 4 to 6 lines long: flowers axillary, nearly sessile, the bract linear-lanceolate; ovary linear, 2 lines long: dilated base of the calyx 4 lines long, the slightly curved tube (8 lines long) dilated above, with a lanceolate very long-attenuate blade (3 inches long and 5 lines broad at base) yellowish down the middle and thickly dotted with purplish brown; diaphragm at base of the tube funnelform, glabrous: stamens 5: stigma cup-shaped, cleft to the middle, the acuminate lobes incurved: capsule broadly ellipsoidal, 8 lines long, shortly stipitate. Rio Blanco, among grass near streams; July. (180.)

Aristolochia Tequilana. Of the same section: stems long, herbaceous, trailing, villous, as also the petioles and peduncles: leaves cordate, acute, with a rather deep sinus and rounded basal lobes, with scattered short appressed hairs above and hispid on the veins beneath, 2 or 2½ inches long; petioles 8 or 10 lines long: peduncles axillary, ½ inch long; bract small, cordate: ovary villous, clavate: calyx with a broad dilated base (4 lines long) closed by a thin shallow-funnelform diaphragm, the geniculate tube (6 lines long) narrowest in the middle and bordered by a triangular-subcordate limb nearly an inch long: stamens 5: style-column very short, the fleshy lobes erect, oblong, obtuse: capsule globose, 6 lines long, abruptly stipitate. Tequila, under bananas. (413.) — Throat spotted with dark brown, the limb and tube lighter.

Aristolochia longipes. Of the same section, the long trailing herbaceous stems from a thick branching root: leaves cordate with a shallow sinus, acute, somewhat scabrous, 4 inches long and broad; petioles stout, an inch long or more: flowers in very slender elongated axillary panicles; bracts cordate, 3 or 4 lines long; peduncles 3 to 5 inches long, the floral bracts lanceolate; ovary densely villous, linear, 8 lines long, the slender base nearly naked: calyx with oblong dilated base (5 lines long) closed by a fleshy funnelform diaphragm, the broad tube (6 or 7 lines long) abruptly recurved on itself, very glabrous within, terminating in a lanceolate limb (2 inches long) surrounding the throat: stamens 5: lobes of the stigma fleshy, erect, short-triangular, acutish: capsule oblong (10 lines long) upon a stout clavate channelled stipe, dehiscing from the summit. Barranca, running over rocks. (139.) — Color a dull greenish purple.

Aristolochia Guadalajarana. Of the same section: stems herbaceous from a branching root, trailing, pubescent with soft spreading hairs: leaves very shortly petiolate, ovate to ovate-oblong, obtuse, cordate at base, 2 inches long or less, somewhat appressed-pubescent, ciliate, reticulately veined beneath: peduncles 4 lines long; bract leaf-like: ovary linear, pubescent: calyx straight, the oblong dilated base (6 lines long) guarded at the mouth by a rather rigid narrow intruded tube; calyx-tube narrow (8 lines long), with a dark brown oblong obtuse or emarginate limb (15 lines long) surrounding the mouth: stamens 5, as long as the column: capsule oblong, obtuse, nearly an inch long, stipitate. Rio Blanco, in moist places; June. (27.)

Piper leucophyllum, C. DC. A small tree in thick clumps. Rio Blanco, in a deep barranca near water; October. (676.)

Piper ——? Shrub, 8 feet high, glabrous, the thin ovate acute or shortly acuminate basi-nerved leaves 2 inches long or less, on short slender petioles: spikes slender, rather shorter than the leaves; stamens apparently 4 or more. Barranca, in dense moist shade. (122.)

Peperomia gracillima. With the habit of and closely allied to *P. umbilicata:* root bulbous: leaves orbicular, $1\frac{1}{2}$ inches in diameter or less, centrally peltate, green above, cupreous beneath: aments sessile, filiform, 4 inches long or less. Rio Blanco, in the deep recesses of overhanging rocks; September. (585.)

Loranthus Palmeri, Watson. Rio Blanco, growing on *Bursera Palmeri;* September. (610.)

Loranthus calyculatus, DC., var. with narrow acutish leaves (3 or 4 inches long by 5 to 12 lines broad) and smaller flowers (15 lines long). Guadalajara; August. (277.) — Frequent on various kinds of trees, peach, orange, olive, oleander, mesquite, and willow.

Phoradendron rubrum, Griseb.? Leaves linear, attenuate to the base, 2 or 3 inches long by 2 to 4 lines broad, straight or somewhat falcate: spikes an inch long or less, 2–3-jointed; berries red, in 1 to 3 (usually 2) contiguous whorls. Chapala, growing in thick bunches. (719.)

Euphorbia umbellulata, Engelm. Rio Blanco, on hills; July. (751.)

Euphorbia radioloides, Boiss.? Larger (3 to 8 inches high) than Seemann's originally described specimens, reddish throughout, villous with spreading hairs: appendages entire: seeds deep salmon-color. Rio Blanco, on the grassy shaded sides of ravines; October. (687.)

Euphorbia adenoptera, Bertol. Rio Blanco; September. (567.)

Euphorbia (Zygophyllidium) retroscabra. Retrorsely scabrous-hispid, the slender stem (2 feet high) from a tuberous root (an inch in diameter or more), with opposite or verticillate branches: leaves opposite or the upper cauline verticillate, linear (1 to 3 inches long), scabrous, shortly petiolate; stipules obsolete: involucres in diffuse terminal cymes, turbinate, 1½ lines long, glabrous or very minutely puberulent; lobes short; appendages of the glands entire, suborbicular, white or yellowish: capsule smooth: seeds ecarunculate, ovate, irregularly tuberculate between shallow depressions. Rio Blanco, on grassy hillsides; July. (157.)

Euphorbia (Cyttarospermum) Guadalajarana. Stem erect, very slender (18 inches high), angled, glabrous, nearly simple: leaves alternate (the lowest opposite), linear (1 to 1½ inches long), deflexed, sparsely villous and ciliate, the petiole (3 or 4 lines long) inserted a little above the rounded base of the blade: peduncles axillary, slender, about equalling the leaves, dichotomous and more or less hispid, the linear-acuminate bracts long-villous: involucres turbinate, purplish, slightly villous; lobes lacerate; glands narrowly oblong, appendaged with 5 to 7 long purple setæ: ovary glabrous; styles simple, spreading. Rio Blanco, in shaded ravines; September. (548.)

Euphorbia Francoana, Boiss. Stems very succulent. Tequila, in shaded ravines. (387.)

Euphorbia plicata, Watson. A form (4 to 6 feet high) with the appendages usually denticulate, and the floral leaves like the cauline; involucres mostly sterile. Chapala, on hilltops. (710, 720.) — The species is near *E. Xanti*, Engelm., which has similar plicate glands, but its leaves are small and linear, the inflorescence less dense, and the appendages of the glands much longer.

Euphorbia sphærorrhiza, Benth. Two feet high; appendages white becoming pink; seeds subglobose and smooth. Rio Blanco, on hillsides; July. (158.)

Euphorbia radians, Benth. Rio Blanco, on grassy hillsides; July. (749.)

Jatropha cordata, Muell. Arg. A shrub, 6 to 10 feet high; juice yellowish, soon drying to a sulphur-colored powder. Barranca. (114.)

Jatropha angustidens, Muell. Arg. About 2 feet high; flowers very fragrant. Barranca, on mountains. (141.)

Croton repens, Schlecht. A small shrub. Rio Blanco, on shady hillsides; August. (329.)

Croton ciliato-glandulosus, Ort. A shrub, 4 feet high. Guadalajara, in ravines; July. (273.)

Croton ——? An apparently diœcious shrub, 6 feet high, with lanceolate acuminate eglandular leaves (1 to 1½ inches long), entire, without stipules, nearly glabrous above, finely stellate-pubescent beneath: male racemes very slender and elongated, loose, the very slender pedicels 1 to 3 lines long; sepals and petals 5; stamens about 15 on a very villous receptacle. Barranca. (93.) — A strongly marked species, but not identified in the absence of fruit.

Croton ——? A stellately scabrous shrub, 2 feet high, the young shoots and leaves very densely white stellate-tomentose; leaves thin, ovate- or oblong-lanceolate, acuminate, biglandular, serrulate, sparingly strigose-scabrous above, stellately so on the veins beneath; petioles rough, 2 to 10 lines long: spikes sessile, the numerous female flowers crowded at the base; calyx-lobes short, triangular, glabrous: ovaries stellately pubescent and hispid; styles elongated, bifid. Chapala, on stream banks. (706.)

Manihot angustiloba, Muell. Arg. A shrub, 4 feet high; staminate calyx lemon-color, 6 to 9 lines long. Barranca. (142.) — Rio Blanco, on shady hillsides; July. (156.)

Acalypha sessilifolia. Diœcious, with numerous subdecumbent herbaceous stems (a foot high or less) from a woody rootstock, hispid and somewhat pubescent: leaves sessile, oblong to oblong-obovate, acute at each end or obtuse above, 4 to 12 lines long, serrate, appressed-hispid both sides: spikes terminal, slender, 1 to 2½ inches long, the staminate dense, the pistillate rather loose; pistillate flowers 1 or 2 in the axils of minute bracts, rarely perfecting fruit, the bract then becoming reniform, 5-toothed, a line long; styles pectinately divided: capsule hispid. Rio Blanco; June. (38, staminate.) — The pistillate specimen in the Cambridge set is numbered 27, which is certainly a mistake.

ACALYPHA FILIFERA. Near *A. Caroliniana;* nearly glabrous: leaves cuneate at base, very finely stellate-pubescent beneath, subciliate and the teeth setosely tipped: fruiting bracts with very long tortuous filiform lobes: capsule glabrous. Barranca, in moist shady places. (111.)

ACALYPHA HYPOGÆA. Annual, 2 or 3 inches high, with short branches, somewhat hispid and pubescent: leaves oblong-ovate, acute, rounded or subcuneate at base, sparingly appressed-hispid on both sides and minutely dotted, 10 lines long or less, on a slender petiole: pistillate spikes dimorphous; the terminal sessile, 3–4-flowered, with broadly cordate 9-toothed bracts (2 or 3 lines long), the smooth capsule with short simple styles and subglobose seeds; flowers of the axillary spikes minute, developing single-celled naked ovaries at the apex of long (2 to 6 inches) filiform pedicels, the ovaries burying in the ground and perfecting a single larger seed: staminate flowers not detected. Rio Blanco, on the wet side of a cañon; September. (595.) — A very curious and peculiar species. The pedicellate ovaries bearing subterranean fruit appear to correspond to the pedicellate flower with a 1–2-celled ovary which occasionally terminates the pistillate spike in some other species.

TRAGIA NEPETÆFOLIA, Cav., var. SETOSA. A more than usually hispid form, the teeth of the ovate to linear leaves mostly tipped with 1 to 3 stiff bristles. Rio Blanco, on damp hillsides; June. (65.)

STILLINGIA ZELAYENSIS, Muell. Arg.? Rio Blanco, on river banks; June. (73.) — Resembling 823 Parry & Palmer, so named, but with the spike much more slender and open. It differs from the description of the species in its smaller sessile capsules (5 lines long, including the very thick base), and smaller seeds (2½ lines long).

CORYTHEA * FILIPES. A shrub, 6 feet high, with numerous slen-

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* CORYTHEA; new genus of *Euphorbiaceæ*, subtribe *Hippomaneæ*. Flowers monœcious, apetalous, the small perianth of 4 to 6 nearly distinct valvate (?)

der branching stems, the branchlets, petioles, and pedicels finely pubescent: leaves thin, oblong-ovate, acutish, rounded or cuneate at base, crenately serrate, glabrate above, somewhat pubescent beneath, 1 to 2½ inches long, on short petioles; stipules scarious, linear: male aments half an inch long, of brown scarious very deeply concave and imbricated bracts, each subtending 6 to 8 exserted minute flowers, which are soon deciduous from the jointed pedicels; calyx 4-parted: female flowers few, from small scaly buds at the base of young shoots, the pedicels very slender, about an inch long, bracteolate near the middle; calyx 6-parted, subpersistent: capsule somewhat rough-tuberculate, 1¼ lines long, soon dehiscent: seeds smooth. Barranca. (90.)

Another peculiar euphorbiaceous species of uncertain affinities, but probably belonging to the *Hippomaneæ*, was collected at Guadalajara (641) in fruit. It is a nearly glabrous shrub, 8 to 12 feet high, the lanceolate acuminate leaves (2 to 4 inches long) acute at base and petiolate, sharply denticulate, pinnately few-veined, eglandular, villous-pubescent beneath: peduncles axillary, 2–3-fruited, an inch long: capsules on stout clavate pedicels (6 to 8 lines long), 8 lines broad, abruptly tipped with the base of the united styles, subtended by 5 green oblong sepals 3 lines long: seed subglobose (3½ lines broad), ecarunculate, dark colored and somewhat roughened; albumen salmon-colored, the erect flattened cotyledons nearly as broad as the seed. It is known as "asafran," and the seeds are eaten, resembling walnuts in taste.

TREMA MICRANTHA, Blume. A shrub, 10 feet high, with flesh-colored fruit. Barranca. (105.)

DORSTENIA DRAKENA, Linn. Barranca, among shaded rocks. (140.) — "Barbasco" of the natives, reputed to be poisonous, and applied in powder or decoction to wounds for the destruction of larvæ.

DORSTENIA CRISPATA. Rootstock thick and scaly, an inch or two long: leaves rather thick, ovate, obtuse, cordate at base, crenately

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sepals. Male flowers minute in axillary sessile aments, several in the axils of the eglandular scarious imbricated galeate bracts, on short jointed pedicels; stamens 3, the free filaments very short. Female flowers on elongated solitary pedicels from the axils of scaly bracts; ovary 3-celled, 3-ovuled; styles distinct. Capsule separating into 2-valved cocci from the persistent columella. Seed estrophiolate, globose. Embryo erect, the broad flat cotyledons longer than the radicle. — A shrub, with alternate membranous serrate leaves.

Nearly related to *Actinostemon*, but with a fully developed (though small) calyx in both the male and female flowers. The name has reference to the helmet-shaped bracts of the male aments.

5–7-lobed, crispately denticulate, 1 to 1½ inches long and exceeding the petioles, very scabrous but naked above, finely pubescent beneath (especially the veins), as also the petioles, peduncles, and receptacles: peduncles equalling or exceeding the leaves; receptacles suborbicular, eccentrically peltate, 8–12 lines broad, the black margin somewhat crispate: female flowers few and scattered. Rio Blanco, in low wet places; June. (39.) — "Barbodillo"; used like the last.

Urera Caracasana, Griseb. A small tree, 18 feet high, with dark pink flowers and very stinging foliage. Barranca. (133.)

Boehmeria Palmeri. A shrub, 8 feet high, covered throughout (except the upper side of the leaves) with a fine soft pubescence: leaves opposite and alternate, or on the branchlets all alternate, ovate-lanceolate, acuminate, rounded at base, or the alternate ones subcuneate at base and with petioles two or three times as long, the larger 3 to 5 inches long by 1½ to 2½ broad, crenately toothed, slightly scabrous and minutely strigose above, at length bullate: spikes mostly leafy at top, 2 to 4 inches long: fruit pubescent, ovate, more or less compressed, immarginate. Tequila, near water. (419.) — Related to *B. bullata*.

Pouzolzia Palmeri. A shrub, 5 to 8 feet high, with smooth brown bark, the branchlets pubescent: leaves ovate or oblong-lanceolate, narrowly and acutely acuminate, cuneate at base, entire, not canescent, ciliate, finely strigose above, subtomentose beneath, 1 to 3 inches long by ½ to 1½ broad; stipules narrowly long-acuminate: flowers monœcious, in dense clusters, pubescent, the male 4-androus; fruiting perianth lanceolate, greenish, narrowly winged laterally above, narrowly 5-toothed at and below the summit. Barranca, in shade. (116.)

Pouzolzia nivea. Closely resembling the last, but the smaller leaves (1 to 1½ inches long) white beneath with a dense fine tomentum, more ovate and less acutely acuminate; stipules acute to acuminate: fruiting perianth narrowly winged laterally and upon the back, 3–5-toothed at the summit. Same locality. (117.)

Salix taxifolia, HBK. Barranca. (85.)

Taxodium mucronatum, Ten. Barranca. (130.) — "Sabino." A straight tree, 50 feet high and 2 to 4 feet in diameter; no knees observed.

Pinus oöcarpa, Schiede. Rio Blanco. (15.) — Only comparatively young trees were seen, 25 feet high and a foot in diameter. The wood is of little value even for fuel.

Microstylis ocreata. Stem a span high, angular, with a loose sheathing bract at base: leaves 2, with loose closed sheaths, the sessile blade narrowly or broadly elliptical, the lower obtuse or acutish, 1½ to 2 inches long, the upper acute and somewhat smaller: raceme rather loose, 2 or 3 inches long; bracts spreading, persistent, a line long or less; pedicels short (1½ lines in fruit): flowers yellow; lateral sepals semicordate, acute, closely contiguous behind the posticous lip, the lower attenuate-lanceolate and slightly longer; petals linear; lip broadly triangular, acute, with narrowly hastate or rounded basal lobes: capsule (immature) oblong, 2 lines long. Rio Blanco, on grassy hillsides; August. (350.)

LIPARIS GALEOTTIANA, Hemsl.? Near *L. elliptica*, Reichenb. f., but distinct from it, at least as represented in herb. Gray by 1410 Fendler, from near Tovar, Venezuela, the same region from which the original of *L. elliptica* came. Palmer's specimens differ especially in the longer, more slender, and more curved column, and in the lip (5 lines long), which is subquadrate-elliptical, broad and very obtuse at the summit and somewhat cordate at base. The ovary is very slender, scarcely thicker than the pedicel, and the brownish petals are longer than the sepals. The lip is yellowish, deeply tinged and strongly veined with dark brown. Rio Blanco, on grassy hillsides; August. (349.)

BLETIA CAMPANULATA, Llav. & Lex. Agreeing nearly with the characters as given by Reichenbach (Bonplandia, 2. 22). The laminæ of the lip (1½ inches long) broaden upward and terminate abruptly near the deep sinus of the broadly obcordate middle lobe, and the veins of the lateral lobes are very prominent or even wing-dilated. Barranca. (127). — Palmer describes the lip as light purple below, canary-color in the middle, and dark purple above.

BLETIA ——? Tall, with longer, narrower, and longer-acuminate leaves than the last, the flowers nearly as large; sepals more acuminate; middle lobe of the lip subquadrate, little contracted above the very broad lateral lobes, crispate, subtruncate above and apiculate, the 5 laminæ broadest in the middle, three of them gradually narrowing upward nearly to the apex; lateral veins not prominent: capsule 2 inches long, narrow, doubly winged at the angles. Rio Blanco, in grassy bottoms; September. (752.) — Apparently the same as 2812 Bourgeau, referred to *B. campanulata*.

BLETIA ——? Habit and foliage similar to the last, but with a single leaf and the flowers smaller (an inch long): sepals and petals oblanceolate, acute, nearly equal; lip not crispate, the lateral lobes triangular, obtuse (5 or 6 lines long), the middle long-produced (6 or

7 lines), moderately dilated toward the end, round-truncate or slightly emarginate and apiculate, the 3 laminæ very broad at the base of the middle lobe and again near the summit, ending abruptly. Rio Blanco, on grassy hillsides; August. (337.) — Color a "beautiful dark salmon and red."

BLETIA ——? Of the *B. verecunda* group, but low and slender, the narrow leaves a span long: flowers few (6 or 7 lines long), narrowed and scarcely gibbous at base, "cream-color within, amber without"; lateral sepals subfalcate, acute, equalling the ligulate obtuse petals; lip flabelliform, the lateral lobes parallel with the broad middle one, which is not produced and but slightly broadened upward, crispate, as also the 3 broad laminæ. Rio Blanco, on rocky hillsides; August. (336.)

SPIRANTHES GRAMINEA, Lindl. Rio Blanco, in damp shade; October. (747.) — Resembling the original 224 Hartweg except that the lower sheaths appear to be more completely closed; hardly the species of the Atlantic States so called.

SPIRANTHES AURANTIACA, Benth. & Hook. Rio Blanco, in deep barrancas; September. (581, but written 481 in the Cambridge set.) — Flowers and bracts orange-color; the foliage blackens as soon as placed in paper.

HABENARIA SPATHACEA, Rich. & Gal. Stem from a soft tuberous root, over a foot high, covered with sheathing spathe-like leaves (3 or 4 inches long): flowers 2 or 3, lemon-color, on long pedicels within large dilated foliaceous bracts; sepals broad, 5 lines long; petals 2-parted, the upper division twice broader and subfalcate lip subequally 3-cleft nearly to the base, 6 or 8 lines long. Rio Blanco, on grassy hillsides; September. (342.) — A peculiar species which can scarcely be mistaken.

HABENARIA JALISCANA. A foot high from a small tuberous root, stout and leafy: leaves lanceolate, or the lower ovate, acute, sheathing, 3 inches long or less: raceme short and open, with large foliaceous bracts: sepals ovate, acute, nearly equal (4 lines long), the lateral subfalcate; petals 2-parted and lip 3-parted, the divisions strongly falcate excepting the ligulate-spatulate obtuse middle lobe of the lip, its longer (6 lines) lateral lobes and the lower lobes of the petals approximate on each side, linear, acuminate, the upper petal-lobes contiguous to the upper sepal; spur narrowly clavate, 12 to 15 lines long: column with fleshy oblong appendages at base 1½ lines long; stigmatic processes 1½ lines long. Rio Blanco, in moist bottoms; August. (343.) — Flowers greenish yellow. This (as the following) may be some one of the species named by Richard & Galeotti, but their descriptions certainly do not apply to the specimens.

HABENARIA GUADALAJARANA. Habit of the last; leaves ovate, sheathing, shortly acuminate or acute, $1\frac{1}{2}$ inches long or less: raceme rather slender, 4 inches long, the bracts equalling the ovaries: sepals $2\frac{1}{2}$ or 3 lines long, the upper broadly ovate, acute, sharply carinate, the lateral oblong-lanceolate, acute; middle lobe of the lip narrowly ligulate, slightly shorter than the subfiliform lateral lobes and lower segments of the petals, the upper divisions of the petals narrowly lanceolate, acute, slightly falcate; spur clavate, equalling the ovary: processes nearly a line long; appendages at base of the column very thick and verrucose. Guadalajara, in wet bottoms; August. (276.) — Flowers greenish yellow. With this in the Cambridge set is a small specimen with fewer and smaller flowers and narrower acuminate leaves, which belongs to some other species.

MARANTA ARUNDINACEA, Linn. Tequila, in the shade of rocks. (418^2.)

PITCAIRNIA PALMERI. Acaulescent, somewhat furfuraceous throughout, the basal bracts ending in retrorsely spinose filiform appendages: leaves of sterile shoots few (6 to 8), very narrowly linear, entire, sparsely villous, 4 inches long; leaves of flowering stems (6 to 15 inches high) all bract-like, erect, very narrowly attenuate and convolute; floral bracts narrow, shorter than the reflexed pedicels (4 to 8 lines long): sepals narrow, acuminate, nearly glabrous; petals nearly thrice longer ($1\frac{1}{2}$ inches), narrow, light red, curved upward: stamens and style included: capsule 3 lines long. Rio Blanco, in crevices of shaded rocks, often abundant; June. (16.)

PITCAIRNIA JALISCANA. Acaulescent: basal bracts spinosely margined and appendaged; leaves furfuraceous beneath, entire, linear, 12 to 15 inches long by 3 or 4 lines broad: flowering stem many-bracted, mostly glabrous, about 2 feet high including the half as long glabrous raceme; floral bracts mostly colored, dilated, acuminate, much exceeding the ascending pedicels: petals bright scarlet, linear, nearly 2 inches long, twice longer than the linear acuminate more or less colored sepals: stamens and style slightly exserted: capsule narrow, 6 lines long. Rio Blanco, in the crevices of rocks in deep ravines; August. (348.)

NEMASTYLIS TENUIS, Benth. & Hook. Perianth pink with a shade of yellow on the outside. Rio Blanco, in grassy openings, very abundant; July. (165.) — "Coquistle"; the bulbs are collected for food.

NEMASTYLIS VERSICOLOR. Radical leaves elongated (to $2\frac{1}{2}$ feet long), 1½ or 2 lines wide, plicate and retrorsely scabrous on the margins of the folds: stems 1½ to 2 feet high, subterete, smooth, with two rather rigid bracts at first plicate and retrorsely spinulose-scabrous: spathes terminal, nearly equal and equalling the pedicels (1½ to 2 inches long), smooth, 1–4-flowered: perianth 9 lines long, concolorous both sides, the outer segments cuneate-obovate, abruptly short-acuminate, violet, the inner with a short broadly cuneate claw, broadly elliptical with a subhastate base, blue-violet with an obtuse orange-colored apiculation, and an angular band of yellow connecting the basal lobes: stamineal column 3 lines long; anthers 2 lines long, with a broad connective, equalling the style-divisions: capsule oblong-obovate, 6 lines long. Rio Blanco, among grass near water; July. (182.) — "Cacomite"; the bulbs are sold in the markets, and eaten either boiled or roasted.

SISYRINCHIUM —— ? A yellow-flowered short-leaved species. Rio Blanco, in moist places; June. (18.)

ZEPHYRANTHES PALLIDA, Roem. Flowers white turning to dark pink. Rio Blanco, in rich moist places; June. (72.)

SPREKELIA FORMOSISSIMA, Herb. Rio Blanco, on shady ledges and hillsides; June. (71.)

BOMAREA AFFINIS, Kunth? Glabrous throughout, or the leaves very slightly pubescent beneath near the base; perianth tipped with green, at first sulphur-color, then salmon, dotted with brown. Tequila, in the barranca, among underbrush. (420.)

PROCHNYANTHES* VIRIDESCENS. Glabrous: flowering stem 4 to 6 feet high, from a short caudex covered with broad clasping bracts (4 to 6 inches long, and at length wholly fibrous), few-leaved near the base: leaves a foot long or more by 1 to 1½ inches broad, acuminate, attenuate below into a long winged petiole, somewhat scabrous especially on the margins; bracts above few and distant; floral bracts lanceolate, half an inch long: pedicels ascending, 1 to 1½ inches long: flowers greenish yellow with a tinge of brown; ovary narrowly oblong,

* PROCHNYANTHES; new genus of *Agaveæ*. Perianth persistent, its tube sub-cylindrical at base, abruptly geniculate and dilated, with erect equal lobes. Stamens inserted at the base of the throat, nearly equalling the lobes; filaments filiform, free; anthers linear, dorsifixed. Ovary 3-celled; ovules numerous; style filiform; stigmas oblong. Capsule membranaceous, sub-globose, loculicidally dehiscent. Seeds numerous, flat-compressed, subdeltoid; testa dark, close. — Stem erect from a short thick erect bract-covered caudex, simple, leafy below, sparingly bracteate above. Leaves unarmed, linear-lanceolate, petiolate, subcoriaceous, many-veined. Flowers racemose, on jointless pedicels, somewhat fascicled (1 to 3) in the axils.

This genus is closely related to *Polyanthes*, differing in its habit and foliage and in the characters of the perianth.

3 lines long, nearly as long as the cylindrical part of the perianth; the dilated portion 9 lines long including the broadly triangular lobes (3 lines long): style shorter than the filaments: capsule 6 lines long. Rio Blanco, on shaded hillsides; June. (9.) — An "amole"; a wash made from the roots is used as an insecticide upon animals.

BRAVOA GEMINIFLORA, Llav. & Lex. Rio Blanco, on grassy hillsides; August. (345, 346, with yellow and red flowers respectively.)

DIOSCOREA REMOTIFLORA, Kunth? Rather nearly answering to Schlechtendal's description, but the very slender compound racemes (as in *D. sparsiflora*, Hemsl.) solitary in the axils and much exceeding the leaves, or in a terminal panicle, and the fruit smaller (7 or 8 lines long). The seeds are nearly surrounded by a suborbicular wing, 3 lines broad. Rio Blanco, in shady ravines; August. (331.)

DIOSCOREA JALISCANA. Very slender, glabrous throughout or nearly so: leaves thin, on slender petioles (6 lines long), 9-nerved, triangular- or ovate-cordate, short-acuminate, 1½ inches long, usually puberulent on the veins beneath: racemes compound, axillary or terminal, the staminate with branches 2 or 3 inches long, loosely flowered, the pedicels 1½ lines long: male perianth parted nearly to the base, 1½ lines broad, greenish yellow; stamens 3, with short triangular filaments: fruiting racemes an inch long or more, the very shortly pedicellate fruit 4 lines long: seed winged at the base, with a narrow outer margin. Rio Blanco; September. (542.)

ECHEANDIA TERNIFLORA, Ort. Rio Blanco, in wet ravines; July. (185.)

MILLA BIFLORA, Cav. Rio Blanco, on hillsides September. (529.) — "San Nicolas."

BESSERA ELEGANS, Schultes. Barranca. (128.)

NOTHOSCORDUM FRAGRANS, Kunth. Rio Blanco, in wet bottoms; June. (70.)

CALOCHORTUS BONPLANDIANUS, Schult. f. Rio Blanco, common on grassy hillsides; August. (338.)

CALOCHORTUS HARTWEGI, Benth., at least the flowering specimens; but hardly distinct from the last. Rio Blanco, on grassy sides of ravines, not common; September. (580.)

XYRIS —— ? Guadalajara, in a swamp; September. (445.) — No species of the genus has hitherto been known from Mexico.

PISTIA STRATIOTES, Linn., var. OBCORDATA, Engler. (*P. obcordata*, Michx.) Lake Chapala; October. (723.)

ERIOCAULON BENTHAMI, Kunth. Rio Blanco, in wet bottoms; June. (44.)

JUNCUS * MARGINATUS, Rostk. Near var. *biflorus*, Engelm. Rio Blanco. (13.) — J. ACUMINATUS, Michx.? Guadalajara. (241.)

CYPERUS SERRULATUS, Watson. Rio Blanco. (14.) — C. SURINAMENSIS, Rottb. Rio Blanco. (191.) — C. ESCULENTUS, Linn. Rio Blanco. (194.) — C. UNIOLOIDES, R. Br., var. BROMOIDES, Clarke. Rio Blanco. (195.) — C. PROLIXUS, HBK. Rio Blanco. (213.) — C. NODOSUS, Willd. Guadalajara. (249.) — C. SESLERIOIDES, HBK. Guadalajara. (290, as given in the Cambridge set; perhaps 250 was intended.) — C. AMABILIS, Vahl. Guadalajara. (433.) — C. FUGAX, Liebm. Guadalajara. (B.) — Also a species too young for determination. Guadalajara. (253.)

KYLLINGA CÆSPITOSA, Nees. Barranca. (82.) — Same, var. ELATIOR, Boeckl. Rio Blanco. (192.) — K. ODORATA, Vahl. Guadalajara. (253[a], as reported; should probably be 233.)

RHYNCHOSPORA, diseased. Rio Blanco, on rocky hills, among pines. (202.)

ELEOCHARIS PALUSTRIS, R. Br.?; immature. Guadalajara. (225.) — E. QUADRANGULATA, R. Br. Guadalajara. (431.)

FIMBRISTYLIS LAXA, Vahl. Guadalajara. (232.) — F. CILIATIFOLIA, Britton, *n. sp.* (271.)

SCLERIA RETICULARIS, Michx., var. PUBESCENS, Britton. Guadalajara. (434.)

PASPALUM † LIVIDUM, Trin. Guadalajara. (245.) Also a variety (?), used for sodding embankments. Rio Blanco. (206.) — P. HUMBOLDTIANUM, Fluegge. Rio Blanco and Guadalajara. (189, 286.) — P. PLICATULUM, Michx. Rio Blanco and Guadalajara. (190, 468.) — P. PANICULATUM, Linn., var.? Barranca. (144.) — P. NOTATUM, Fluegge. Guadalajara. (295.) — Undetermined species. Guadalajara. (243.) (592, 617.)

PANICUM COLONUM, Linn. Rio Blanco. (193.) — P. KUNTHII, Fourn.? Rio Blanco. (207, 208.) — P. BULBOSUM, HBK. Rio Blanco. (209.) — P. CÆSPITOSUM, Swartz. Rio Blanco. (254.) — P. DIVARICATUM, Linn. Tequila. (362.) — P. (§ PTYCHOPHYLLUM) —— ? An excellent forage grass, much used for fodder. Tequila. (372.) — P. FILIFORME, Linn. Tequila, Guadalajara, and Rio Blanco, taking possession of old fields. (366, 454, 502.) — P. PASPALOIDES, Pers. Guadalajara, in water. (429.) — P. CRUS-GALLI, Linn., forms. Guadalajara. (430.) — P. VIRGATUM, Linn.,

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* *Juncaceæ* and *Cyperaceæ* determined by Dr. N. L. BRITTON.
† *Gramineæ* determined by Dr. GEORGE VASEY.

var. Rio Blanco. (510.) — P. OAXACENSE, Fourn. Rio Blanco, in deep cañons; arundinaceous, recumbent on rocks and bushes, rarely over 6 feet tall. (535.)

OPLISMENUS SETARIUS, Roem. & Schult.? Guadalajara. (463.)

CHÆTIUM BROMOIDES, Benth. Guadalajara. (475, 619.)

SETARIA GLAUCA, Beauv., varieties. Rio Blanco and Guadalajara. (211, 246.) Guadalajara. (293.) — S. VERTICILLATA, Beauv. Tequila. (404?, reported as 484.)

PENNISETUM MEXICANUM, Hemsl.? Rio Blanco, in a garden. (514.) — P. SETOSUM, Rich.? Rio Blanco. (677.)

TRIPSACUM FASCICULATUM, Fourn. Rio Blanco. (508.) — Undetermined species. Rio Blanco. (509.)

LEERSIA HEXANDRA, Sw. Guadalajara. (244.)

ARUNDINELLA, undetermined species. Rio Blanco. (12.) — Rio Blanco. (525, 526?, reported as 562.)

CENCHRUS MYOSUROIDES, HBK. Guadalajara. (765.)

HILARIA CENCHROIDES, HBK., varieties. Rio Blanco and Guadalajara. (197, 296.) — "Gramma"; used medicinally.

ÆGOPOGON GRACILIS, Vasey. Guadalajara and Rio Blanco. (247, 505.) — Æ. GEMINIFLORUS, HBK., and var. Guadalajara. (479.) Rio Blanco. (557.)

CATHESTICUM ERECTUM, Vasey & Haeckel, var. Rio Blanco and Guadalajara. (196, 270.) — "Gramma"; used medicinally.

IMPERATA HOOKERI, Rupr. (*I. arundinacea* of American authors. *I. brevifolia*, Vasey.) Guadalajara. (444.)

MANISURIS GRANULARIS, Sw. (396?, reported as 366.)

TRACHYPOGON POLYMORPHUS, Haeckel, var. Guadalajara and Rio Blanco. (467, 527.) Also subvar. SECUNDUS, Haeckel. Rio Blanco. (303.)

CHRYSOPOGON NUTANS, Benth., var. Rio Blanco. (511.) — C. MINOR, Vasey, *n. sp.* Rio Blanco. (590.) — C. ——, *n. sp.*? Rio Blanco. (513.)

HETEROPOGON CONTORTUS, Roem. & Schult. Guadalajara. (767.) — Undetermined species. Rio Blanco. (589.) — Rio Blanco. (A.)

ANDROPOGON LIEBMANNI, Haeckel. Guadalajara. (227.) — A. SACCHAROIDES, Sw., var. PERFORATUS, subvar. PALMERI, Haeckel. Rio Blanco. (305.) — A. TENER, Kunth, var. Rio Blanco. (504.) — A. HIRTIFLORUS, Kunth, var. Rio Blanco; used for thatching. (506.) — A. FASTIGIATUS, Sw. Rio Blanco. (507, 588.) — A. BREVIFOLIUS, Sw. Rio Blanco. (593.) — Undetermined species. Guadalajara. (466.) — Rio Blanco. (591.)

Aristida setifolia, HBK.? Rio Blanco. (501.) Also a variety of same. Guadalajara. (284.) — Undetermined species. Guadalajara and Rio Blanco. (474, 476, 516.) — Rio Blanco. (520, 521.) — Rio Blanco. (768.) — Rio Blanco. (769.)

Epicampes mutica, Fourn.? Rio Blanco. (518, 519.)

Muhlenbergia lycurioides, Vasey, *n. sp.* Guadalajara. (489.) The same as 680 Botteri. — M. affinis, Trin. Rio Blanco. (522.) — M. longiglumis, Vasey, *n. sp.* Guadalajara. (766.) — Undetermined species. Guadalajara. (457.) — Guadalajara. (481, 482.) Rio Blanco. (515.) — Rio Blanco. (523, 524.) — Rio Blanco. (645.) — Rio Blanco. (682.) — Guadalajara. (770.)

Sporobolus Indicus, R. Br., var.? Rio Blanco; "Lindrilla," sometimes twisted into ropes. (205, 302 reported as 502.) — S. argutus, Kunth, var. Guadalajara. (294.) — Undetermined species. Rio Blanco. (512.)

Agrostis verticillata, Vill. Guadalajara. (230, 231.)

Perieilema crinitum, Presl. Guadalajara. (499.)

Lycurus phalaroides, HBK.? Guadalajara. (459.)

Trisetum deyeuxioides, Kunth. Rio Blanco. (210.)

Tristachya leiostachya, Nees. Rio Blanco. (304.)

Microchloa setacea, R. Br. Rio Blanco and Guadalajara. (198, 616.)

Chloris elegans, HBK. Rio Blanco. (199.) — C. submutica, HBK. Guadalajara. (242.)

Bouteloua bromoides, Lag. Rio Blanco. (188.) — B. Fourierana, Vasey. (*Triathera gracilis*, Fourn.?) Rio Blanco. (200.) — B. hirsuta, Lag., var. Palmeri, Vasey. Rio Blanco. (201.) — B. juncifolia, Lag.? Rio Blanco. (301.) — B. tenuis, HBK.? Guadalajara. (480.) — B. racemosa, Lag. Rio Blanco. (503.)

Eleusine Ægyptiaca, Pers. Guadalajara. (435.) — E. Indica, Gaertn. Guadalajara. (255, 478.)

Opizia stolonifera, Presl. Guadalajara. (615.)

Diplachne imbricata, Scribner. Rio Blanco. (311?, reported as 331.)

Poa infima, HBK. Guadalajara. (483.)

Eragrostis lugens, Nees. Rio Blanco. (203.) — E. limbata, Fourn. Guadalajara. (234.) Same as 1305 Bourgeau. — Undetermined species. Guadalajara. (240.) Same as 2167 Mueller.

Acrostichum * araneosum, D. C. Eaton, *n. sp.* Rootstock creep-

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* The determinations and descriptions of the following Cryptogams are from Professor D. C. Eaton.

ing, rather stout, chaffy: stalks slender, chaffy with thin narrow acuminate long-ciliate scales; fronds 5–7 inches long; the sterile 10 lines wide, oblong-linear, narrowed at the base, subacute at the apex, beneath sparingly resinous-dotted, both surfaces and the edges webby-pubescent with slender stellate hairs, veins mostly twice forked, veinlets crowded; fertile fronds half the width of the sterile, acuminate, stellate-pubescent above. Rio Blanco, in wet shady spots in ravines: August. (333.) — Fertile stalks 7 or 8 inches long; sterile ones about 2 inches long. *A. Mulleri*, Fournier, has a similar pubescence of very delicate 6–8-rayed stellate hairs, but is a much smaller plant with oval-lanceolate fronds. More abundant specimens might possibly show a connection between the two.

POLYPODIUM AUREUM, Linn., var. AREOLATUM. Tequila, growing in the crevices of rocks. (376.) — This fern is usually epiphytic, although Galeotti collected it (*P. fulvum*, Mart. & Gal.) on calcareous rocks. Liebmann found it only on trees, and questioned the accuracy of Leibold, who reported it as growing on the graves of Indians.

POLYPODIUM THYSSANOLEPIS, Al. Braun. Rio Blanco, on the tops of adobe walls; October. (730.)

POLYPODIUM PLESIOSORUM, Kunze. Among shady rocks at Tequila; not much seen. (374.)

GYMNOGRAMME PEDATA, Kaulf. Rio Blanco, on earth in deep shady ravines; July. (151.)

GYMNOGRAMME TARTAREA, Desv. Guadalajara, on the shady side of gravel pits and banks; July. (216.)

NOTHOLÆNA SINUATA, Kaulf. The typical form. Guadalajara, on shady embankments and old walls and among rocks in deep gullies and cañons; October. (633.)

NOTHOLÆNA FERRUGINEA, Hooker. With the last (632), and in similar places at Rio Blanco; September. (551.)

NOTHOLÆNA BRACHYPUS, J. Smith. Rio Blanco, on shady banks; June. (57.) Also among rocks in shady ravines; October. (733.) Barranca, on shady banks. (80.) — Some of the fronds are over a foot long.

NOTHOLÆNA AURANTIACA, D. C. Eaton, *n. sp.* Rootstocks entangled, covered with narrow rigid blackish scales: stalks slender, dark brown, 3 or 4 inches long; fronds pentagonal-deltoid, 1 or 2 inches long, and nearly as broad, bipinnatifid, the lower pair of pinnæ having the inferior segments prolonged, especially the basal ones, and again lobed, second pair larger than the third; upper surface scantily hispidulous, lower surface ceraceous with deep yellow powder, and densely scaly with entire cordate-ovate brown imbricated scales, which cover all but the lips of the lobes: sporangia submarginal. Near Barranca, from dry and exposed places on mountain sides. (83.) — This has fronds with something of the outline of *N. Hookeri*, but rather smaller and more sharply deltoid. The copious cinnamon-colored scales, contrasted with the orange powder and with the deep green of the upper surface, give it a very peculiar appearance. Mr. Baker's *N. deltoidea*, as described, must be a good deal like it in some respects, but lacks the ceraceous powder.

NOTHOLÆNA LEMMONI, D. C. Eaton. Chapala, on walls and among rocks on shaded hillsides. (701.) — Fine specimens; the powder of the lower surface pure white.

NOTHOLÆNA GRAYI, Davenport. Taken from the face of large rocks in a cañon at Rio Blanco; September. (555.) — Large specimens, like Schaffner's 962.

NOTHOLÆNA PALMERI, Baker. Crevices of rocks in a deep cañon at Rio Blanco; September. (541.) — Differing in no respect from the original specimens (991 Parry & Palmer), figured in Hooker's Icones Plantarum, t. 1678.

PELLÆA RIGIDA, Hooker. Rio Blanco, among rocks in shady ravines; October. (729.)

PELLÆA SEEMANNI, Hooker. Guadalajara, among rocks on shaded hillsides; July. (300.) Rio Blanco, on walls densely shaded by Opuntias; October. (732.) — These plants have more decompound fronds and smaller segments than the original. No. 87 of the collection of 1885, which I had taken for a smooth form of *Cheilanthes microphylla*, is the same thing.

PELLÆA TERNIFOLIA, Link. Rio Blanco, in the crevices of shaded rocks. (764).

PELLÆA ANGUSTIFOLIA, Baker. Rio Blanco, on the shaded sides of ravines; July, August. (177, 306.) Also var. CUNEATA, Baker. Tequila, in crevices of rocks. (358.)

PELLÆA MARGINATA, Baker. Barranca, on shaded earth. (81.) — Rio Blanco; August. (307.) Also var. PYRAMIDALIS, Baker. Rio Blanco; September. (761.)

PELLÆA CORDATA, J. Smith, var.? A form with auriculate-hastate pinnæ, the fronds pinnate or sparingly bipinnate, which may perhaps be best referred to this species. Rio Blanco, in ravines; September. (543.)

PELLÆA FLEXUOSA, Link. Rio Blanco, on the tops of adobe walls; October. (731.)

Cheilanthes Cooperæ, D. C. Eaton. Barranca, in shaded places on earth and among rocks. (78.) — These specimens have larger, more decompound, and much more pilose fronds than the Californian plant, but the texture is the same, and the pilosity consists of the same "nearly white articulated often gland-tipped and viscid hairs." In spite of the temptation to describe a new species, I am persuaded that this is only the larger and more fully developed form of *C. Cooperæ.*

Cheilanthes viscosa, Link. Guadalajara, on the shaded side of an embankment of earth; July. (292.)

Cheilanthes myriophylla, Desv. Guadalajara, with the last (291), and on embankments among bushes; September. (494.) Also Rio Blanco, in masses on exposed rocks in deep cañons; July. (58.)

Cheilanthes Palmeri, D. C. Eaton, *n. sp.* Stalks densely clustered on a short rootstock, 4 to 6 inches long, bearing a few broad thin scales, and more or less pubescent, like all the rhachises, with soft many-jointed hairs; fronds 8 to 9 inches long, two thirds as broad, ovate, pointed, herbaceous in texture, above green and puberulent, beneath sparingly ceraceous with yellow globules, bipinnate; lowest pair of pinnæ not longer than the second; pinnules oblong-lanceolate, inferior ones longest, the larger ones pinnately cut into 6 or 7 oblong or rounded lateral lobes on each side, and a larger subcaudate terminal one; involucres narrow, very delicate, subcontinuous. Guadalajara, on a shady bank in a deep cañon; July. (223.) — This fine *Aleuropteris* is very different from any form of *C. farinosa*, in that it is a larger plant, quite herbaceous in texture, softly pubescent everywhere except on the lower surface, and has the pinnæ and pinnules as decidedly caudate as those of the common forms of *Pteris aquilina.* With the large plant came a smaller and younger one, having the divisions less plainly caudate, but with the same texture, pubescence, and ceraceous powder.

Adiantum convolutum, Fournier. Rio Blanco, under bushes in shady ravines. (762.) — The mature fronds are all sterile, and have very much the appearance of *A. emarginatum*, but the pinnules are very obscurely denticulate. There is a little greenish spot in the axils of the branches of these specimens, which I have not seen in the Californian species. A single very immature frond shows the transversely oblong involucres which belong to both species, but not to *A. glaucophyllum*, Hooker, of which Fournier's name was made a synonym by Keyserling. Fendler's no. 68 from Venezuela seems to be good *A. convolutum*, and 238 Ghiesbreght from Chiapas is typical *A. glaucophyllum.*

ADIANTUM CONCINNUM, HBK. Barranca, among shaded rocks near water. (75.) — Dr. Palmer notes that the young fronds when living have a fine bright bronzy color, which is lost in drying.

ADIANTUM TRICHOLEPIS, Fée. Barranca, among rocks in very much shaded places, or near water. (74.) Tequila. (406.) — Fine specimens, the fronds fully 16 inches long and nearly as broad, quadripinnate and even partially quinquepinnate at the base. The rootstock is as stout as that of *Polypodium vulgare*, very scaly, knotted and distinctly creeping, one fragment being over two inches long. "Commonly called *Silantrillo de pozo;* this plant is made into a tea, and taken for chills and fever."

ADIANTUM PATENS, Willd. Rio Blanco, among rocks in deep ravines; July. (176.) Guadalajara, on earth embankments in shady cañons. July. (222.) — "Has the smell of sweet clover."

BLECHNUM OCCIDENTALE, Linn. Barranca, near a ditch. (77.)

ASPLENIUM TRICHOMANES, Linn., var. REPENS, Davenport. Barranca, on damp shady mountain-sides, on earth. (79.) — Copiously radicant at the apex, as is seen in *Camptosorus*, and often in the allied *A. crenulatum.*

ASPLENIUM MONANTHEMUM, Linn. Rio Blanco, on the shady side of a high bluff; September. (562.) — Large specimens, sometimes with 7 or 8 sori on a pinna.

ASPLENIUM PUMILUM, Swartz. Tequila, on the face of an embankment of earth. (375.)

ASPIDIUM PATENS, Swartz. Barranca, among rocks or in holes in the earth in deep cañons. (76.) Guadalajara, September. (451, 455.)

ASPIDIUM MEXICANUM, Kunze. Rio Blanco, in deep ravines; July. (149). Guadalajara, on an embankment, in shade; July. (288.)

WOODSIA MOLLIS, J. Smith. Guadalajara, on earth in shady ravines and cañons, many plants growing together; July, September. (217, 452.) Rio Blanco; October. (763.)

ANEIMIA HIRSUTA, Swartz. Tequila, among other plants on the shaded sides of embankments. (405.)

ANEIMIA ADIANTIFOLIA, Swartz. Guadalajara, among rocks in deep ravines; September. (439.)

OSMUNDA REGALIS, Linn. Rio Blanco, on the border of the river in a deep cañon; October. (660.)

PSILOTUM TRIQUETRUM, Linn. Rio Blanco, in crevices of rocks; October. (688.)

SELAGINELLA BINERVIS, Liebm. Rio Blanco, in damp rocky recesses; September. (558.)

2. *Descriptions of some New Species of Plants.*

CARDAMINE LYALLII. Glabrous: stem erect from a running rootstock, simple or branched, a foot or two high: leaves few (4 to 8), petiolate, undivided, reniform to cordate, the margin sinuate, 1 to 3 inches broad: raceme pedunculate; flowers white: pods an inch long or less, on spreading pedicels, rather shortly attenuate to a very short style: radicle cleft to the middle. — *C. cordifolia*, Watson, Bot. King, 19, in part; Gray, Proc. Amer. Acad. 8. 376; Torr. Bot. Wilkes, 229. In the Cascade Mountains of Oregon and Washington Territory (*Wilkes*, *Lyall*, 29 *Hall*, *G. R. Vasey*, *J. Howell*); Blue Mountains, Oregon (*Cusick*); Clover Mountains, Nevada (*Watson*). With fewer, broader, and blunter leaves and more glabrous than *C. cordifolia* of the Rocky Mountains. It more nearly resembles the European *C. asarifolia*, which differs in habit and has the pods more attenuate.

ARABIS (TURRITIS) CONFINIS. Biennial, rarely somewhat glaucous; stems erect, one or several, usually simple, 1 to 3 feet high: lower leaves oblanceolate, usually dentate, finely stellate-pubescent or sometimes glabrous, the cauline oblong to linear-lanceolate, auriculate: flowers white or pinkish: pods more or less spreading or suberect, a line broad or less, straight or slightly curved, usually more or less attenuate above and beaked: seeds small, narrowly oblong, winged. — *A. lævigata*, Hook. Fl. Bor.-Am. 1. 43. *Turritis glabra*, and var. *β*, Torr. & Gray, Fl. 1. 78 and 666. *T. brachycarpa*, Torr. & Gray, l. c. 79. *T. stricta*, Torr. Fl. N. Y. 1. 53, not Grah.; Gray, Gen. Ill. 1. 144, t. 59. *A. Drummondii*, Gray, Manual, 69. From the lower St. Lawrence (Tadoussac, *Pickering*) along the Great Lakes to Lake Winnipeg (*Bourgeau*), and more rarely southward (Mt. Willard, *Faxon*; Dracut, Concord, and Brookline, Mass., *Dame*, *Deane*, *Faxon*; Thimble Islands, Conn., *A. L. Winton*; Cayuga Co., N. Y., *Dudley*; Elgin and Dixon, Ill., *Vasey*). It includes all the "A. Drummondii" of the Atlantic region.

Of related species, A. DRUMMONDII, Graham, is confined to the western mountains, glaucous and glabrous, or usually pubescent below with appressed hairs attached by the middle, with broader straight erect blunt pods, and broadly elliptical winged seeds. — A. HIRSUTA, Scop., has all its leaves more or less hairy or ciliate, the very narrow pods erect, and the suborbicular very narrowly winged seeds nearly in one row. — A. PERFOLIATA, Lam., is glaucous, with the lower leaves usually more or less hirsute or coarsely stellate-pubescent, the very narrow pods strictly erect, and the crowded very irregular somewhat turgid seeds marginless. The position of the radicle is variable, and may be accumbent or incumbent in seeds from the same pod. In an attempt to reduce to order the American members of this genus it has seemed necessary to propose the following new species, all belonging to the section *Turritis*.

ARABIS BOLANDERI. Biennial, more or less pubescent throughout with soft stellate hairs, the solitary stem much branched, a foot or two high: radical leaves not seen; the cauline lanceolate, auriculate, entire, 1 or 2 inches long: flowers small, rose-colored: pods mostly divaricately spreading on pedicels a line or two long, glabrous, straight, obtuse with a broad sessile stigma, 6 to 18 lines long, the valves 1-nerved to the middle: seeds orbicular to elliptical, narrowly winged, somewhat in two rows. — Yosemite Valley or Mono Pass (*Bolander*); mountains of Washington Territory (*Brandegee*); also collected by *Dr. Torrey*, a more glabrous form, probably in the mountains of California, but ticketed in his herbarium as from Colorado.

ARABIS PERENNANS. Perennial, with a usually branching and somewhat woody base, roughly stellate-pubescent or sometimes glabrous above, about a foot high: lower leaves broadly spatulate to narrowly oblanceolate, dentate or sinuate, the petioles sometimes ciliate, the cauline linear-oblong, auriculate, mostly entire: flowers small, often pale: pods divaricately spreading or reflexed, usually curved, glabrous, 1 or 2 inches long by a line broad or less, obtuse or acutish, the small stigma sessile: seeds orbicular, very narrowly margined. — *Turritis patula*, Gray, Ives's Rep. 6. *A. arcuata* and *A. retrofracta*, Watson, Bot. King Exp. 18, in part. Distributed by Pringle (1881) under the name *A. Holbœllii*, var. *perennans*. From northern Nevada and Utah to Arizona and the San Bernardino Mountains in California.

ARABIS BECKWITHII. Resembling *A. subpinnatifida*, biennial, hoary with a fine dense stellate pubescence: stem erect, a span high: leaves entire, an inch long or less, the radical oblanceolate, the cauline lanceolate, auriculate: flowers rose-color, 3 to 6 lines long: pods glabrous (or slightly pubescent when young), spreading and arcuate, 2½ inches long by a line wide, acutish, the stigma sessile: seeds broadly elliptical. — Nevada (Quartz Mountains, *Beckwith*; near Carson City, *Watson*; Candelaria, *Shockley*); San Bernardino Mountains, California (*Parish Brothers*, 1302).

ARABIS LEMMONI. Perennial, low (a span high or less), glaucous, hoary below with fine densely stellate pubescence, the stems several from a branching caudex, slender, glabrous above: lower leaves spatulate-oblanceolate, rarely with one or two teeth, 6 to 9 lines long, the petiole sometimes ciliate, the cauline oblong-lanceolate, auriculate, mostly glabrous or nearly so: flowers small, rose-colored, the sepals pubescent: pods ascending or widely spreading on short pedicels (1 to 3 lines), glabrous, curved, 1 or 2 inches long by $\frac{2}{3}$ of a line wide, more or less attenuate to a sessile stigma or short style: seeds in one row, orbicular, narrowly winged. — *A canescens*, and var. *latifolia*, Watson, Bot. King Exp. 16, and Bot. Calif. 1. 32, 2. 431. In the mountains from western Wyoming (*Parry*), Montana (*Richardson*, *Watson*, *Canby*), and British America (Bow River Pass and Silver City, *Macoun*), to northern Nevada (*Watson*) and California (*Lemmon*, *Mrs. Austin*), and Washington Territory (Mt. Adams, *Suksdorf*).

ARABIS PARISHII. Low and cespitose (2 to 4 inches high), very finely stellate-pubescent throughout, the simple slender stems from a much branched caudex: leaves entire, the lower numerous, linear-oblanceolate, 6 lines long or less, the cauline few, linear, not auriculate: flowers rose-color, 3 or 4 lines long: pods glabrous, ascending on pedicels 2 or 3 lines long, an inch long (including the elongated filiform style) by a line broad, attenuate above; valves 1-nerved and veined: seeds somewhat 2-rowed, elliptical, narrowly winged. — In Bear Valley of the San Bernardino Mountains, California, at 6,500 feet altitude (*S. B. Parish*, June, 1886).

ARABIS PULCHRA, M. E. Jones in herb. Perennial, canescent throughout with a fine stellate pubescence, the stems erect (a foot high) from a branching woody base: leaves entire, not rosulate at base nor auriculate, the lower narrowly oblanceolate (1 or 2 inches long), the upper linear-lanceolate: flowers usually large (3 to 7 lines long) and deep rose-color, soon spreading or reflexed: pods pendent on pedicels 3 or 4 lines long, finely pubescent, $1\frac{1}{2}$ to $2\frac{1}{2}$ inches long by $1\frac{1}{2}$ lines wide, the valves 1-nerved and veined, and stigma sessile: seeds small, in two rows, orbicular, winged. — Valleys of western Nevada (*Stretch*, *Shockley*, *Jones*), to San Bernardino and San Diego Counties, California (*G. R. Vasey*, *Parish Brothers*, *W. G. Wright*). It has been considered a doubtful variety of *A. arcuata*.

THELYPODIUM STENOPETALUM. Biennial, glabrous, branching from the base, the slender erect or ascending stems 1 or 2 feet high: leaves all entire, glaucous, narrowly oblanceolate to linear-lanceolate, strongly auriculate at base, acutish, 2 inches long or less: racemes elongated, the spreading pedicels 2 or 3 lines long: calyx very narrow, purplish, 4 or 5 lines long; petals whitish, exserted, the blade very narrowly linear; filaments exserted: pods (immature) ascending, stipitate, 2 inches long, beaked with a rather slender style half a line long or more. — In Bear Valley, San Bernardino Mountains, California, on stony hillsides near the upper lake (*S. B. Parish*, June, 1886). Somewhat resembling *T. sagittatum* and *T. Nuttallii*.

Silene longistylis, Engelm. in herb. Cespitose with a slender much branched caudex, finely pubescent throughout with very short spreading subglandular hairs; stems slender, a foot high or less: leaves narrowly oblanceolate, acute, an inch long or less, the cauline 1 or 2 pairs: inflorescence loose and pedicels slender: calyx ovate-cylindrical, 3 lines long, the teeth broadly ovate; petals white, the narrow claw scarcely auricled and very pubescent, the blade cleft nearly to the base into 4 elongated linear lobes, and the narrow appendages entire: stamens and styles long-exserted: capsule nearly sessile. — On Scott's Mountains, northern California, at 6,000–7,000 feet altitude (*Engelmann*, August, 1880); Ashland Butte, southwestern Oregon (*Henderson*, June, 1886). Near *S. Lemmoni* and *S. Palmeri*.

Drymaria viscosa. Annual, prostrate, diffusely branched; stems and branches glabrous or nearly so: leaves linear-spatulate, somewhat fascicled, 6 lines long or mostly much less, glandular-pubescent or glabrate: flowers nearly sessile in loose corymbs: sepals viscid-pubescent, scarcely a line long; petals included, bifid: capsule oval, few-seeded, equalling the sepals. — At Socono in northern Lower California (*C. R. Orcutt*, April, 1886).

Bursera Schaffneri. Branchlets stout and rigid: leaves glabrous and somewhat glaucous, pinnate, the rhachis bisulcate above, not margined; leaflets 1 to 3 pairs, one or both of the upper pair sometimes confluent with the upper leaflet, obovate, obtuse, cuneate at base, entire, faintly nerved, 3 to 5 lines long: fruit solitary or clustered at the ends of the branchlets on stout reflexed pedicels (1 or 2 lines long), triangular-obovate, acutish, 3 or 4 lines long. — In the Morales and San Miguelito Mountains, near San Luis Potosi (90 and 91 *Shaffner*, 1876); distributed as *Pistacia Mexicana*.

Lupinus Cusickii. Dwarf (2 to 4 inches high), much branched from the biennial or perennial (?) root, canescent throughout with soft appressed hairs: leaflets 5 to 8, oblanceolate, slightly less villous above, 3 to 9 lines long, the petioles usually elongated: peduncles mostly very short, the loosely few-flowered racemes shorter than the leaves: flowers purple, 3 or 4 lines long; calyx narrowly lobed, $1\frac{1}{2}$ to 3 lines long; banner glabrous; keel ciliate: pods villous, with short appressed hairs, 2–3-seeded, 4 or 5 lines long. — On sterile hillsides in Eastern Oregon (*W. C. Cusick*, July, 1886). Differing from *L. aridus* chiefly in the shorter and softer pubescence, and the shorter pedicels and racemes.

LUPINUS (PLATYCARPOS) SHOCKLEYI. Nearly acaulescent, silky-pubescent throughout, the hairs somewhat spreading on the petioles and pedicels: leaflets 9 to 12, broadly spatulate or oblanceolate, glabrous above, 4 to 8 lines long: racemes shortly pedunculate, but little exceeding or shorter than the leaves; flowers scattered: calyx narrow, silky; petals "blue" or "purple," little exceeding the sepals, 2 or 3 lines long: pods oblong-ovate, papillose, villous only on the margins, nearly 6 lines long, 2-seeded. — In the Mohave Desert, San Bernardino County, California (*Parish Brothers*, May, 1882); near Soda Spring, Esmeralda County, Nevada (*W. H. Shockley*, May, 1886). Near *L. brevicaulis*.

HOSACKIA NIVEA. Annual, silvery throughout with closely appressed silky pubescence, the spreading branching stems several from the base, 6 inches long or more: leaflets 3 to 7 on a short dilated rhachis, oblong-obovate, obtuse, 2 to 6 lines long: peduncles about equalling the leaves, 2-flowered, naked or with one or two small leaflets at the summit: calyx 3 lines long, the lanceolate-triangular teeth mostly shorter than the tube; corolla purple, twice longer: pods straight, silky-pubescent, many-seeded, 6 lines long. — At Socono, in northern Lower California (*C. R. Orcutt*, May, 1886). Of the *H. rigida* group, but an annual.

DALEA GLABERRIMA. Glabrous throughout: stems erect and branching (2 feet high), woody at base from an elongated slender perennial root: leaflets 4 to 8 pairs, cuneate-obovate to -oblong, rounded or retuse above, 3 to 6 lines long: spikes pedunculate, narrow, loosely flowered, and becoming 3 to 6 inches long; bracts obovate, abruptly acuminate, equalling the calyx, herbaceous and persistent: calyx turbinate-campanulate, scarcely over a line long, somewhat scarious with broad acute green lobes; petals deep purple, 2 lines long: stamens long-exserted. — On sand-hills, 30 or 40 miles south of Paso del Norte, Chihuahua (*C. G. Pringle*, September, 1886). A quite peculiar species, somewhat resembling *D. tuberculata*.

DALEA SEEMANNI. Near *D. Greggii*, shrubby, erect, diffusely much branched, the glandular-dotted branchlets finely tomentose: leaflets 2 to 4 pairs, canescent with a very short subsilky pubescence, on a rhachis 1 to 6 lines long, cuneate-oblong, obtuse, distinctly glandular beneath, 1 to 2½ lines long: racemes shortly pedunculate, dense,

½ to 2 inches long; bracts lanceolate, acuminate, pubescent, nearly equalling the villous calyx: calyx-teeth very villous, broad at base, acuminate, as long as the turbinate tube; petals dark purple, 3 lines long. — Collected by Seemann in the Sierra Madre, probably in Durango, and by C. R. Orcutt at Socono, in Lower California, April, 1886.

ASTRAGALUS HENDERSONI. Thinly pubescent throughout with soft woolly hairs, the numerous stems erect or ascending from a stout rootstock, 1 to 2 feet high: leaflets 6 to 10 pairs, narrowly oblong, obtuse or retuse, 6 to 9 lines long; stipules lanceolate: pedunculate racemes exceeding the leaves, few-flowered: calyx tubular-campanulate, dark-villous, 3 or 4 lines long, the narrow teeth nearly equalling the tube: pods reflexed, 2-celled, very fleshy-coriaceous, upon a stipe twice longer than the calyx, turgid, oblong to oblong-obovate, with a stout prominent ventral suture, the dorsal less prominent, very abruptly mucronate, glabrous, rugose, 8 to 11 lines long by 4 thick. — Open hillsides in the foothills of the Siskiyou Mountains, Josephine County, Oregon (*L. F. Henderson*, July, 1886). A very peculiar species, with the strictly 2-celled fruit nearly as fleshy as in the *Scytocarpi*, but dehiscent, stipitate, and reflexed.

ASTRAGALUS ACCIDENS. Rather stout, sparingly pubescent, the numerous stems a foot long or more: leaflets 10 to 15 pairs, oblong, retuse, cuneate at base, glabrous above, appressed-pubescent beneath, 6 or 8 lines long on a rhachis 3 to 6 inches long: peduncles about equalling the leaves, bearing a short raceme: flowers reflexed; calyx campanulate, dark-pubescent, 3 lines long, the teeth nearly equalling the tube; corolla yellowish, the narrow erect banner 6 or 7 lines long: ovary white-pubescent; pod 2-celled, stipitate (stipe as long as the calyx), coriaceous, turgid, oblong-ovate, subsulcate on the back, the ventral suture somewhat prominent, straight, reflexed, pubescent, 4 or 5 lines long. — Southern Oregon (*T. J. Howell*, April, 1881). Pod approaching that of *A. Mortoni*, but usually more compressed and broader, stipitate, and reflexed. Most nearly allied to the last.

ASTRAGALUS (ERIOCARPI) LECTULUS. Dwarf, closely cespitose, prostrate, densely silky-tomentose; stems very short: leaves an inch long, with 2 to 4 pairs of oblong-elliptical or oblanceolate leaflets 2 or 3 lines long: raceme shorter than the leaves, few-flowered, and very shortly pedunculate: calyx tubular, pubescent with soft white hairs, 3 lines long including the short narrow teeth; corolla purplish, 4 to 6 lines long: pods densely hairy, 6 lines long, compressed-elliptical with the sutures approximate, nearly straight, acutish, the very short beak abruptly incurved. — Common in sandy soil in Bear Valley, San Bernardino Mountains, at 6,000 feet altitude (*C. C. Parry*, 1876; *S. B. Parish*, June, 1886); in the Sierra Nevada, near Sonora Pass, at 10,000 feet altitude (*W. H. Brewer*, July, 1863). With fewer leaflets, smaller flowers and pods, and shorter peduncles than any other species of the group. Occasionally some of the lower leaves are perfectly glabrous.

The limits of *A. inflexus* and *A. Purshii* of this group are very difficult to define. From a study of a considerable amount of material, it appears that normal A. INFLEXUS is usually rather tall, covered throughout with a long soft villous pubescence, the calyx-teeth long-attenuate and lax, and the pods usually an inch long, strongly arcuate and acuminate. It is found in Oregon, Washington Territory, and northwestern Nevada. — A. PURSHII is low and cespitose, often dwarf, the pubescence shorter and closer, the calyx-teeth shorter and usually straight, the pod varying much in length and in amount of pubescence. The flowers vary in color, size, and breadth of the calyx, and the pubescence in its villosity. Forms occur that are not with certainty distinguishable from *A. inflexus*. It was originally described as having flowers an inch and a half long; they are about 8 or 10 lines in length, and are no larger in Douglas's specimens in herb. Kew. It ranges from Fraser's River to northern Idaho, northwestern Wyoming, northern Utah and Nevada, Siskiyou County, California, and in the eastern foothills of the Sierra Nevada to Tejon Pass and the San Bernardino Mountains.

PHILADELPHUS COULTERI. Six to eight feet high, with slender hanging branches; branchlets subappressed-pubescent: leaves lanceolate, acute, rounded at base, sparingly denticulate, densely white-pubescent beneath, the upper surface more sparsely substrigose-pubescent and when young glandular-puberulent, 1 or 2 inches long: flowers mostly solitary, very fragrant, an inch broad or more, the calyx and short pedicel densely white-silky: summit of the ovary somewhat hairy. — Zimapan (77 *Coulter*); foothills of the Sierra Madre near Monterey, Mexico (*C. S. Sargent*, April, 1887). Differing from *P. Mexicanus*, to which Coulter's specimen has been referred, in its dense pubescence, the non-acuminate leaves, and the hairy summit of the ovary.

COTYLEDON ATTENUATA. Short-caulescent, and the stem shortly branched; flowering stems several, slender, 6 to 8 inches high: leaves numerous, scattered, abruptly narrowed from the clasping base, subterete or flattened, 1 or 2 inches long by a line wide, those on the flowering stems shorter and less attenuate, the lower linear and the upper lanceolate: racemes a terminal pair, with frequently one or two short lateral ones, secund, 1 to 3 inches long; bracts very small, ovate; pedicels very short: sepals oblong-ovate, acutish, 1½ lines long; petals twice longer, yellow, tinged with brown and with a greenish midvein, lanceolate, united a fourth of their length, equalling the erect long-beaked carpels. — At San Quentin, Lower California (*C. R. Orcutt*, May, 1886). Nearly related to *C. edulis*.

COTYLEDON PARVIFLORA, Hemsl., var. (?) SQUAMULOSA. Flowers still smaller, the purple petals 1½ lines long: squamulæ large and conspicuous, half the length of the petals, yellow, cuneate-flabellate, thickened on the upper margin. — On cool slopes or in the thin soil of ledges, on the Potrero and Mapula Mountains, twenty miles south of Chihuahua (731 *Pringle*, October, 1886); distributed as *Sedum squamulosum*. Roots fascicled-tuberous. The habit is more that of a *Sedum* than of a *Cotyledon*, and the petals are united scarcely a fourth of their length.

PASSIFLORA BRIGHAMI. Near *P. lunata:* leaves subcoriaceous, obdeltoid in outline (2½ to 3 inches on each side), subcuneate at base with the sides somewhat curved, the upper margin more or less deeply sinused between the acutish angles; main nerves setosely excurrent; ocelli usually 2 pairs; petioles 3 or 4 lines long: peduncles scarcely equalling the petioles, jointed near the summit: flowers campanulate, 8 lines long; petals white; lobes of the corona linear-clavate, somewhat thickened on the margins and angular, 2½ lines long: ovary tomentose; fruit subglobose, 6 lines long. — Collected by me on the banks of the Chocon River, Guatemala; March, 1885. I have also photographs of the plant taken by Mr. W. T. Brigham. It is distinguished from *P. lunata*, Willd., by the more triangular and cuneate leaves, fewer ocelli, shorter pedicels, tomentose ovary, and smaller fruit. *P. lunata* and *P. coriacea*, Juss., were collected in the same region.

PASSIFLORA (GRANADILLA) GUATEMALENSIS. Glabrous: stems subterete: leaves membranous, ovate, peltate, 3-nerved, entire or usually slightly 3-lobed toward the apex, the lobes acute and setosely tipped, rounded at base, 2½ to 4 inches long, on eglandular petioles 1 to 2 inches long and inserted 3 to 6 lines from the margin; stipules reniform, setiferously toothed: peduncles shorter than the petioles; bracts oblong-ovate, an inch long or less, few-toothed near the cordate base, the teeth and acute apex setosely tipped: flowers white, rotate-campanulate, $1\frac{1}{2}$ inches broad; segments of outer corona filiform, very slender, thickened at the apex, the inner similar but stouter and half as long, inflexed: fruit globose, $1\frac{1}{2}$ inches in diameter: seeds over 2 lines long. — Banks of the Rio Dulce, in the Chocon River bottoms, and at base of hills near Yzabal, Guatemala; March and April, 1885. Resembling *P. membranacea*, Benth.

PASSIFLORA (EUDECALOBA) CHOCONIANA. Glabrous: leaves broadly subcordate in outline, 2 or $2\frac{1}{2}$ inches long by 3 or more broad, 3-lobed to below the middle, the lobes oblong-lanceolate, acute or acutish, entire; petiole with 2 pairs of glands; stipules semi-orbicular, entire: pedicels solitary, naked, equalling the petioles: flowers purplish, rotate-campanulate, 2 inches broad; segments of outer corona very slender, 6 lines long, the inner in several series, much shorter, incurved. — Banks of the Chocon River, Guatemala; March, 1885. Still another species was collected by me, in the forest of the Chocon River bottoms, with thin, transversely oblong, and very prettily variegated leaves, but without flowers or fruit.

OROGENIA FUSIFORMIS. Resembling *O. linearifolia* nearly, but stouter, with a long fusiform root, and the underground base sheathed with scarious bracts: fruiting peduncle 3 or 4 inches long, and the much larger fruit $2\frac{1}{2}$ lines long. — In Plumas County, California (*Mrs. R. M. Austin*, 1880), and among sagebrush near Truckee, Nevada County (*C. F. Sonne*. March to May, 1886).

PEUCEDANUM CIRCUMDATUM. Stems solitary from a deep-seated subglobose or oblong and constricted tuber nearly half an inch thick, glabrous or puberulent, a foot high or less, simple or branched: leaves with broadly dilated bases, ternate-quinate, the segments once or twice pinnatisect; lobes linear, 1 to 3 or 4 lines long: rays few, unequal, $\frac{1}{2}$ to $2\frac{1}{2}$ inches long in fruit; involucels of 8 to 10 broadly oblanceolate bracts, exceeding the flowers, yellowish green, becoming scarious: flowers yellow: fruit oblong-elliptical, 3 or 4 lines long, on short pedicels, with broad solitary vittæ between the prominent ribs. — Abundant on hillsides in the Wallowa region of eastern Oregon (*W. C. Cusick*, June, 1886). Much resembling *P. utriculatum*, but with a different root.

PEUCEDANUM KINGII. (*P. graveolens*, Watson, Bot. King's Exp. 5. 128.) The prior publication of *P. graveolens*, Benth. & Hook. Gen. Pl. 1. 919 (1867), the *Anethum graveolens*, Linn., necessitates a change in the specific name of our plant. The synonymy as given in the Bibliographical Index may be extended, for the plant was first collected by Nuttall in the Rocky Mountains, and named by him on his tickets *Cynomarathum saxatile.* It is therefore the *Seseli Nuttallii* of Gray, Proc. Amer. Acad. 8. 287, in large part. Geyer's similar specimens, which had been referred by the elder Hooker to *Musenium tenuifolium,* Nutt., are also noted in Benth. & Hook. l. c. 884 as being a species of *Peucedanum.* The plant of Parry's collection which was included with Nuttall's under *Seseli Nuttallii* remains uncertain. It is scarcely a congener of the *Seseli Hallii,* Gray, described with it. In the very ripe fruit of Parry's specimen the albumen is apparently surrounded by a thin continuous layer of resinous matter, while what appear to be empty vittæ are scattered through the somewhat corky pericarp. *Seseli Hallii,* which is also the *Oreosciadium acaule,* Gray, the *Deweya* (?) *acaulis* of Torrey, has the fruit of a *Carum* (as Bentham has stated in a note in herb. Gray), though it differs in habit.

PODISTERA * NEVADENSIS. Obscurely puberulent: caudex with numerous very short crowded branches bearing tufts of leaves: leaves small (3 or 4 lines long), with sheathing petioles, rather thick, the 3 to 7 lanceolate segments acute and entire: peduncles very short (9 lines long or less); umbels 2 to 4 lines broad, of 3 to 5 umbellets which are either sessile or very shortly pedicellate; involucels as long as the umbellets: fruit little over a line long, nearly sessile, crowned with the persistent calyx, smooth; vittæ small and flattened, 3 in the intervals and about 6 on the commissure. — *Cymopterus* (?) *Nevadensis,* Gray, Proc. Amer. Acad. 6. 536. Near the top of Mt. Dana, California, at 13,000 feet altitude, forming large dense convex mats among the rocks (1739, 2717 *Brewer,* June, 1863, in flower; 1424 *Lemmon,* August, 1878, in fruit).

MICROSERIS ANOMALA. Low, subcaulescent, sparingly pubescent, with solitary elongated (6 inches long) 1-flowered peduncles: leaves

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* PODISTERA; new genus of *Umbelliferæ, Euammineæ.* Calyx-teeth prominent. Petals lanceolate, acuminate, inflexed. Disk with an undulate margin; stylopodium depressed; styles elongated. Fruit elliptic-ovate, somewhat laterally compressed; carpels dorsally compressed, oblong-pentagonal in cross-section, the ribs slender and distant; vittæ several in the intervals and on the commissure. Carpophore 2-parted. Seed flat on the face, not sulcate. — A dwarf perennial cespitose acaulescent herb. Leaves pinnately parted. Umbel much contracted, the rays nearly obsolete. Involucre none; involucels foliaceous, unilateral, 3–5-cleft, by the reduction of the rays often forming a false involucre. Flowers white or pinkish.

Most nearly related to *Pimpinella,* from which it differs in its prominent calyx-teeth and in its whole habit. The name has reference to the entanglement of the pedicels and involucels.

laciniately pinnatifid with few attenuated lobes: involucre 8 lines long, rather many-flowered, the narrowly lanceolate acuminate bracts imbricated in about 2 series, the outer mostly somewhat smaller: achenes (immature) narrow, glabrous: pappus in 2 series, the outer of several (5 to 10) hyaline linear-lanceolate denticulate paleæ ($\frac{3}{4}$ line long), the inner of 5 scabrous awns (3 lines long). — Santa Cruz Island, California (*H. C. Ford*, April, 1887). The habit and involucre wholly that of *Microseris*; the pappus more like that of *Krigia*.

AMARANTUS (AMBLOGYNE) PRINGLEI. Erect, slender, a foot high or more, glabrous or very nearly so: leaves linear-oblanceolate, petiolate, mostly 1 or 2 inches long: inflorescence leafy, monœcious; bracts lanceolate, spinulose-acuminate, equalling the fruiting calyx (a line long or less); staminate flowers few, mingled with the pistillate ones, small, with narrow acute sepals; sepals of the pistillate flowers distinct, equal, green with a broad scarious margin, obovate, obtuse or retuse, and somewhat denticulate, the broad claw becoming gibbously thickened in fruit: utricle circumscissile near the base; margin of the calyptra retracted. — Common on rocky hills near Chihuahua (*C. G. Pringle*, September, 1886).

EUPHORBIA (CHAMÆSYCEÆ) TOMENTULOSA. Suffruticose, diffusely much branched, a foot high or less, pubescent throughout with a very fine tomentum: leaves round-ovate or broadly elliptical, somewhat oblique, slightly cordate at base, obtuse, crenulate, shortly petiolate, 2 to 4 lines long and about equalling the internodes; stipules attenuate: involucres small in small terminal cymes, turbinate, tomentose; lobes narrow, ciliate; glands 4, rounded, the white appendage transversely oblong or rounded: capsule subglabrous, purple, obtusely lobed: seed purplish, irregularly rugose and pitted. — At Rosario in northern Lower California (*C. R. Orcutt*, May, 1886). Near *E. fruticulosa*, Engelm.

EUPHORBIA (ZYGOPHYLLIDIUM) UNIGLANDULOSA. Annual, low and slender (6 inches high and less), glabrous: stipules glandular; leaves opposite or somewhat alternate, on slender petioles, ovate to oblong, truncate or cuneate at base, obtuse or acutish, denticulate, often with a few teeth near the base, the larger upper ones 6 or 8 lines long: involucres small ($\frac{1}{2}$ line long), with subquadrate lacerate lobes; gland solitary, reniform, with a white appendage: styles deeply cleft; capsule smooth, a line long: seeds subglobose, ecarunculate, irregularly tuberculate. — On the shaded talus of cliffs in the Mapula Mountains, Chihuahua (*C. G. Pringle*, October, 1886).

Dorstenia Choconiana. Caulescent, the simple stem a foot high or less, erect from a slender running rootstock, glabrous or with the petioles slightly puberulent: stipules subulate; leaves thin, glaucous and glabrous, or the veins beneath somewhat roughened, oblong-lanceolate, acuminate, abruptly cuneate at base by the decurrence of the blade upon the petiole, 2 to 6 inches long, entire (in the smaller specimens) or usually pinnately 7–9-lobed, the deep sinuses mostly rounded and the lobes acute or acuminate: peduncles slender, an inch long or less; receptacles subhemispherical or turbinate, half an inch broad or less, green, glabrous beneath or nearly so, the margin entire. — In dry stream-beds in the forest at the head of Black River, a branch of the Chocon, Guatemala; March, 1885.

Quercus Sadleriana, R. Brown (Campst.), Ann. & Mag. Nat. Hist. 7. 249 (1871). A peculiar white-oak, 4 to 6 feet high: buds oblong, densely silky; branchlets glabrous: stipules silky; leaves deciduous, broadly oblong or oblong-obovate, acute or acutish, somewhat cuneate or narrower at base, pinnately veined and rather acutely dentate, 2 to 3 inches long by 1 to $1\frac{3}{4}$ broad (or larger, *Brown*), shortly petiolate, glabrous, tomentulose beneath when young: aments 2 to 4 inches long; bracts silky; sepals ovate; stamens about 8: acorns maturing the first year, sessile or nearly so; cup shallow, tuberculate, 5 or 6 lines broad; nut oblong, obtuse, about 8 lines long; stigmas on short spreading styles. — Summit of the Coast Range, Curry County, Oregon (*Thomas Howell*, June, 1884); Siskiyou Mountains, Del Norte County, California (*T. S. Brandegee*, September, 1885). First collected by R. Brown in 1865, on the Crescent City trail over the Siskiyou Mountains in Oregon, near the California line. It is a clearly distinct species. Of the other species described by him in the article cited, *Q. Œrstedtiana* is evidently *Q. Breweri*, Engelm., and his name has the priority. *Q. echinoides* is probably only a small form of *Q. densiflora*. What he refers doubtfully to *Q. oblongifolia*, Torr., is Kellogg's *Q. vacciniifolia*. His *Q. Jacobi*, from Vancouver's Island, may be a variety of *Q. Garryana*, as he suggests; but specimens in herb. Gray, collected by Lyall on that island, have a deeper, larger, and more scaly cup, and a very peculiar look. It may prove to be distinct.

Notylia Guatemalensis. Pseudobulb very small, 1–3-leaved: leaves flat, rather thin-coriaceous, narrowly oblong, 2 to 6 inches long by 6 to 12 lines broad: raceme pendulous, rather loosely many-flowered, 3 inches long including the short peduncle; bracts small, lanceolate, equalling the somewhat reflexed pedicels: sepals distinct, greenish, spreading, lanceolate, concave, 2 lines long; petals as long, white dotted with orange, lanceolate, somewhat falcate, incurved: lip white, ecallose, hastate with a shortly cuneate base, the short rounded lobes and lower margin recurved, the upper margin somewhat incurved: column greenish. — Forests of eastern Guatemala; April, 1885. Described from specimens now in flower at Cambridge. Clearly distinct from all species of Central America of which I find record.

Ornithocephalus Pottsiæ. Leaves (about 12) fleshy, falcate, acute, jointed at base, 1 to 1½ inches long by 2 or 3 lines wide: raceme twice longer than the leaves, erect, shortly pedunculate, about 12-flowered, the rhachis somewhat triangular by the decurrent midvein and lobes of the bracts; bracts cordate, acute or the upper acutish, clasping, the rounded recurved lobes minutely denticulate: ovary twisted and flower inverted; sepals rounded, deeply concave, greenish white with a green excurrent midnerve; petals twice longer (1½ lines), white, cuneate-reniform, minutely denticulate above, the lower margins recurved; lip broadly lanceolate, constricted in the middle, the lower portion thick, round-auricled, without lamellæ, white at base and bright green above, the upper portion abruptly reflexed against the sepals, thin, greenish: column with a conical margined nectariferous pit at the base of the lip; beak white. — On trees near the Rio Dulce, Guatemala; described from specimens flowering in Cambridge, August, 1886. In habit the plant resembles *Oncidium iridifolium* very closely, which is frequent near Yzabal upon the branches of trees overhanging streams.

Bletia Pottsii. Terrestrial, the subglobose corm-like pseudobulbs an inch or more in diameter: sterile stems 2–3-leaved, the leaves thin, plicate, about a foot long by 6 to 12 lines broad: scape 2 or 3 feet high, simple, several-flowered, the closely sheathing distant bracts short (½ inch or less) and blunt; floral bracts green, lanceolate: sepals spreading, light rose-color, acute, the upper oblong, 9 lines long, the lateral broadly lanceolate and falcate, 6 lines long; petals as long, erect, acutish, deeper colored; lip 6 lines long, the broad lateral lobes greenish below and veined within with brownish red, purplish and obliquely rounded above, the middle lobe reflexed and its sides recurved, undulate, emarginate, purple, 5-costate, the three middle costæ prominently crested and yellowish. — On dry slopes bordering the Camino Real near El Mico, Guatemala; in bloom April 27th, 1885; described from specimens flowering at Cambridge. This and the preceding species are named in remembrance of the kindness and hospitality of Mr. and Mrs. Thomas J. Potts of Yzabal.

BRAVOA SINGULIFLORA. Stem with a large bulb-like base ($1\frac{1}{2}$ inches in diameter), from a short rootstock and a cluster of slender tuberous roots, 3 feet high: leaves numerous, linear, a foot long or less by 2 to 4 lines broad, with undulate margins, dilated at base; cauline leaves short and very narrow; floral bracts subulate to deltoid: flowers solitary (rarely geminate?), very shortly pedicellate, greenish white, the tube somewhat purplish, 15 lines long including the ovary; lobes oblong, 3 or 4 lines long: stamens exserted from the tube, the anthers about equalling the lobes: style included: capsule oblong, 10 lines long: seeds thin. — On shaded slopes of mountains near Chihuahua (*C. G. Pringle*, September, 1886).

AGAVE (MANFREDA) PLANIFOLIA. Perennial rootstock a very thick roundish corm, persistent for three or four years, covered with the fibrous remains of the sheaths of dead leaves; flowering stem 4 or 5 feet high: leaves rather succulent and pliant, flat or nearly so, not spotted, minutely denticulate, the basal (4 or 5) narrowly oblong, acuminate, narrowed to the sheathing base, 8 to 12 inches long by 1 to $2\frac{1}{4}$ broad, the cauline (6 or 8) similar, reduced above to bracts: perianth about 9 lines long above the ovary, the segments three or four times longer than the tube: stamens long-exserted: capsule ovate, 8 lines long. — Abundant on warm sandy or gravelly banks near streams in cañons of the Mapula Mountains, Chihuahua (*C. G. Pringle*, 1886).

CAMASSIA CUSICKII. Bulbs clustered (1 to 12), large (1 or 2 inches thick or more), and bearing numerous (8 to 20) large glaucous leaves (1 to $1\frac{1}{2}$ feet long by 6 to 18 lines broad): stems 2 or 3 feet high; pedicels 6 to 12 lines long or more: flowers large, pale blue, the narrow segments 3- (rarely 5-) nerved, persistently spreading: capsules oblong, abruptly acute, transversely veined, 6 or 8 lines long: seeds obovate, shining. — On slopes of the Eagle Creek Mountains, eastern Oregon, at 4,000 to 6,000 feet altitude (*W. C. Cusick*, May and October, 1886). Very near *C. esculenta* in its more essential characters, differing from it in its larger bulb, more numerous leaves, and stouter and more clustered habit, growing on hillsides instead of in wet meadows, and the bulb nauseous, pungent, and inedible. The bulb of *C. esculenta* is always cooked by the Indians before being eaten, but it is said to be tasteless in its raw state.

ERYTHRONIUM HENDERSONI. Leaves mottled: peduncle 1–2-flowered: petals recurved-spreading, about $1\frac{1}{2}$ inches long, pale purple with a very dark purple base, this purple centre of the flower surrounded by a tinge of pale yellow; inner petals auriculate above the very short claw, the auricles fleshy and subsaccate and the two scales subglobose-inflated: filaments purple, very slender and attenuate, about twice longer than the rather short brownish anthers (2 lines long): style narrowly clavate, shorter than or about equalling the stamens, the triangular-cupulate stigma very shortly 3-lobed. — Near Ashland, Jackson County, Oregon (*L. F. Henderson*, April, 1887), and at Grant's Pass, Josephine County (*T. Howell*, the same month).

Erythronium citrinum. Resembling the last: flowers rather smaller, the petals lemon-color, with a broad orange-colored spot near the base and the tips becoming tinged with pink, the inner auriculate; auricles scale-bearing or calliferous on the inner side and the broad median pair of scales rather thin: filaments, especially the inner ones, somewhat stouter, yellowish or white, as also the anthers. — In the Deer Creek Mountains, Josephine County, Oregon (*T. Howell*, April, 1887). The specimens are 3-flowered.

Erythronium Howellii. Resembling the preceding: leaves mottled (?): petals pale pink or becoming so, with a deep orange-colored spot toward the base, the inner narrowed downward, without auricles or scales: stamens white, the filaments very slender. — At Waldo, Josephine County, Oregon (*T. Howell*, April, 1887). These species of southern Oregon form a closely related group, characterized by the short style and very shortly lobed cupulate stigma, and distinguished from each other by the color of the flowers and by the character or absence of the appendages of the inner petals. It is upon such characters that we must depend to distinguish the members of the confused *E. grandiflorum* group, which have a longer style and linear (at length recurved) stigmas. Unfortunately it is difficult to recognize the differences in any but fresh or recently dried specimens. It is probable that investigation will prove *E. grandiflorum* to be distinguishable from the species prevalent in the Rocky Mountains, as well as from the *E. giganteum* of the lower Columbia, and the *E. revolutum* of the coast. The original of Pursh's *E. grandiflorum* (1814) was collected on the Clearwater, and the only specimens from that region in herb. Gray (from Spalding) are too poor for examination. *E. revolutum* (1810) was founded upon plants collected by Menzies near the coast, possibly in California. When the characters of these species can be determined with satisfactory probability others may follow.

Juncus Congdoni. *Graminifolius:* annual, with several low and mostly simple stems (2 to 4 inches high), leafy at base: leaves nearly as long, channelled above: flowers in a few (1 to 4) few-flowered mostly sessile heads, rarely solitary: sepals 2 or 3 lines long, the inner usually shorter, acuminate, scariously margined: stamens 3: capsule oblong, acutish, $1\frac{1}{2}$ lines long: seeds smooth and shining. — On the Chowchilla River, Merced County, California (*J. W. Congdon*, June, 1885). Somewhat resembling fasciculate forms of *J. bufonius*, but the stems not branched and heads few, the flowers triandrous, and the seeds smoother and shining.

XXII.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

ON THE BEHAVIOR OF SOUND AND DECAYED WOOD AT HIGH TEMPERATURES.

By Henry B. Hill and Arthur M. Comey.

Some time ago, at the request of Mr. Alexander Agassiz, President of the Calumet and Hecla Mining Company, one of us studied the behavior of sound and decayed wood at high temperatures, in order to determine the minimum point of ignition of decayed wood, and the lowest temperature at which volatile decomposition products were evolved. Through the kindness of Mr. Agassiz, we are able to present to the Academy the result of the investigation.

I. ON THE MINIMUM POINT OF IGNITION OF DECAYED WOOD.

By Henry B Hill.

After a series of preliminary experiments to determine the conditions most favorable to ignition and the form of apparatus best adapted to the purpose, I had made a cylindrical air-bath of sheet-iron fitted with a suitable aperture for the admission of air and a short vertical draught pipe, which was sufficient to maintain a free circulation of air when the bath was heated. A horizontal perforated shelf was fixed in the bath, parallel to the axis of the cylinder, and in order to prevent direct radiation or conduction of heat this shelf was covered with a double layer of asbestos paper so arranged as to leave an air space of about five millimeters between the two layers.

Above the shelf was placed the bulb of the thermometer, and close beside it the sample to be tested. The bulb of the thermometer was further protected from the heat radiated from the sample shortly before ignition by a double screen of asbestos paper. On the upper side of the air bath was cut a rectangular opening closed with a movable mica plate, through which the samples could be introduced and the ignition noted.

In order to avoid loss of heat by radiation the bath was surrounded by a loose envelope of asbestos paper, which allowed the hot gases from the lamps beneath to circulate about the bath. For determining temperatures below 200° I used a small mercurial thermometer; for temperatures above 200°, an air thermometer with constant air manometer, on the plan described some time since by Professor J. P. Cooke.* This thermometer proved to be extremely convenient, and its indications agreed closely with those of the mercurial thermometer in the neighborhood of 200°.

In preliminary trials, which I made with sound pine wood, I soon found that the ignition point was greatly affected by the way in which the sample was heated. If the temperature was slowly raised, the wood was thoroughly carbonized before the ignition point was reached, and the observed ignition point was merely that of charcoal. Thus four samples of pine-wood, slowly heated, ignited when the thermometer reached 405°, 407°, 415°, and 417°, while freshly burned pine charcoal ignited at 403°, 405°, and 408°, at successive trials. Pieces of the same wood (when the bath was quickly heated) ignited at 360°, 365°, and 372°, and when dropped into the heated bath they also took fire at lower temperature.

In order to determine the lowest possible point of ignition, it was therefore evidently necessary to make successive trials, in each case introducing the sample into the bath heated to a definite temperature, and lowering this temperature a few degrees at a time until the sample failed to ignite. Small pieces of wood (0.5 gram) usually ignited, if at all, within fifteen or twenty minutes; larger pieces (15 grams) sometimes required heating for an hour or longer.

The samples of wood which I examined were all portions of timbers from the Calumet and Hecla Mine, and varied greatly in physical properties. They were: —

A.	Pine	from	the	14th level	about	5	years	in the mine.
B.	"	"		7	"	6	"	"
C.	"	"		6	"	7	"	"
D.	"	"		6	"	8	"	"
E.	"	"		7	"	8	"	"
F.	Hemlock	"		9	"	5	"	"
G.	"	"		7	"	7	"	"
H.	"	"		6	"	9	"	"
I.	"	"		12	"	10	"	"

* These Proceedings, XVII. 22.

From these I selected a variety of samples differing most widely in their physical properties and appearance, and examined with most care those portions which were most decayed. While it was evident that a large variation in the size of the piece of wood taken produced a corresponding variation in the ignition point, it seemed to me advisable to determine at the outset the comparative points of ignition of the various portions, using in each case pieces of approximately the same size, and subsequently to determine the variation caused by taking larger pieces. In the following determinations pieces of wood measuring about 1.6 cubic centimeters were used, and since the wood was very light they weighed about half a gram each.

A. Inside Wood, sound.

°	
285	failed.
300	ignited.
300	"

B. Inside Wood, sound.

°	
300	failed.
305	"
318	"
330	ignited.

C. (*a.*) Sap-wood.

°	
252	ignited.
250	"
252	"
250	"
245	"
243	"
239	"
232	failed.

C. (*b.*) Inside.

°	
248	ignited.
243	"
242	"
238	"
230	failed.

D. (*a.*) Sap-wood, decayed fibrous.

°	
245	ignited.
243	"
238	"
238	"
233	"
232	"
230	"
226	failed.

D. (*b.*) Sap-wood, decayed fibrous.

	°	
	228	ignited.
	226	"
	222	"
	218	"
	218	"
	215	failed.
(*c.*)	**238**	ignited.
	224	failed.
(*d.*)	**235**	ignited.
	227	failed.

E. Sap-wood, decayed.

°	
260	ignited.
250	"
245	"
245	"
239	"
235	"
233	"
233	"
230	"
230	"
228	failed.

F. Inside Wood, sound.

°	
285	ignited.
275	failed.

G. (*a.*) Sap-wood, decayed.

°	
255	ignited.
247	"
240	"
235	"
230	"
223	"
219	failed.

G. (*b.*) Inside Wood, decayed.

°	
233	ignited.
230	"
223	"
220	"
212	failed.
218	ignited.
215	"
210	"
205	failed.
208	ignited.
205	failed.

G. (*c.*) Inside Wood, decayed.

°	
228	ignited.
224	"
220	"
215	failed.

H. (*a.*) Inside Wood, sound.

°	
315	ignited.
303	"
297	"
288	"
278	"
255	"
245	failed.

H. (*b.*) Sap-wood.

°	
235	ignited.
202	failed.

I. Sap-wood.

°	
215	failed.
225	ignited.
220	"
215	failed.

The following table gives the lowest observed ignition point of each sample tested, together with the temperature, at which the wood failed to ignite.

	A.	B.	C. (*a.*)	C. (*b.*)	D. (*a.*)	D. (*b.*)	D. (*c.*)	D. (*d.*)
Ignited,	300°	330°	239°	238°	230°	218°	238°	235°
Failed,	285	318	232	230	226	215	224	227

	E.	F.	G. (*a.*)	G. (*b.*)	G. (*c.*)	H. (*a.*)	H. (*b.*)	I.
Ignited,	230°	285°	223°	208°	220°	255°	235°	220°
Failed,	228	275	219	205	215	245	232	215

It will be seen that the ignition point of the pine wood varied from 330° in the comparatively sound portion of B to 218° in the decayed fibrous portions of D. Among the samples of hemlock, F, which was quite sound, ignited at 285°, while a portion of G, which though compact was completely softened by decay, ignited at 208°.

It is hardly necessary to say that the actual temperature of the sample at the time of ignition was very much above that of the bath, so that the observed temperatures are those at which oxidation became sufficiently rapid to heat the sample to self-supporting combustion. The great differences in the temperatures which were found necessary to effect this rapid oxidation seemed to be conditioned chiefly by the degree of porosity, the more porous woods giving free access to the oxygen of the air and at the same time conducting heat, but slowly, so that their temperature was rapidly raised to the point of ignition by the oxidation started at lower temperature.

In several cases I watched more closely the progress of the oxidation by introducing into the bath a second thermometer, whose small bulb was brought near the sample of wood. For some time the two thermometers showed the same temperature, then, the temperature of the bath remaining constant, the second thermometer began to rise slowly at first, and afterwards so rapidly that it had to be withdrawn from the bath before the sample actually took fire.

Since it seemed probable that the oxidation of a porous wood would not materially be retarded by increasing its volume, while the loss of heat by conduction and radiation must be diminished, I proceeded to test the effect of increasing the size of the sample taken upon the ignition point. For this purpose I selected that portion of G which had already shown the lowest ignition point. On repeating the determination with small bits of the wood, it gave a somewhat lower temperature than that before obtained, and by increasing the size of the sample it was found that the ignition point was materially lowered. The specific gravity of the wood obtained by measurement varied somewhat, but was not far from 0.3.

Weight.	Approximate Volume.	Temperature.
Grams.	c. c.	°
0.5	1.7	208 ignited.
0.5	1.7	206 "
0.5	1.7	204 "
0.5	1.7	202 failed.
3.0	10.0	200 ignited.
3.0	10.0	197 "
3.0	10.0	195 "
3.0	10.0	191 "
3.0	10.0	186 "
3.0	10.0	181 "
3.0	10.0	176 failed.
9.0	30.0	175 ignited.
9.0	30.0	170 failed.
18.0	60.0	171 ignited.
16.8	56.0	166 "
15.5	51.7	163 "
15.8	52.7	158 "
17.0	56.7	154 failed.
13.0	43.3	154 "

It will be seen that the point of ignition with 0.5 gram of the wood was 204°; with 3 grams, 181°; with 9 grams, 175°; and with 16 grams, 158°. The dimensions of my air-bath were such that no larger pieces of the wood could be used, and, moreover, from the material at my command it was impossible to obtain larger compact pieces of this particular sort of wood. It would seem probable, however, that with larger masses of this porous wood ignition could easily be started by a much lower initial temperature.

II. ON THE DECOMPOSITION OF WOOD AT HIGH TEMPERATURES.

By Henry B. Hill and Arthur M. Comey.

Although preliminary experiments had shown that gaseous products of decomposition were formed from wood in considerable quantity only at comparatively high temperatures, it seemed to us of interest to follow the reaction more closely, and to determine quantitatively the extent of the decomposition at various temperatures. Since the investigation was originally undertaken to determine whether this decomposition had any practical importance, it also seemed advisable to select the conditions usually met with in practice, and to heat the wood in a slow current of air rather than *in vacuo* or in a current of an inert gas. Since volatile products were formed in but small quantities, it was useless to attempt any separation or identification of them other than the discrimination between the carbonic dioxide directly formed and the carbon volatilized in other forms. The carbonic dioxide we determined by absorption in a standard solution of baric hydrate, and the volatile carbon by the same method after combustion with copper oxide. The method we employed was as follows. A definite weight of wood in the form of small fragments was introduced into a glass tube and heated in an air-bath to the requisite temperature. Through the tube was then drawn a slow current of air, which had been freed from volatile carbon compounds and carbonic dioxide by passing over red-hot copper oxide and washing with potassic hydrate. A wash-bottle filled with a concentrated solution of baric hydrate, through which the air passed in entering the tube, served to prove the complete removal of the carbonic dioxide. On leaving the tube, the air passed through a measured quantity of a baric hydrate solution of known strength, and the complete absorption of the carbonic dioxide was proved as before by means of a wash-bottle containing a stronger solution of baric hydrate. The air thus freed from carbonic dioxide was led over a small roll of copper gauze heated to redness, and the carbonic dioxide thus formed absorbed as before in a measured quantity of a standard solution of baric hydrate, while a second wash-bottle with baric hydrate served to control the absorption. After the lapse of a sufficient time, the amount of carbonic dioxide directly formed, and that formed by the combustion of the volatile carbon compounds was determined by titration of the baric hydrate solutions with oxalic acid, phenolphthalein being used as an indicator. The oxalic acid used contained 2.8636 grams of pure crystallized oxalic acid to the litre, and one centimeter of the solution was therefore equivalent to one milligram of carbonic dioxide. While it was evident that any volatile acids formed and carried into the baric hydrate would be counted as carbonic dioxide, direct experiments convinced us that the error introduced in this way, even at the higher temperatures employed, was inappreciable. For convenience in the comparison of our results we have in each case calculated the number of milligrams of carbonic dioxide directly and indirectly formed in one hour from each gram of wood.

Our first series of experiments was made with sound pine wood.

I. 2 grm. of wood when heated for 1 hour at 220° gave 13.35 mg. direct and 3.5 mg. indirect CO_2.

II. 2 grm. of wood when heated for 2 hours at 200° gave 10.6 mg. direct and 4.1 mg. indirect CO_2.

III. 2 grm. of wood when heated for 2 hours at 180° gave 3 mg. direct and 1.8 mg. indirect CO_2.

IV. 2 grm. of wood when heated for 3 hours at 162° gave 2.6 mg. direct and 2.1 mg. indirect CO_2.

V. 2 grm. of wood when heated for 5 hours at 143° gave 1.7 mg. direct and 2 mg. indirect CO_2.

VI. 2 grm. of wood when heated for 7 hours at 123° gave 1.3 mg. direct and 2.8 mg. indirect CO_2.

Sound Pine Wood.

	Temperature.	Milligrams of CO_2 in one Hour for each Gram of Wood. Direct.	Indirect.
	°		
I.	220	6.67	1.75
II.	200	2.65	1.03
III.	180	0.75	0.45
IV.	162	0.43	0.35
V.	143	0.17	0.20
VI.	123	0.09	0.20

In order to determine whether the indirect carbonic dioxide was formed wholly or in part from the volatile constituents of the wood, which were volatilized without decomposition, two successive determinations were made at the same temperature, with the same sample of wood and the products formed determined as before.

I. 2 grm. of sound pine wood heated for 2 hours at 200° gave 11 mg. direct and 4 mg. indirect CO_2.
II. The same wood heated for 2 hours more at 200° gave 9 mg. direct, and 3 mg. indirect CO_2.

	°	Direct.	Indirect.
I.	200	2.75	1.00
II.	200	2.25*	0.75*

Although the decomposition was less rapid during the second heating, the ratio between the direct and the indirect carbonic dioxide remained essentially unchanged.

Before proceeding further, we were interested to determine whether a pure form of cellulose would yield similar results. We therefore made three experiments with washed Swedish filter paper; and found that a similar, though much more slow, decomposition ensued.

I. 3 grm. washed Swedish filter paper heated for $3\frac{1}{3}$ hours at 210° gave 4.1 mg. direct and 2.3 mg. indirect CO_2.
II. 3 grm. washed Swedish filter paper heated for $4\frac{1}{3}$ hours at 180° gave 1.5 mg. direct and 2.5 mg. indirect CO_2.
III. 3 grm. washed Swedish filter paper heated for 7 hours at 160° gave 0.3 mg. direct and 2.3 mg. indirect CO_2.

Swedish Filter Paper.

	Temperature.	Milligrams of CO_2 in one Hour for each Gram.	
	°	Direct.	Indirect.
I.	210	0.41	0.23
II.	180	0.11	0.19
III.	160	0.01	0.10

With decayed pine wood, a portion of sample D mentioned in the preceding paper, we obtained the following results: —

I. 1.5 grm. of the wood when heated for 1 hour at 196° gave 12 mg. direct and 4.3 mg. indirect CO_2.
II. 1.5 grm. of the wood when heated for $1\frac{1}{4}$ hours at 180° gave 10.6 mg. direct and 4.3 mg. indirect CO_2.

* Referred to original weight of air-dried wood.

III. 1.5 grm. of the wood when heated for 1¼ hours at 158° gave 4.6 mg. direct and 1.9 mg. indirect CO_2.

IV. 1.5 grm. of the wood when heated for 3¾ hours at 140° gave 6.1 mg. direct and 3.5 mg. indirect CO_2.

V. 1.5 grm. of the wood when heated for 5 hours at 120° gave 3 mg. direct and 4.2 mg. indirect CO_2.

VI. 1.5 grm. of the wood when heated for 6 hours at 100° gave 2.9 mg. direct and 4.6 mg. indirect CO_2.

Decayed Pine Wood.

	Temperature.	Milligrams of CO_2 in one Hour for each Gram of Wood. Direct.	Indirect.
	°		
I.	196	8.00	2.87
II.	180	5.65	2.29
III.	158	2.45	1.01
IV.	140	1.08	0.59
V.	120	0.40	0.56
VI.	100	0.32	0.51

We have made no experiments with sound hemlock, but with decayed hemlock we have obtained the following results. The wood taken was from sample G used in the preceding paper.

I. 1.5 grm. of the wood when heated for 1 hour at 195° gave 19.3 mg. direct and 7.8 mg. indirect CO_2.

II. 1.5 grm. of the wood when heated for 1⅙ hours at 180° gave 16.6 mg. direct and 4.6 mg. indirect CO_2.

III. 1.5 grm. of the wood when heated for 1 hour at 160° gave 8.8 mg. direct and 2.7 mg. indirect CO_2.

IV. 1.5 grm. of the wood when heated for 1 hour at 140° gave 3 mg. direct and 0.7 mg. indirect CO_2.

V. 1.5 grm. of the wood when heated for 1½ hours at 120° gave 1.7 mg. direct and 0.5 mg. indirect CO_2.

VI. 1.5 grm. of the wood when heated for 2 hours at 100° gave 1.5 mg. direct and 0.5 mg. indirect CO_2.

Decayed Hemlock Wood.

	Temperature.	Milligrams of CO_2 in one Hour for each Gram of Wood. Direct.	Indirect.
	°		
I.	195	12.87	5.20
II.	180	9.49	2.63
III.	160	5.87	1.80
IV.	140	2.00	0.47
V.	120	0.76	0.22
VI.	100	0.50	0.16

XXIII.

CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

XXVIII. — THE EFFICIENCY OF SMALL ELECTRO-MOTORS.

By H. E. H. Clifford.

Presented by Charles R. Cross, March 9, 1887.

The following tests of electro-motors are presented as giving a good example of the efficiency of some of the smaller motors in use at the present day. They have been exclusively devoted to the determination of efficiencies, the subjects of governing and of smoothness of running under different loads being left out of consideration. The only other series of tests which has been published in this country, so far as I have been able to learn, is that made on motors and dynamos at the International Electrical Exhibition held at Philadelphia in 1884.*

The tests have been carried on in the Physical Laboratory of the Massachusetts Institute of Technology during the years 1885–86, by Messrs. F. A. Pickernell, H. G. Pratt, D. P. Bartlett, and the writer, students at the Institute.

The number of machines tested was thirteen. I give below their names, together with either a brief description of their peculiarities or a reference to some publication in which they are described.

Griscom. — S. P. Thompson's Dynamo-Electric Machinery, 2d ed., p. 429.

Ayrton and Perry. — Ibid., p. 432.

Gramme "Machine à petite lumière." — Ibid., p. 120

Gramme Magneto. — Ibid., p. 117.

Thompson. — Ibid., 1st ed. p. 354.

Deprez. — Prescott's Dynamo-Electricity, p. 707.

Monarch. — An electro-magnet revolving within a ring-shaped electro-magnet making use of consequent poles. The ordinary split-ring commutator is used.

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* Report of Examiners of Section XXIX. Supplement to the Journal of the Franklin Institute, March, 1886.

Cleveland. — The armature made up of two shuttle-wound armatures mounted on the same shaft but placed at right angles to each other. This armature revolves in a strong field produced by two field magnets, wound so as to have consequent poles at their middle. Instead of brushes, four anti-friction rollers are used in connection with a four-part commutator. The pressure of these rollers is adjusted by springs.

Model Edison Dynamo. — A miniature machine of the Edison pattern, but series-wound instead of shunt-wound.

Diehl. — The field magnets hinged at the yoke so that the distance of the pole pieces from the armature is capable of adjustment, and the armature made up of two Siemens shuttle-wound armatures at right angles to each other on the same shaft. The motor is shunt-wound. Two sizes were tested.

Hill. — The field magnets are placed below the armature, which revolves between cast-iron pole pieces. The armature consists of a series of eight spools of wire arranged in couples, the axes of adjacent couples being at right angles to each other. The motor is series-wound. Two sizes were tested.

The efficiency of a motor is equal to the horse-power delivered, divided by the rate of consumption of electrical energy by the motor; that is, if H. P. = horse-power delivered, C = current in ampères, and E = electro-motive force in volts as measured at the terminals of the machine, efficiency $= \frac{\text{H. P.}}{\frac{\text{C E}}{746}}$.

The instruments used in the determination of C and E were Sir William Thomson's current and potential galvanometers. These had previously been carefully calibrated and found to be correct to within 0.2% in the positions at which they were used in the tests. In cases where the compensating magnets had to be used, their intensity was carefully determined on each day of use, so that no material error should be introduced from this source. As far as possible, however, the use of the magnets was avoided.

For measuring the power given out by the smaller motors a raw-hide belt or a cotton cord was passed completely around a brass pulley on the motor shaft, the upper end being attached to a spring balance and the lower to a scale pan. By varying the weight in the scale pan the speed of the motor could be changed. A Chatillon balance weighing to $\frac{1}{2}$ oz. was used. In the tests on the Gramme Magneto and the Gramme "à petite lumière," the machines were placed on a cradle dynamometer, a modification of the form devised by Prof. Brackett of Princeton, and a dynamo machine was used as a friction brake. By closing the circuit of the dynamo through greater or less resistance, the work done, and consequently the power absorbed by the brake, could be varied.

In testing small motors great care must be taken in measuring the speed accurately. In these tests the speed indicator from a small siren was used. This was connected to the motor by an endless band passing from the pulley on the motor shaft to a pulley of the same diameter on the siren. The power required to run this indicator was excessively slight, and in computing the work done was neglected. The slip of the belt was negligible as shown by numerous tests. With the Magneto and Gramme "à petite lumière" a continuously recording engine counter was used connected to the motor by means of a flexible spiral spring.

The following table gives in parallel columns the name of the motor tested, the current in ampères, the electromotive force in volts at the motor terminals, the activity in horse-power, the maximum efficiency, and the speed for maximum efficiency in revolutions per minute.

TABLE I.

Name of Motor.	C.	E. M. F.	H. P.	Maximum Efficiency.	Speed.
				%	
Griscom	3.94	6.74	.006	17.0	1400
Ayrton & Perry	14.40	11.10	.082	38.4	831
Gramme "à petite lumière"	5.29	157.60	.945	84.5	2227
Magneto Gramme. . . .	12.60	27.40	.138	29.8	2067
Thompson	4.90	8.50	.012	21.7	2370
Deprez	4.74	10.40	.011	16.6	2140
Monarch	4.85	5.78	.004	10.1	578
Cleveland	6.78	12.00	.054	49.8	1360
Model Edison	0.82	90.50	.051	51.4	4065
Diehl 1	7.65	16.50	.021	12.3	4180
Diehl 2	6.12	15.10	.031	24.9	2480
Hill 1	4.77	10.30	.010	14.8	2036
Hill 2	5.04	15.10	.032	31.6	3030

The table below gives the tests in full made on the model Edison dynamo, and illustrates very well the relation of speed and efficiency.

This machine is built somewhat after the style of the old Edison Z machine. It is series-wound and has about the resistance (hot) of an Edison incandescent lamp, old style. The dynamo is an exceedingly neat and smooth running machine. The motor runs without vibration and with no sparking, and heats up but very little even at the highest speed. It has been run for two minutes at a speed of 10,000 revolutions per minute. The great speed here obtained by such simple means, together with the readiness with which it can be varied within wide limits, indicates the availability of such a motor in any physical experiments in which a great speed of revolution is needed, as in studies of the velocity of light, the duration of the electric spark, etc.

TABLE II.

Revolutions per Minute.	Electromotive Force in Volts.	Current in Ampères.	Horse-Power put in.	Horse-Power taken out.	Efficiency. Per Cent.
1715	75.8	1.050	.1070	.0278	26.0
1934	75.6	0.987	.1000	.0290	29.0
2372	77.4	0.942	.0978	.0320	32.7
2414	75.6	0.892	.0904	.0306	33 6
2748	75.6	0.835	.0846	.0312	36.9
2895	75 6	0.807	.0817	.0310	38.0
3085	89.8	0.990	.1192	.0462	38.8
3136	76.4	0.795	.0814	.0311	38.2
3200	90.2	0.960	.1160	.0448	38.6
3234	78.0	0.803	.0840	.0328	39.1
3722	76.4	0.685	.0702	.0291	41.5
3750	91.9	0.890	.1100	.0466	42.6
3957	98.8	0.940	.1246	.0544	43.7
3992	91.9	0.840	.1035	.0454	43.8
4065	90.5	0.820	.0995	.0512	51.4
4284	98.8	0.875	.1160	.0533	45.9
4310	90.7	0.780	.0948	.0426	45.0
4352	98.6	0.850	.1124	.0516	45.9
4860	96.6	0.750	.0971	.0437	45.0
4910	98.8	0.775	.1027	.0490	47.7
4922	100.0	0.812	.1094	.0519	47.5
4975	96.4	0.720	.0930	.0399	42.9
5050	95.8	0.690	.0886	.0376	42.4
5640	96.0	0.690	.0888	.0388	43.7
5870	95.8	0.660	.0847	.0365	43.1
6100	95.3	0.610	.0779	.0299	38.4
6130	95.9	0.630	.0810	.0321	39.7
6206	95.5	0.620	.0794	.0315	39.7

One of the chief advantages derived from the use of electro-motors is the small weight per horse-power developed. The motors which we have tested, with one exception, the Gramme "Machine à petite lumière," have been intended for doing very light work, and the efficiency exhibited is not of course nearly as high as would be shown with larger machines. Activities ranging from 1.31 horse-power to .004 horse-power have been obtained with efficiencies varying from 84.5% to 10.1%. Professors Ayrton and Perry in their paper on "Electro-Motors and their Government," (Journal of Society of Telegraph Engineers, 1883,) state that motors may be constructed to deliver one horse-power per one hundred pounds of dead weight. Table III. shows the horse-power per pound weight of the various motors tested and in no case does it rise as high as .01 of a horse-power. Their own motor, as will be seen by referring to the table, gives but .0045 of a horse-power per pound of dead weight. In the most efficient machine tested, the horse-power delivered per 100 lb. dead weight of machine falls a little short of .8 of a horse-power. I think that for moderately small motors about 300 lb. per horse-power would be a closer figure, although with larger motors this would of course be considerably reduced.

TABLE III.

Name of Motor.	Weight in Pounds.	Maximum Horse-Power delivered.	Horse-Power per Pound Weight.
Griscom	2.80	.0202	.0072
Ayrton and Perry	39.00	.1738	.0045
Gramme "à petite lumière"	172.00	1.3160	.0077
Magneto Gramme	70.00	.1512	.0022
Thompson	6.30	.0138	.0022
Deprez	9.60	.0138	.0015
Monarch	6.10	.0041	.0007
Cleveland	18.50	.1290	.0032
Model Edison	15.25	.0544	.0036
Diehl 1	9.50	.0209	.0022
Diehl 2	20.00	.0309	.0015
Hill 1	7.00	.0120	.0017
Hill 2	16.00	.0374	.0023

Rogers Laboratory of Physics, March, 1887.

PROCEEDINGS.

Seven hundred and ninety-third Meeting.

May 25, 1886. — Annual Meeting.

The President in the chair.

The President announced the death of Leopold von Ranke, Foreign Honorary Member; and of Charles Edward Hamlin and Charles Upham Shepard, Resident Fellows.

The Corresponding Secretary read a letter from Mr. Richard S. Greenough, announcing the shipment of a portrait of Galileo as a gift to the Academy.

On the motion of the Corresponding Secretary, it was

Voted, To meet, on adjournment, on June 16, 1886.

The reports of the Council and of the Librarian were read and accepted.

The report of the Rumford Committee was read and accepted, as follows: —

The Rumford Committee present the following report of what has been done by them since the last annual meeting of the Academy.

The committee approved bills amounting to $447.49 for printing in the Proceedings all the papers which related to Light and Heat.

In June, 1885, $1000 was voted by the Academy for the use of the committee in encouraging investigations upon Light and Heat. Of this sum, $300 was put at the disposal of Prof. E. C. Pickering, to assist in the continuation of his great work on stellar photometry and photography. The same sum ($300) was allowed to Mr. W. H. Pickering, to aid him in the prosecution of his work on dry-plate photographing, and for a research on a new standard of light. The unexpended balance of the $1000 (viz. $400) will revert to the treasury.

It was voted to recommend to the Academy the appropriation of $500 from the income of the Rumford Fund for the construction and mounting of instruments to be used by Mr. W. H. Pickering in observations upon the solar corona at the time of the total eclipse of the sun, on August 28, 1886. The other expenses of the expedition to the West Indies for this purpose will be paid by the members of the party.

The committee think that the time has come for making another award of the Rumford Premium. They have spent much time in weighing carefully the claims of several candidates, all of whom are of great merit. After careful consideration of the subject, they have voted unanimously to recommend to the Academy that the Rumford Premium be awarded to Prof. S. P. Langley, of Allegheny Observatory, for his researches on radiant energy. To carry out the objects of this report, the committee recommend the adoption of the votes appended to this report.

Respectfully for the committee,

J. LOVERING, *Chairman*.

May 25, 1886.

In accordance with the recommendation of the Rumford Committee, it was

Voted, That the Rumford Premium be awarded to Prof. S. P. Langley for his researches on radiant energy.

Voted, That the Treasurer be authorized to pay from the income of the Rumford Fund the sum required for the preparation of the gold and silver medals to be presented to Professor Langley.

Voted, That the Treasurer be authorized to pay from the income of the Rumford Fund $500 for the construction and mounting of instruments to be used in observations of the solar corona at some appropriate station in the West Indies during the solar eclipse of August 28, 1886.

The following appropriations were voted: —

For general expenses	$2,200.00
For publications	2,000.00
For the library	1,226.45

The annual election resulted in the choice of the following officers: —

JOSEPH LOVERING, *President.*
OLIVER W. HOLMES, *Vice-President.*
JOSIAH P. COOKE, *Corresponding Secretary.*
WILLIAM WATSON, *Recording Secretary.*
AUGUSTUS LOWELL, *Treasurer.*
HENRY W. HAYNES, *Librarian.*

Council.

WOLCOTT GIBBS,
CHARLES L. JACKSON,
CHARLES R. CROSS, } of Class I.

BENJAMIN E. COTTING,
SERENO WATSON,
ASA GRAY, } of Class II.

ANDREW P. PEABODY,
JOHN C. ROPES,
FREDERICK W. PUTNAM, } of Class III.

Rumford Committee.

WOLCOTT GIBBS, JOSIAH P. COOKE,
EDWARD C. PICKERING, JOSEPH LOVERING,
JOHN TROWBRIDGE, GEORGE B. CLARK,
ERASMUS D. LEAVITT, JR.

Member of the Committee of Finance.

THOMAS T. BOUVÉ.

The President appointed the following standing committees: —

Committee of Publication.

JOSIAH P. COOKE, ALEXANDER AGASSIZ,
ASA GRAY.

Committee on the Library.

HENRY P. BOWDITCH, AMOS E. DOLBEAR,
BENJAMIN A. GOULD.

Auditing Committee.

HENRY G. DENNY, THOMAS T. BOUVÉ.

Seven hundred and ninety-fourth Meeting.

June 16, 1886. — ADJOURNED ANNUAL MEETING.

The PRESIDENT in the chair.

The report of the Treasurer was read and accepted.

Since it had been questioned whether a quorum was present at the annual meeting of May 25, 1886, it was

Voted, To confirm and approve the votes and ballots then taken and declared.

It was also

Voted, To amend the statutes of the Academy by inserting the words "the Librarian" after the word "Treasurer," in Chapter II., paragraph 2.

Professor Cross read the following papers: —

Some Experiments relating to the Melting Platinum Standard of Light. By Charles R. Cross.

The Inverse Electromotive Force of the Voltaic Arc. By Charles R. Cross and William E. Shepard.

The Efficiency of small Electro-motors. By H. E. H. Clifford and S. D. Bartlett.

Professor William M. Davis made a verbal statement on the probable vertical distribution of temperature and pressure in thunder-storms, illustrating it by a vertical section showing isothermal and isobaric lines.

The following papers were presented by title: —

On a Form of a combined Yard and Meter adapted for the exact Determination of the Relation between the Lengths of these standard Units. By William A. Rogers.

Contributions from the Cryptogramic Laboratory of Harvard University: I. On the Anatomy and Development of Agarum Turneri, Post. & Rupr. By James E. Humphrey. II. On the Morphology of Ravenelia glandulæformis. By G. H. Parker.

Seven hundred and ninety-fifth Meeting.

October 13, 1886. — Stated Meeting.

The President in the chair.

The President announced the death of Ephraim Whitman Gurney, William Ripley Nichols, Charles Callahan Perkins, and Henry Hobson Richardson, Resident Fellows.

Oliver Whipple Huntington, of Cambridge, was elected a Resident Fellow in Class I., Section 3.

The Corresponding Secretary read the following letters: from M. Lacaze-Duthiers, acknowledging his election as Foreign Honorary Member; from the President of the University of Japan, announcing the foundation of the University; from the Superintendent of the United States Naval Observatory, in relation to the publication of its meteorological observations.

A circular from the American Committee of the International Congress of Geologists, requesting the Academy to unite with other societies in inviting this Congress to hold its next meeting in the United States, was also read; and it was thereupon

Voted, That the President be authorized to sign, on behalf of the Academy, the invitation to be addressed to the International Congress of Geologists.

On the motion of the Corresponding Secretary, it was

Voted, That the thanks of the Academy be presented to Mr. Richard S. Greenough for his valuable present of the portrait of Galileo.

A biographical notice of Henry Hobson Richardson, by the Rev. Phillips Brooks, was read by the Corresponding Secretary.

Seven hundred and ninety-sixth Meeting.

November 10, 1886. — MONTHLY MEETING.

The PRESIDENT in the chair.

Professor Pickering presented a paper entitled, —

Observations of the Light of the Stars. By Paul Stroobant.

Remarks were made by Professors Samuel P. Langley, Charles A. Young, and E. C. Pickering upon the wedge photometer, and the subject was discussed at length by Messrs. Davis, W. H. Pickering, A. Hall, Peters, and Edmands.

Professor Cleveland Abbe alluded to the experiments on ventilation described by Dr. Morrill Wyman.

Seven hundred and ninety-seventh Meeting.

December 8, 1886. — MONTHLY MEETING.

The PRESIDENT in the chair.

Professor Farlow presented, by title, a communication entitled, —

On certain Cultures of Gymnosporangium, with Notes on certain Rœsteliæ. By Roland Thaxter.

Mr. Sereno Watson presented, by title, the following: —

Contributions to North American Botany: Revisions of Portulacaceæ, Malvaceæ, etc., with some Miscellanea. By Asa Gray.

Seven hundred and ninety-eighth Meeting.

January 12, 1887. — STATED MEETING.

The PRESIDENT in the chair.

The Rumford Committee submitted a report recommending several appropriations from the income of the Rumford Fund, and it was accordingly

Voted, That an appropriation of five hundred dollars ($500) be made to assist Professor H. P. Bowditch in calorimetric researches on the heat of the human body.

Voted, That an appropriation of two hundred and fifty dollars ($250) be made to Professor Trowbridge, to aid in his researches on radiant energy.

Voted, That an appropriation of seventy-five dollars ($75) be made to Professor Cross, to aid in his researches on the influence of thermo-electric currents and other thermal actions upon the accuracy of the Munich shunt method of measuring very strong currents of electricity.

Voted, That an appropriation of two hundred and fifty dollars ($250) be made to Professors Cross and Holman to aid them in their researches on thermometry.

On the motion of the Librarian, it was

Voted, To appropriate one hundred dollars ($100) for the rent of the alcoves in the reading-room of the Athenæum; also, to appropriate one hundred and ten dollars ($110) for shelving an additional alcove.

The following papers were presented: —

On the Acceleration of Gravity at the Harvard Physical Laboratory. By Edwin H. Hall.

On new Methods for observing the Action of Colored Liquids on Living Protoplasm. By George L. Goodale.

Seven hundred and ninety-ninth Meeting.

February 9, 1887. — MONTHLY MEETING.

The PRESIDENT in the chair.

The following papers were presented: —

On the Coahuila Meteorites. By Oliver W. Huntington.

The Chinook Wind, and its Effect on the Isotherms and Isobars of the daily Weather Map. By William M. Davis.

Eight hundredth Meeting.

March 9, 1887. — STATED MEETING.

The PRESIDENT in the chair.

The following gentlemen were elected members of the Academy: —

John Ritchie, Jr., of Boston, to be a Resident Fellow in Class I., Section 2.

Thomas Messenger Drown, of Boston, to be a Resident Fellow in Class I., Section 3.

Jesse Walter Fewkes, of Cambridge, to be a Resident Fellow in Class II., Section 3.

David Gordon Lyon, of Cambridge, to be a Resident Fellow in Class III., Section 2.

Joseph Henry Thayer, of Cambridge, to be a Resident Fellow in Class III., Section 2.

Edward Jackson Lowell, of Boston, to be a Resident Fellow in Class III., Section 3.

Martin Brimmer, of Boston, to be a Resident Fellow in Class III., Section 4.

William Edward Story, of Baltimore, to be an Associate Fellow in Class I., Section 1.

George Davidson, of San Francisco, to be an Associate Fellow in Class I., Section 2.

Matthew Carey Lea, of Philadelphia, to be an Associate Fellow in Class I., Section 3.

John Newton, of New York, to be an Associate Fellow in Class I., Section 4.

John Strong Newberry, of New York, to be an Associate Fellow in Class II., Section 1.

John Wesley Powell, of Washington, to be an Associate Fellow in Class II., Section 1.

Daniel Cady Eaton, of New Haven, to be an Associate Fellow in Class II., Section 2.

Joel Asaph Allen, of New York, to be an Associate Fellow in Class II., Section 3.

Addison Emery Verrill, of New Haven, to be an Associate Fellow in Class II., Section 3.

Horatio C. Wood, of Philadelphia, to be an Associate Fellow in Class II., Section 3.

Henry Adams, of Washington, to be an Associate Fellow in Class III., Section 3.

William Robert Ware, of New York, to be an Associate Fellow in Class III., Section 4.

The following papers were presented : —

On new General Reactions with Sodiumacetacetic and Sodium-malonic Ethers. By Arthur Michael.

Observations of Variable Stars in 1886. By Edward C. Pickering.

Professor Cross presented the following papers: —

The Efficiency of small Electro-motors. By H. E. H. Clifford.

On Tests of a Commercial Storage-Battery. By Edward E. Higgins.

Professor Jackson presented, by title, the following papers: —

On Benzoltrisulphonic Acid. By C. Loring Jackson and John F. Wing.

On the Action of Nitric Acid on Symmetrical Trichlorbenzol. By C. Loring Jackson and John F. Wing.

Professor Pickering called attention to the circular concerning the Boyden Fund issued by the Harvard College Observatory.

Eight hundred and first Meeting.

April 13, 1887. — MONTHLY MEETING.

The Academy met at the Peabody Museum of American Archæology and Ethnology, Cambridge.

The PRESIDENT in the chair.

The Corresponding Secretary announced that he had received letters from Messrs. Thomas M. Drown, Edward J.

Lowell, David G. Lyon, and Joseph H. Thayer, acknowledging election as Resident Fellows; and from Messrs. Henry Adams, George Davidson, Daniel C. Eaton, M. Carey Lea, John S. Newberry, John Newton, John W. Powell, William E. Story, and Horatio C. Wood, acknowledging election as Associate Fellows.

The President announced the death of Professor August Wilhelm Eichler.

The President announced that he had accepted, in the name of the Academy, the invitation to send a delegate to the centennial celebration of Columbia College.

Professor Frederick W. Putnam presented a paper, entitled, —

"Account of Explorations in Ohio, with Special Reference to the Discovery of Objects made of native Copper, Silver, Gold, and Iron in the Mounds."

The following papers were presented by title: —

Contributions to American Botany: I. Notes upon some Genera of Coniferæ. II. List of a Collection of Plants made in the State of Jalisco, Mexico, by Dr. Edward Palmer, in 1886. III. Descriptions of New Species of Plants from the Western United States and Chihuahua. By Sereno Watson.

Eight hundred and second Meeting.

May 11, 1887. — Monthly Meeting.

The Academy met at the house of the Recording Secretary, 107 Marlborough Street.

The President in the chair.

The President invited the attention of the Fellows to the special object of the meeting, which was the presentation of the Rumford Medals which had been voted to Professor S. P. Langley, at the last annual meeting, for his researches on radiant energy. He was happy to see so large an attendance of Fellows to welcome Professor Langley, as he had honored the Academy by coming from his distant home to receive the medals in person. Before presenting the medals, he asked the indulgence of the Academy while he gave a hasty sketch of the work which had won for Professor Langley the award of the Rumford Premium.

The progress of science, by enlarging our ideas of the complex operations of nature, has introduced a new phraseology for describing them which would be unintelligible to men of a former generation. The chemistry of the sun and astro-physics would have had no meaning for them. Formerly, the two great divisions of Astronomy were designated as Practical and Physical; Physical Astronomy being limited to the mathematical development of the law of gravitation. The application of physical instruments, such as the thermo-electric thermometer, the spectroscope, the phosphoriscope, and the photographic camera, — all now common servants of astronomy, — to the analysis of the luminous, calorific, and chemical radiations from the sun, has given a wider meaning to Physical Astronomy; so that what was once understood by that phrase may be more properly called mathematical or mechanical astronomy, — the *Mécanique Céleste* of Laplace.

Long familiarity with the facts of gravitation has made science insensible to its mysterious mode of action; although the labors of Faraday and Maxwell make it improbable that it acts independently of a material medium between the attracting bodies. On the other hand, the radiations of light and heat have been brought completely under the control of the theory of undulations. While the intensity of light depends partly on the physiological adaptation of the eye, radiant energy can be revealed to physical instruments capable of measuring the amount of heat which is emitted. Thermo-electricity was discovered by Seebeck, of Berlin, in 1821. In 1834, Melloni constructed his highly sensitive thermo-electric thermometer (called the thermo-multiplier), by means of which he proved that the laws of reflection, refraction, dispersion, absorption, interference, and polarization apply to heat as well as to light, and that the theory of undulations is as true of one as of the other.

While astronomy was winning new victories every year in studying the motions of the heavenly bodies, there seemed to be no hope that it could ever detect the motion of a star in the line of vision, as its disk is immeasurably small and a spurious one. Great interest was felt, therefore, in the attempts of Huggins and others to solve this problem by the displacement of the dark lines in the stellar spectrum. The validity of the theory of this displacement was tested by applying it to the eastern and western edges of the sun's equator, which are moving opposite ways with a known velocity. Professor Langley's plan of testing the validity of his instrument, by taking the light first from the two poles of the sun and then from the two edges of the equator, was ingenious and convincing. What he did on this problem told incidentally in his researches on radiant energy, assuring him of the superiority in dispersive power of Rutherford's fine gratings over the most powerful battery of prisms. Moreover his visit to Mount Ætna, in 1878, enabled him afterwards to make a happy selection of a station for his mountain observations.

When Professor Langley began his work on solar energy, he found that the thermo-multiplier did not give reliable results. In 1851 Svanberg had described in a volume of the *Poggendorff Annalen* a new method of measuring heat by applying it so as to disturb the electrical balance in Wheatstone's bridge, and he expressed the hope that the new instrument would be found to rival, if not to exceed in delicacy, the thermo-multipliers of Nobili and Melloni. This was the only hint which Professor Langley had in the invention of his famous instrument, the spectro-bolometer, the first description of which was published in the Proceedings of this Academy for 1881. At that time the instrument was from ten to thirty times more sensitive than the thermo-multiplier, acted more promptly, and gave measurable results. Even the heat of the moon, on which the largest telescopes had pronounced with no certain sound, surrendered to the touch of the bolometer.

Physicists were generally of the opinion that light and heat were transmitted by separate undulations, or at least were independent properties of the same undulation, as the maximum of light in the prismatic spectrum is in or near the yellow, while the maximum of heat is outside of the red. Dr. J. W. Draper predicted that the two maxima would coincide in a normal spectrum, produced by a diffraction grating. But the heat from the grating was too small to be measured by any instruments at his command, and he was able to verify his prediction only to the extent of showing that the total heats on the two halves of this spectrum were equal. At this juncture, Professor Langley entered the field with his bolometer. He had at his command two of Rutherford's gratings, ruled upon metal; one having 17206 lines to the inch (or 681 to the millimeter), the other having half of that number. The rays from the grating fell upon a concave mirror, and were concentrated upon the bolometer. The deviation of the rays was measured by a divided circle, and the wave-lengths calculated. No collimator was used, and there was no absorption except by the atmospheres of the sun and the earth. The absorption by the earth's atmosphere was calculated by comparing noon observations with those taken near to sunrise and sunset. The absorption of violet light was great, and of the most luminous rays greater than for red light or the infra-red waves. The inference was drawn that outside of our atmosphere the sun would be bluish.

Armed with his new and powerful instrument of research, Professor Langley went on a scientific expedition to Mt. Whitney, in Southern California, in 1881, with the purpose of measuring the solar constant of radiation and the absorption produced by the earth's atmosphere; occupying, successively, three stations at 800, 4000, and 4800 meters of elevation, where the rarity and dryness of the air promised a greater degree of accuracy in his work. Observations were made with the actinometer of Violle and the pyrheliometer of Pouillet synchronously with those of the bolometer. With a Hilger glass prism of the finest quality and workmanship and a Rutherford grating, for the prismatic and normal spectra, the bolometer revealed to his intellectual eye a region of invisible solar activity outside of the red greater than that which the eye had ever seen.

On his return to the Allegheny Observatory he found that he could continue his work at this lower level with advantage, since his study of atmospheric absorption enabled him to eliminate its influence upon his measurements. He corrected the errors introduced into the prismatic spectrum by the absorption of a glass prism, by repeating the observations with prisms of rock-salt, fluor-spar, and quartz. In the spring of 1882 he repeated his work upon the normal spectrum with one of Professor Rowland's admirable gratings ruled upon a concave surface of metal. It contained 18050 lines, 142 to the millimeter, and exposed a ruled surface of 129 centimeters. Being of short focus, it gave a specially hot spectrum.

The general conclusions which had been reached were these: that light, heat, and chemical action coincided in the curves which expressed the distribution of these various forms of energy; that absorption was inversely as the wave-length; that the greater energy in the luminous region was there in spite of its greater absorption; that the maximum energy was near the yellow; and that the new district which had been added to the normal spectrum was greater than the visible and invisible spectrum which had been known before. Moreover, the general continuity of the curve of energy was broken at several places by deep valleys, indicating the presence of cold bands instead of hot ones.

At this stage of his investigation Professor Langley encountered a most delicate and difficult problem. The prism furnishes the most heat; the grating gives the wave-length; but the laws of refraction and dispersion necessarily distort the prismatic spectrum, and lead to false conclusions in regard to the distribution of solar energy. Professor Langley happily combined the grating and prism so as to be able to translate the prismatic spectrum into the normal spectrum. He had here to deal with three unknown quantities, viz. the prismatic deviation, the index of refraction, and the wave-length. The relation between this deviation and the index of refraction is well established. The relation between this deviation and the wave-length is obscured by theoretical and mathematical difficulties. This relation has been expressed by various formulas, derived from the undulatory theory of light, and involving preconceived ideas in regard to the atomic constitution of the luminiferous ether. A fair criticism can be passed upon these formulas, that they disagree with each other, and, in extreme cases, involve results which are contradicted by observation. All of them are expressed by a descending series of terms, involving many constants which must be determined by observations made within a limited range of the visible spectrum. Professor Langley undertook to solve the problem experimentally by a happy combination of a grating and a prism.

If the deviation of a homogeneous ray by a grating is observed, the corresponding wave-length is given by a simple rule. Within the limits of visibility there is no difficulty. Outside of these limits, the diffraction deviation must be indicated by heat-energy; and that becomes insufficient with the Rutherford gratings in the extreme parts of the infra-red. But the concentrated heat from one of Rowland's exquisite gratings affects the delicate strips of the latest bolometers even in the longest wave-lengths. Professor Langley's experimental devices in this case were beautifully complex. Rays were condensed upon a fine slit, and then went to the grating. Those of definite wave-lengths were accumulated upon a second slit, and formed there a sharp spectrum. Invisible spectra were superimposed at this slit upon the visible spectrum; but their wave-lengths were simple multiples of the wave-lengths of the visible spectrum. This compound spectrum was sent next through a prism, and its components deployed out into separate columns. The prismatic deviation of the visible spectrum was measured with the eye. By groping with the bolometer in the dark for the invisible ones their deviation was measured, and therefore their indices of refraction. Two results were reached: 1. The relation between the wave-length and the index of refraction for the invisible rays was determined experimentally: 2. The validity of the theoretical formulas of Cauchy, Redtenbacher, Briot, and Wüllner for expressing this relation was confronted with the facts of observation, in order to discover which of them were most trustworthy, and within what limits the best could be safely used.

In August, 1886, Professor Langley published a paper on "Hitherto unrecognized Wave-Lengths," in which he describes a modification in the bolometer arrangement by which it was adapted to the electric light. His latest refinements on the bolometer, supplemented by an improved Thomson galvanometer for measuring its indications, have culminated in an instrument capable of revealing the presence of one millionth of a Centigrade degree, and of giving reliable measures down to the hundred-thousandth of a degree. He gives additional observations on wave-lengths, deviations, and indices of refraction, made with three different gratings of Rowland, and with lenses and prisms of rock-salt in place of glass. In applying the formulas for dispersion the constants must be determined by observations with highly dispersive prisms. This was first done by Professor Baden Powell of Oxford. Adopting Cauchy's formula, he came to the conclusion that the greater wave-lengths converged towards a constant value, and that the maximum value was not far beyond the red. Professor Langley has compared his experimental results with the various formulas which assign the relation between wave-length and the index of refraction, and has come to the conclusion that, while there is great choice between them, no one of them can be trusted in its application to wave-lengths which are far beyond the visible spectrum.

This paper concludes with an interesting summary of the extreme range in the length of heat-waves, as given by the eye alone, or by the united aid of phosphorescence, photography, and the bolometer. While Newton's scale of wave-lengths had a compass of less than an octave, which others in recent times have extended, somewhat doubtfully, to about an octave and one half, the bolometer in the hands of Professor Langley has ranged over eight times the length of Newton's spectrum by actual measurement, and has indicated the existence of energy in a field six times greater for some kind of heat. In one sense Professor Langley has bridged over the gulf between the shortest wave-length of sound and the longest wave-length of heat. If, however, he should succeed, as he certainly may, in discovering waves of heat as long as the shortest waves of sound, the broadest chasm will still remain open; for the rapidity of undulation of these longest waves of heat will exceed that of the shortest waves of sound as many times as the velocity of light is greater than the velocity of sound. And we must still ask the question, What use has nature, with her economy of means and her law of continuity, made of those fifty octaves, or thereabouts, which have no employment in heat or sound?

I have said nothing of the most recent work of Professor Langley on the solar-lunar energy, hoping that he himself may be willing to address you upon that subject.

To what, now, shall we say that science is indebted for the startling results which I have hastily and imperfectly presented to you? Is it to the bolometer? That led to no discoveries in the hands of its first inventor, and remained unknown and useless, with one slight exception, for nearly thirty years. No doubt, Professor Langley improved vastly upon the original delicacy of the bolometer; but still it was only an instrument of wonderful precision, demanding all the more skill in him who used it. Therefore, we owe the discoveries which I have attempted to describe to the intelligence which was behind the instrument; to the perseverance and courage which were disheartened by no difficulties; to the originality which Professor Langley displayed in the complex combinations of the most delicate apparatus; to the enthusiasm which brought to his aid all the appliances of science and art from the highest sources; and to the confidence which he inspired in academies and private friends, so that his work might not languish for want of funds.

And now, Professor Langley, it is my most agreeable duty and privilege to present to you, in the name of the American Academy, and in the presence of these numerous Academicians who are here assembled to administer Count Rumford's trust, the gold and the silver medals, which together make the Rumford Premium. Be pleased to accept, with these medals, my hearty congratulations, and the warm felicitations of all the members of this Academy, for the brilliant results with which your long and patient work on Solar Energy has been crowned.

Professor Langley, on receiving the medals, made the following reply: —

Mr. President, — My labors have met with kind recognition before, but with none that has touched me so nearly as the present, which I receive in the city of my birth at the hands of those many of whose names have been honored ones with me from my earliest years, and through you, to whom I have looked as a master in physical science since my boyhood. The thanks I would express through you to the Academy which has thus greatly honored me are very deeply felt.

As to the work I have done in connection with the subject of heat, I am glad to believe, on your assurance, that it is such as the great forecaster of our modern physical doctrine of the subject would have approved ; and it will, now and always, be a lasting gratification to me that it has been thus fortunate in being connected with the name of Count Rumford.

You have spoken of the labors that I have carried on ; but when I remember that a later discoverer than Rumford tells us how, even as a little child, he was so impressed with the wonder and mystery of radiant heat, that he then dedicated his life to its study, I am glad to remember too, that, if I cannot resemble Melloni in the great results he achieved, I am at least happy in this, that the principal labors of my maturer life have been upon the plan which pleased my childish thought, so that these researches to which you allude have been to me a delight rather than a task.

The work then of which you speak has never seemed hard, or a thing to seek relief from, but always rather like a solace ; and it is still something which I trust to follow through the rest of life, without needing any reward other than it brings in itself ; though when there comes such approbation as yours, I can rejoice in it yet more.

Your kindness and the occasion will, I hope, gain indulgence for what is personal in that I have just said, and which is all I have to say, except that I would ask to be allowed to mention that the bolometer, to which you have specially alluded, was devised to meet an actual necessity. The most successful use of the thermopile demands at least as many years of apprenticeship as are given by the successful performer on a musical instrument ; for the full results to be obtained from any such apparatus, which deal chiefly with invisible radiation, are only to be reached after such long and patient practice as few care to give.

I may say that I had already given more time to becoming familiar with what the thermopile could do, than it would have taken me to acquire another language, before I found myself unable to prosecute the research on the distribution of heat in the normal spectrum with it, so that I was perhaps then entitled to conclude that I had reached the limit of its sensitiveness. I gave, accordingly, nearly the whole of another year to incessant experiment for the purpose of devising a more sensitive instrument than science then possessed. I cannot remember that I took the principle from any source then familiar to me; but I think I was unconsciously guided by some dimly apprehended recollection of the electric pyrometer of Sir William Siemens, which I certainly had read of before.

When the bolometer was completed and in active work, I sought to get a knowledge of the literature of the subject (if it had a literature), and only then learned from my friend, Professor Rood, of the nearly forgotten paper by Svanberg, and which I believe I was the means of bringing to public notice in my first communication on the subject to the Academy.

At the request of the President, Professor Langley then went on to speak informally to the Academy of some as yet unpublished results of his work with the bolometer on the heat-spectrum of the moon.

The following papers were presented: —

Biographical Notice of the late Ephraim Whitman Gurney. By Charles F. Dunbar.

The Law governing the Propagation of Signals in Electric Circuits. By William W. Jacques.

An Instrument for showing the forms of Undulatory Electric Currents. By William W. Jacques.

On the Spectrum of the Sun. By John Trowbridge.

The following papers were presented by title: —

Contributions from the Physical Laboratory of Harvard College: I. The Atmospheric Spectrum. II. On the Existence of certain Elements in the Sun. III. Radiation from Rock-Surfaces. IV. Efficiency of Secondary Generators. By John Trowbridge.

Reduction Factor of a Galvanometer Coil. By J. J. Skinner.

REPORT OF THE COUNCIL.*

MAY 24, 1887.

During the last year the Academy has lost by death eight members; — viz. five Resident Fellows: Charles Francis Adams, Nathaniel E. Atwood, Ephraim Whitman Gurney, William Ripley Nichols, Charles Callahan Perkins; and three Foreign Honorary Members, Georg Curtius, August W. Eichler, and Bernhard Studer.

RESIDENT FELLOWS.

CHARLES FRANCIS ADAMS.

The roll of our deceased members is headed by the name of one of the most distinguished, — the Hon. Charles Francis Adams. Mr. Adams was born at the corner of Tremont and Boylston Streets in Boston, on the 18th of August, 1807. His father, the late President John Quincy Adams, was then a Senator of the United States from Massachusetts, and Boylston Professor in Harvard College. He successively resigned these posts, and accepted the appointment of Minister to St. Petersburg from Mr. Madison; and to this place he took his infant son Charles in 1809. Mr. J. Q. Adams subsequently went as Envoy to Ghent and to Great Britain, and during this last mission Mr. C. F. Adams was at school at Ealing, near London. On his father's transfer to the Secretaryship of State, Mr. Adams came to America and entered the Boston Latin School. He graduated at Harvard College in 1825, and afterwards studied law and was admitted to the bar, but never engaged extensively in practice. He was a contributor to various periodicals in early manhood, and wrote on some important political questions in the administrations of Jackson and

* Notices of Curtius, Eichler, and Studer could not be prepared for this volume; but notices of Richardson and Von Ranke, necessarily omitted last year, are now given.

Van Buren. Though not at all eager for public life, he consented to serve in the State Legislature from 1841 to 1843 in the lower House, and in the upper in 1844 and 1845. At this time he undertook the editorship and chief support of a newspaper in the Anti-slavery Whig interest. In 1848 he accepted the nomination of the Free Soil Party as Vice-President, with Ex-President Van Buren at the head of the ticket. After the election of General Taylor, Mr. Adams was not in active political life till he was chosen to Congress in 1858, and again in 1860. In March, 1861, he was appointed Minister to England by President Lincoln, and remained till released by Mr. Johnson, in May, 1868. In 1871 he was on the Geneva Arbitration Commission. In 1873 he delivered a memorable address on Mr. Seward at Albany. In the previous year his name was much canvassed for the Presidency of the United States, and later for the Governorship of Massachusetts. Towards the end of his life, the effect of his severe anxiety in England was shown by a gradual obscuring of his mind, and he died in Boston on the 18th of November, 1886.

Mr. Adams was chosen a member of this Academy on January 28, 1857, in Class III. Section IV. He was elected Vice-President in 1872, and President in 1873. As such he was selected to deliver the Anniversary Address in 1880, and he had made considerable preparation for it; but finding it a more serious task than he had supposed, his constant reluctance to fall below his own standard induced him to withdraw from its delivery and from the presidency, and for the last six years of his life he lived in retirement.

Mr. Adams rarely took part in our proceedings, and it might be thought, by a superficial observer, that the services he rendered to us were little more than the giving his name as President, the graceful and dignified occupancy of the chair, and that mutual recognition of distinguished men and distinguished societies which always has been and always should be felt as a source of honor to both. I believe the truth to be far otherwise. I believe the work Mr. Adams did for his country is exactly what we need more of in just such associations at this day; and that our younger members, who are full of modern ideas of philosophical and scientific work, may well be recalled by his example to an older and perhaps less common, but none the less noble, conception of the fitting pursuits of a great mind.

The section to which Mr. Adams belonged was that of Literature and the Fine Arts, and therein unquestionably lay his real and favorite tastes. He engaged in active politics, first by his pen and afterwards by his personal presence, from the highest and purest motives. His father wished him to do so; his fellow citizens cast their eyes on him; his sense of duty to his country and the right deduced that there was political work for him to do. He could no more have refused to work with his pen and his tongue under such persuasions, than he could have shut his ears to a trumpet note, or his eyes to the voltaic arch. His career is a living example of the inherent difference between inclination and adaptation to a special work. He did, and did well, admirably, gloriously well, what it was his duty and his place to do, — what his surroundings and his elements fitted him to do; but his tastes and his wishes were constantly laid aside, suppressed, one might say crushed, in the stern sacrifice of inclination to obligation. In this respect, his career is a most impressive lesson to our younger academicians, — I do not mean members of this Academy only, but our young students everywhere, who fancy they have ended the matter when they say their actual pursuit is one of their own liking or selection. Still more in the character of the work he did, do I believe we find a still closer lesson for ourselves, that we shall do well to ponder.

Mr. Adams's tastes, as I have said, were essentially those of a scholar. His father stated of him more than once, that he was made to be a hermit. He gathered around him a valuable library, even before inheriting the larger and more miscellaneous collection of his father, — and he loved to live in it. His delight was in what is called standard or classical literature, — not merely the classics of the Latin and Greek languages, but those works in all the tongues of cultured Europe that have gone through a process of sifting similar to that through which the ancient classics have passed, — those which their own and subsequent ages have alike found worth keeping. In the perusal of these he was indefatigable. He could settle down in middle life to a thorough course of study with a systematic arrangement of time, a settled purpose of labor, a patient grappling with difficulties, which would do honor to a youth at college, laboring for the scholarship on which his daily bread was to depend, — doubly honorable in a man of wealth and assured social position, who could not easily be called to account for ignorance or indolence, had such indeed been his failings. I find in his diary mention of his studying at the same time Persius, Goethe, Adam Smith, Gallatin, and the Duchess d'Abrantes, a little of each at a time, with careful opinions noted on their respective literary value. In such departments of literature — history, biography, political and moral science, the higher kinds of poetry and fiction — he was never tired of exercising his thoughts, and, if he felt suitable inspiration, his pen. It was the sort of study that he had learned from his father, and that his father had learned from the great lights of his boyhood, of whom Edmund Burke might be taken as the prince and model. In their steps Mr. Adams was content to tread.

The more modern lines of thought; experimental science, whether applied to matter or to mankind; the kind of speculation which aims at discovery rather than development, at criticising rather than confirming; the subjective poetry and the skeptical theology of the day, — found little sympathy from him. There were principles in literature, in philosophy, in politics, and in religion which were as assured to him as the rules of grammar or the period of the earth's revolution. He was a conservative in the true, not the false, use of the word; not because he was the least of a coward, or the least averse to reform, but because for him the old had not been exhausted, and he could not see that the mere fact of novelty was any proof of truth. He was at once, like his ancestors, deliberate and careful in his thoughts, ardent and intrepid in his feelings. His opinions were slowly formed, and, when formed, energetically, if need be passionately maintained. His articles in the North American Review and his various published addresses will give a good idea of his line of thought and style of expression — simple, clear, firm, dignified. He was drawn away to politics too early to develop his literary studies to the full, but he never lost them.

It would not be doing justice to Mr. Adams to omit mention of two especial tastes which he early formed and always retained. He was a devoted lover of music, — never tired of listening to good performers, with a mingling of enjoyment and criticism rarely found. He was also an eager student of numismatics, and had formed a choice and interesting collection of coins, both ancient and modern. He was never tired of studying this, and found time to perfect his knowledge and improve his cabinet in the busiest hours of his English mission, attending coin sales to the no slight chagrin of the professional dealers.

At the same period he feasted on the great galleries of art, both public and private; and on Sundays he employed his never-failing attendance on public worship as a means of cultivating his knowledge of sacred architecture, by visiting in succession numbers of the singularly interesting churches that lie hid in the labyrinth of the city of London. It is needless to say that the Palladian style of these edifices appealed to his Congregational instincts far more than the richer Gothic. Whatever accessory notions he gained, his primary object was to worship, and not to gaze.

In the field of politics, and still more in that of diplomacy, to which a sense of duty, and not inclination, brought him, the work of Mr. Adams, the part that he played in the world, is gratefully remembered. But it is a kind of work that we all are in great danger of undervaluing, because it is not experimental, not discovery, — not what we are urged to do again and again, original work. I confess I am getting a little impatient of this phrase, "the need of original work," which seems to sneer at everything that cannot be called new, which is never at rest till it has struck out something to send to a scientific or historical magazine, even while still in a crude state, in order to avoid every possible chance of anticipation. Mr. Adams made no discoveries in politics. He probably would not have been the author of any great original treatise if he had remained faithful to literature. He did not in his study compose what in the semi-Teutonic jargon of the day is called an epoch-making book, like the Wealth of Nations; he did not in Congress devise a plan which instantly saved North and South from the civil war. He did, it is true, as a publicist, play an active part in opening what was announced to be the new era of arbitration instead of war; but however satisfactory the results of the Geneva tribunal are to us, its precedent has not been followed with eagerness, nor have all nations laid down their arms at the feet of similar arbitrators. But Mr. Adams was called upon to do a work quite as important and not less elevated than the discovery of new moral or political truth, — the assertion, namely, and the maintenance, of old rights and old truths, which were in danger of being forgotten or trampled through national frivolity, or triviality, or brutality. He maintained, at the risk of his political prospects and private friendship, that the wealthy men of the North were sacrificing the liberty of their ancestors to the gains of the hour; he maintained, at the risk of his party connections, that North and South must seek to unite on a reasonable common ground, that would maintain the union and liberty of our fathers amid the passions of the hour; he maintained at the utter sacrifice of his comfort, nay, of his very life, that there are eternal obligations between nations, as old as peace and war themselves, which must not and shall not be forgotten and slighted under any pretence of peculiar circumstances and difficulties. That Mr. Adams should have called Americans and English back to these old principles, that he should have refused to let any new discoveries interfere with eternal right and wrong, seems to me on a level with Galileo's reasserting the Copernican system after Tycho Brahe had attempted to reverse it.

We place Mr. Adams among our great men, not because of discoveries like Franklin's or inventions like Whitney's; not for piercing logic like that of Edwards, nor thrilling eloquence like that of Webster; not for triumphs like Scott's in the field, or Allston's in the studio, not, in short, for some achievement that makes foreign nations say, "The Americans have done something new"; — but because his voice and his pen, his acuteness and his firmness, preserved for us that liberty, that peace, and that very existence as a nation without which science and art, logic and eloquence, and all the conquests of war and peace, would be a mockery; and because we owe it to him that the country of Edwards and Franklin and Webster and Whitney is still the country of Allston and Scott, and that the old truths and the old principles still rule throughout the old nation.

NATHANIEL ELLIS ATWOOD.

The life of Nathaniel Ellis Atwood furnishes an instance of success in scientific pursuits achieved against the serious obstacles of lack of means and of elementary instruction.

He was born in Provincetown, September 13, 1807, the son of a poor fisherman, John Atwood. In 1816, the family, the better to pursue their calling, moved to Long Point, the very tip of Cape Cod.

And here young Nathaniel, at the age of nine, began his service in the open fishing-boat. Already at thirteen he did a man's duty on board a schooner engaged in the fisheries on the banks of Newfoundland, and in early manhood he had risen to the command of the vessel. Soon he changed to the coasting trade, and for some time commanded a brig that sailed to the West Indies. But fishing was his favorite employment, and to this he returned, and continued to pursue it till near his sixtieth year. After leaving the sea he still maintained his connection with the fisheries by the manufacture of cod-liver oil, in which he showed much skill, and which he pursued as long as he lived.

Captain Atwood's mode of life was certainly not one favorable to scientific research. But the love of such research was in him, and he allowed no obstacle to stand in the way. He early began to observe the habits and characteristics of fishes, and to read such books on natural history as he could get. Keen observation and a powerful memory enabled him, as time went on, to accumulate a great quantity of novel information, all of which was placed at the service of Dr. Storer when he wrote his Report on the Fishes of Massachusetts, in

1843. Captain Atwood's special knowledge, of course, attracted the attention of Agassiz, who visited him at Long Point in 1852, a visit that was the beginning of a life-long friendship. The acquaintance of scientific men was a stimulus and an aid to him, and led him to redouble his efforts.

In 1857, while a member of the legislature, Captain Atwood was appointed a commissioner, with Judge Chapman and Dr. Henry Wheatland, to report on the artificial propagation of fish. He made experiments on the fecundation of trout eggs, and succeeded in developing the embryos, although the ova died before hatching. The report of the commission was the first document of the kind published in this country.

His reputation as a student of ichthyology became so considerable that he was asked, in 1868, to give a course of lectures on fishes before the Lowell Institute. These lectures, illustrated as they were by quaint anecdotes, were very successful.

He served in the State Senate in 1869, 1870, and 1871, and during his term delivered important speeches on our sea fisheries, and especially on their possible exhaustion. Indeed, he lived to see the subject of ocean and inland fisheries, about which little was known in his youth, submitted to scientific investigation by State and United States commissions, — an investigation to which he was a valuable contributor.

Captain Atwood was a member of the Boston Society of Natural History, the Institute of Technology, and the Essex Institute. He was chosen a Fellow of the Academy in 1868. He died at Provincetown, November 7, 1886.

EPHRAIM WHITMAN GURNEY.

Ephraim Whitman Gurney, the son of Nathan and Sarah (Whitman) Gurney, both of families long settled in Abington, was born in Boston, February 18, 1829. Certain well-defined aptitudes and tastes, together with some external conditions, for a time drew him towards a mercantile career, and it was not until about his nineteenth year that the stimulus received from the reading of his leisure hours and from certain phases of religious inquiry turned him finally to the pursuit of letters. His preparation for college was then effected, with some assistance from private instruction, in sixteen months; he entered Harvard College in 1848, and graduated in 1852, already singled out as a man of especial mark. Plans which he had formed for subsequent study in Cambridge were broken up by a severe illness in the autumn after his graduation, and he remained in Boston for several years, for a time engaged as a teacher in a private school, but steadily carrying on, as it were in silence, the broad system of study and intellectual training, in which his unusual mental maturity and independence made him a sufficient guide for himself.

In 1859 he was appointed Tutor in Latin in Harvard College, and with some difficulty was induced to enter upon the university career, for which he then doubted his own fitness. In 1863 he became Assistant Professor of Latin; in 1867, Assistant Professor of Philosophy; in 1868, Assistant Professor of History; and in 1869, early in the administration of President Eliot, he was made University Professor of History, and, a few months later, Dean of the College Faculty. The last-named position he held for six years, in a period of rapid reorganization and development. The University Professorship he continued to hold until May, 1886, when, upon the resignation of Professor Torrey, he became McLean Professor of History. The brief but important record is closed by his death at Beverly, on the 12th of September, 1886, after a wasting illness of several months. He had been a Fellow of the Corporation of Harvard College from 1884, and of this Academy from 1860.

As a Fellow of the Academy, Professor Gurney is enrolled in the section of Philosophy and Archæology; but the studies which gave him this place were after all but a part of the preparation with which he subsequently entered upon the field of history, in which lay his chief interests. Roman history in its widest relations, the growth of the Roman domestic and political institutions and their influence in shaping the social, political, and legal systems of modern Europe, were the subjects to which all his work seemed to converge, and to the development of which he brought to bear such wealth and variety of attainment as is faintly indicated by his record as an instructor in Harvard College. The classics both Latin and Greek, of which he seemed in the earlier years to be the special student, were the key to his wider inquiry. For its better prosecution, he made himself master of Roman law, secured its introduction among the College studies, and himself gave instruction in it. Even his short service as a Professor of Philosophy was also no real deviation from the general line of his activity. Of the few examples of his work to be found in print, the most remarkable is the letter given at the close of Professor Thayer's "Letters of Chauncey Wright," in which Professor Gurney with wonderful discrimination and felicity of style presents the intellectual lineaments of that rare thinker. And nothing is more striking in the account there given of the growth of Wright's philosophical opinions and of the influences affecting it, than the light which is thrown upon the wide philosophical attainments of the friend, who for many years shared Wright's interests and speculations, or joined issue with him in their daily discussions. But as Professor Gurney said of himself, he cared much more about men than about man; and philosophy, like law and the classics, was after all only tributary to the main current of his studies. Of the nature of this main current, so far as it was exhibited in his public instruction in the University, perhaps no better statement can be made than by transcribing his own carefully prepared titles for the leading courses of study offered by him in his later years: —

Roman History to the Fall of the Republic, with especial reference to the development of political institutions in Greece and Rome.

Political and Legal Institutions of the Roman Empire, and development of the Frankish Constitution to the death of Charlemagne.

The Constitutional and Legal History of France to the end of the fifteenth century.

Few branches of modern investigation or speculation in history, politics, or the origin of institutions, could be foreign to a range of topics like this, in the mind of an inquirer gifted in discerning broad relations, and in interpreting the deeper meanings of political and social movements. And no less comprehensive treatment of an historical field than is here implied could have given adequate scope for a man whose varied interests stimulated him to a constant and vigilant survey of the latest intellectual achievements, in whatever field, and whose knowledge of men was as wide as his knowledge of books, and as carefully perfected. Unhappily as it must seem for the interests of learning, he undertook no printed exposition of the subjects of which so many accomplished students have found him a master. He neither wrote lectures, nor arranged systematic notes for his university instruction, but "talked to his students and met their questions from the fulness of his knowledge, seeming," as one of them has said, "to live in the subject of his discourse," so complete was his mastery of it and its related matter. For the press, although he was an editor of the North American Review for the years 1869 and 1870, he wrote almost nothing. It is therefore to the report of students, colleagues, and friends, who had long recognized him as a competent specialist in so many directions, and of the many scholars, both American and European, who in the warmth of his fireside and among his books sounded his knowledge and felt their own sounded by him, that we must trust for evidence of the loss which historical learning has suffered.

Reference has already been made to the importance of the juncture at which Professor Gurney became Dean of Harvard College. Under the administration of President Eliot, the University was entering upon an era of extraordinary development, both material and intellectual. In devising and carrying out the measures necessary for this transformation, Professor Gurney was from the first a leading counsellor; and in assuming the office of Dean of the College Faculty he took upon himself a share in their execution, for which only his singular combination of qualities and attainments could have been sufficient. In determining the action by which the teaching body expanded its range of instruction, and, by the abandonment of every scholastic tradition, adapted its system to a new university life, his influence was powerful. The great range of scholarship of which he had thorough command gave him an unequalled ability to comprehend and compare the capacities and the needs of many branches of knowledge, and made him in a peculiar manner the trusted colleague of all his associates, at a time when the supporters of the elder university studies might well look with some doubt upon the growing importance of the newer learning, and of the natural and physical sciences. His opinion, never advanced as such except upon a deliberate survey of the whole field, formed by a judgment which on the whole was cautious rather than conservative, never failed to weigh heavily at the decisive moment in any otherwise doubtful balance; nor were the cases few in which his authority lightened for others the responsibility of individual decision.

How important the work done in the transformation of Harvard University was, in its influence upon the higher education in America, need not be considered here. Of the history of one great section of this work, much will be found in the annual reports to the President of the University made by Professor Gurney while Dean of the College Faculty. But the reader will find in these reports few statements of educational theory, and little discussion not required by the practical questions of administration then to be dealt with. It was characteristic of the man that, in all outward expression, the right decision of the subject immediately in hand should be sufficient; and the mass of ripened opinions by which his own mind was fortified, and which came to light in his conversation, he generally cared to display only so far as was necessary in order to convince, in the accomplishment of some definite object.

It was clearly foreseen from the outset, and by none more clearly than by Professor Gurney, that the development of the University system and the great increase in the number of students would require a complete change of relations between the governing body and the mass of young men under its charge, the relaxation of old methods of discipline and the dependence henceforth upon influence rather than constraint; and it devolved upon him as Dean of the College Faculty to take, during the critical years, a most important share in the task of establishing a new tradition. His qualifications for this undertaking were unique. From the date of his appointment as Tutor, his interest in students as individuals, the ease with which he acquired and returned their friendship, his sincere sympathy with misfortune, his patience with failure, and his charity for all short-comings, had made him to a remarkable extent the unofficial counsellor of a long succession of undergraduates, of every possible variety of moral, intellectual, or social quality. To the office of Dean he brought the same capacity for personal attachment and the same ready sympathy, faculties long trained to the perception of character, and a rich store of the matured and cheerful counsel of the man of the world. The influence thus gained was never chilled by any feeling of disparity in years, or purposes, or pursuits. It was strengthened by the sense of sure reliance upon a judgment which never failed to hold its balance undisturbed, and by the charm of a sweet and serene nature. And this kindly authority over students, together with the weight of his advice and example among his colleagues, may be said to have carried the disciplinary administration of the College safely through a period in which it might easily have been wrecked, either by a narrower man, or by one of less steady policy.

Professor Gurney's knowledge of the world was a knowledge both of affairs and of men. No event, social, political, or financial, was indifferent to him or beyond his appreciation. To his colleagues, therefore, the gratifying and unusual choice which made him, while a Professor, also a Fellow of Harvard College, seemed the natural recognition of a life devoted to that institution, and of rare capacities for its service. Closing a career which leaves so little written evidence of that which makes it memorable for his contemporaries, this distinction is a lasting memorial of him, placed in the University of which he was a builder.

WILLIAM RIPLEY NICHOLS.

Fortunately for the cause of science, it is seldom that the Academy has had to deplore the loss of a member at once so young and so prominent as William Ripley Nichols. Though dead at the early age of thirty-nine, he had already for some years been recognized as an authority in most branches of chemistry that relate to sanitation, — particularly in respect to his specialty, the chemistry of potable waters, — and he had likewise played a prominent part in the movement for the establishing of sound methods of scientific instruction, which was contemporaneous with his life.

Professor Nichols was born in Boston, April 30, 1847. He died at Hamburg in Germany, July 14, 1886. During boyhood he was well taught. After having passed through the Roxbury Latin School, he, together with three of his schoolmates, went to Europe in charge of the headmaster of the school, Mr. Augustus H. Buck. During an absence of nearly two years he not only travelled extensively, but, as his period of fruition proved, he must have studied also with no little assiduity. He became proficient in the use of German and French, and was subsequently repeatedly called upon to make particular use of his linguistic powers both as a teacher of these languages and as a scientific investigator.

On his return from Europe, in 1865, Mr. Nichols joined the Sophomore Class in Harvard College, but in the course of a few months he deliberately withdrew from the University and joined the school of the Massachusetts Institute of Technology, then in the second term of its existence. This movement — than which no event in the man's career more clearly marks his native strength and independence of character — was the turning point in his life. He had entered Harvard College with the purpose of devoting himself to the study of languages and to literature, having already enjoyed, as it must have seemed to him, somewhat exceptional advantages in preparation for such a course. But on finding that the knowledge already acquired would count for little or nothing for his immediate advancement, and that the rigid non-elective system of study then in vogue at Cambridge would compel him to spend much time upon subjects which seemed to have no direct connection with his intentions and purposes, he resolutely changed his plan and turned to a school of freer methods. He immediately became interested in the scientific instruction given at the Institute, and devoted himself zealously to study. From that time forth the story of his life is simply one of earnest devotion to the advancement of science, and to the improvement of methods for teaching science.

While yet a student at the Institute, Mr. Nichols served as an assistant in the chemical laboratories and to the teacher of modern languages. At this period were published his first chemical papers, the most important of which was a study of certain oxalates. By the application of modern methods of research he was enabled to rectify in some particulars the work of earlier investigators.

Immediately after his graduation, in 1869, heavier duties were put upon him in his capacity of laboratory assistant, and he was at the same time employed by our lamented associate, Dr. George Derby, then Secretary of the Massachusetts State Board of Health, to investigate a variety of sanitary problems. In addition to these labors, Mr. Nichols did much work for the Rumford Committee of the Academy in collating matters relating to its edition of the complete works of Count Rumford, then in process of publication. He translated anew whatever of Rumford's writings had been published in German or French, and acquitted himself admirably of this by no means easy task. Mr. Nichols's services finally became so important to the committee, that he was authorized to prepare for the press the copy of the last three volumes of Rumford's works, and to take charge of the revision of the proofs. During a visit to Europe he ransacked the libraries of London, Paris, and Munich in the committee's behalf, and was rewarded by the discovery of some inedited writings of Rumford, which were published by the Academy in due course. All the work of this period, as well as that which followed, was thoroughly well done, and gave full satisfaction to every one connected with it.

As a worker, Nichols was distinguished for patience, accuracy, thoroughness, intelligence, and good judgment. Though painstaking to a degree, no trace of pedantry contaminated him. He was never slow or sluggish, and seldom seemed to be in haste. To all appearance, there was plenty of time in each day for the affairs he had to attend to, and, indeed, time to spare. Even when most heavily weighted with the burden of his own multifarious occupations, he would cheerfully read proof for his friends or revise their works; and he was accustomed methodically to answer his share of that innumerable host of letters of inquiry, which in this country pour in like locusts to consume the time and strength of every scientific man who works upon matters of general or public interest. He wrote easily, clearly, and courteously, and his thorough mastery of whatever subject he might present enforced attention and disarmed criticism.

In 1870, Mr. Nichols was appointed Professor of General Chemistry in the Massachusetts Institute of Technology, and it was in this position that the remainder of his life was passed. It is but simple truth to say that through unflagging devotion to the interests of this professorship Nichols worked himself to death. The only wonder is that he held out to work so long. From the first moment of his connection as a student with the Institute, he had clearly recognized the meaning and significance of the new educational movement to which this school gave expression, and from that time forth he labored for it without haste and without rest. Doubtless it was because he wished to see the new ideas nurtured in a virgin soil that he declined President Eliot's invitation to occupy a chemical chair at Cambridge. In the same spirit, he refused, long afterwards, to listen to the proposition that he should accept a professorship in the University of Virginia.

During many years so much of Professor Nichols's time was occupied by his duties as a teacher that his continual scientific productiveness seems wellnigh incredible. Nothing but a most exceptional intelligence and an abounding store of innate strength can explain his remarkable capacity for turning off work, and account for the results of his most useful life. Taken separately, either the work he accomplished in the class-room, or the laborious investigations which were conducted in his laboratory would be quite beyond the powers of most men. He was imbued withal with a deep religious feeling, and was an active participant in the work of his church and of its Sunday school.

An acute attack of pleurisy in June, 1881, left him physically speaking a mere wreck; but his indomitable spirit seemed to burn only the more brightly through suffering. During five long years he struggled, with characteristic energy, perseverance, and good judgment, to regain his health and complete his work, but in vain.

In respect to Professor Nichols's contributions to questions of sanitation, — which at the first glance might perhaps be thought of as largely technical, — it is to be noted that they were always conceived in a thoroughly scientific spirit. No suspicion of venality, or flavor even as of affairs commercial, mercantile, or litigious, will ever be found attached to any statement of his. He was wholly free from a certain tendency to strive for triumph rather than for truth, which has sometimes been supposed to be part and parcel of an "expert's" life, and which is undoubtedly apt to mar the statements of public analysts, and to detract from the respect and esteem in which members of the profession might well be held by the community at large.

There is no room for doubting that Professor Nichols did earnestly desire to alleviate suffering humanity, and to support to the utmost of his power wise schemes for the better ordering of those state and municipal affairs with which chemical science or art has relations; but he had no wish for mere notoriety, or for the overthrowing of adversaries, or for the forcing of crude thoughts or schemes upon an unwilling public. His purpose was simply to seek out the truth and to exhibit it. That the truth would prevail in due course, he had no doubt or fear. By those of us who knew him well, he will always be remembered, not only as an accomplished chemist, but as a loyal, devoted friend, and a thoroughly conscientious Christian man.

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CHARLES CALLAHAN PERKINS.

Charles Callahan Perkins, son of James and Eliza Greene (Callahan) Perkins was born in Boston on the 1st of March, 1823. His grandfather was James Perkins, an eminent merchant, whose name will be long remembered in Boston for his munificent gifts to the Institution for the Blind and to the Boston Athenæum.

Charles Perkins's early years were spent in Boston and at boarding schools in Cambridge. He was afterwards, with his brother Edward, under the care and admirable influence of Dr. and Mrs. Charles Follen. He was finally fitted for college at Burlington, New Jersey, and entered Harvard in the autumn of 1839.

Although he had early formed a habit of reading, he was distinguished in college not so much for proficiency in his studies as for his love of drawing and music. These tastes, which were to color all his later life, had begun to manifest themselves at a very early age; and, freed by the inheritance of an easy fortune from the need of preparing himself for a professional life, he gave full play to his natural bent while at Harvard. He graduated with his class in 1843.

The opportunities for the study of any of the fine arts in America were scanty indeed in those days, and young Perkins soon after taking his degree naturally sought in Europe the examples and the instruction he longed for. He first resided in Rome, giving himself mainly to drawing and painting. Later, and after a brief visit to America, he lived in Paris, studying painting in the studio of Ary Scheffer, but at the same time giving increased attention to the study of music, which soon absorbed the greater part of his time. He had at this period already begun to form plans for the advancement of his favorite arts in America. In a letter to his sister, dated early in 1847, he wrote that he looked forward to the time when, trained and with ripened powers, he might be instrumental, with the aid of others,

* Posthumous.

in organizing musical associations and an Academy of Design at home.

In 1849 he returned to Boston, and interested himself chiefly in music. He took part in concerts, at some of which his own compositions were received with pleasure and approval, and he became President of the Handel and Haydn Society, occasionally conducting their performances. Dissatisfied, however, with his own attainments, and impelled to grasp at the golden opportunities which he saw across the ocean, he again went abroad in 1851, remaining nearly three years, chiefly in Leipzig, applying himself with unremitting devotion to music. This was still his main occupation after he came home, when he renewed his close connection with the Handel and Haydn Society. He always continued to take the warmest interest in this society, and to bear an active part in directing its administration and its performances, serving as its President during the last ten years of his life. In this, as in all the societies in which he was active, he endeared himself to his associates by the strong personal interest he took in them, and by the gentleness and consideration for others which so often smoothed away a difficulty or allayed an irritation.

In June, 1855, Mr. Perkins was married to Miss Frances Davenport Bruen, daughter of the Rev. Matthias Bruen, and two years later he went to Europe with his wife and child, accompanied by Mrs. Perkins's mother and sister, first settling himself in Florence. This was the decisive period of his life. He found himself at the age of thirty-five full of enthusiasm for his pursuits, yet doubtful, perhaps a little discouraged, as to his future career. Excellence in either music or painting demands the devotion of the artist's life, and he had divided his allegiance between the two. In each he had been hampered by the lack of early training, and the industry of later years had failed to supply its place. He had not yet found his vocation. It was now to be made clear to him.

Soon after his arrival at Florence he formed an acquaintance, which speedily ripened into a friendship, with M. Rio, the writer on Christian Art. This eminent scholar saw how remarkably Mr. Perkins's gifts and acquirements, his love of art, his wide acquaintance with its best examples, his zeal, his taste, his patience, combined to fit him for an historian of art. The suggestion was fruitful. The subject was not far to choose. In Florence, under his very eyes, was a field of the highest interest, which had never been thoroughly surveyed. Although the Tuscan school of sculpture was the most remarkable which the world had known since the decline of Greek art, its history had not yet been adequately set forth, and Mr. Perkins applied himself to the task of writing it. With characteristic thoroughness he critically examined all accessible examples of this school, and the documents which bore on the life and works of its masters from the beginning of the thirteenth to the end of the sixteenth century. In 1864, he published "The Tuscan Sculptors," carefully and admirably illustrated by himself. In 1868, this was followed by "The Italian Sculptors," a history of the art in the other Italian cities during the same period. These works were immediately recognized as the standard authorities on the subject, and such they are still acknowledged to be.

His labors on these and kindred subjects were never discontinued during his life. He edited an American edition of Eastlake's "Hints on Household Art" in 1872, and Von Falke's "Art in the House," in 1879. In 1878 he published a work on Raphael and Michel Angelo, and in 1883, the "Historical Handbook of Italian Sculpture." He wrote for the Arundel Society an account of the Sepulchral Monuments of Italy. He gave much time and labor, as critical editor, to the Cyclopædia of Painters and Paintings, of which two volumes were published during his life. His last completed work, written in French, was entitled "Ghiberti et son École," — "une magistrale étude," says so competent a judge as M. Charles Clément. At the time of his death he had begun a History of the Handel and Haydn Society, a part of which has been published, and was engaged upon some writings showing the connection between art and natural forms in plants and animals.

Strongly convinced of the dependence of every artist, even the most original, upon the examples and the ideals which surround and impress him, he took great pains in all his historical work to point out the influences which helped to form the masters of whom he treated; and it is this method, not less than the careful exposition and judgment of their work, which gives his books a permanent value. As a critic of art, whether old or modern, he was discriminating and just, but he loved the mercy that seasons justice. He was always more anxious to find merits than faults. A harsh criticism seemed to give him positive pain.

Since the sculpture of which he wrote could be seen only in Europe, his books could be judged only by European students. Their verdict of appreciation and approval has been decided and well maintained. It is no slight evidence of the esteem in which his work was held, that, in 1869, he was chosen by an almost unanimous vote to be one of the small number of foreign correspondents of the Académie des Beaux Arts, being the first American who had been selected for that honor.

In the same year he returned to Boston to remain, and he then entered upon a period of his life when his attainments were to be made of immediate service to his fellow citizens. Soon after his arrival he urged upon the American Social Science Association the importance of procuring a large collection of casts from the best examples of sculpture, for the use of students and the instruction of the public. It happened at the same time that the Boston Athenæum desired to remove its Fine Arts department in the interest of its rapidly growing Library, and that Harvard College was willing to place the Gray engravings where they would be more accessible than they could be in Gore Hall. Mr. Perkins urged with warmth the design of combining the resources thus offered with his own project, and did more than any one else to foster the conviction that the time had come for Boston to have a public collection of works of art. An article by him in the North American Review, which attracted much attention, contrasted our inertness on this subject with the recent activity of the great European nations, and laid down the principles on which American museums should be founded. These principles were derived from the large purpose he had in view. We must, he said, "aim at collecting material for the education of a nation in art." In every step which was taken to establish the Museum of Fine Arts in Boston he took a leading part. In this, as in all undertakings for the promotion of art, he was eager to make a small beginning, confident that this would lead on to a larger and more perfect growth. He could not wait for the erection of a permanent building on the land granted by the city. He was anxious that the new Museum should immediately enter into activity, and he planned and brought together its first exhibition in the old picture galleries of the Athenæum. When the corporation was fully organized he became its Honorary Director, and chairman of its most important committee. In this capacity he directed the selection of the casts of sculpture which it had been his first object to procure. He labored devotedly in the formation of all its collections, and by gifts, by acts, and by words, he pushed its progress in all directions, inspiring others with some share of his own enthusiasm. Nothing lay nearer his heart than the service he could render the community in this regard; nothing delighted him so much as the advance of the Museum in usefulness and favor.

Another duty came to him. In 1871 he was elected a member of the School Committee of Boston. He was soon placed at the head of the committee on drawing, and there he found the opportunity to carry into effect convictions he had long held. While he considered it important to collect in museums material for the education of a nation in art, he believed not less strongly that this education should begin in the public schools; that from the time a child can guide a pencil, his instruction in drawing should take its start; that such instruction should be carried forward throughout his course, steadily and by an organized method. This method, founded upon the system adopted in England, and known as the South Kensington system, he was mainly instrumental in establishing in our public schools. He believed in it firmly, especially in its value in Boston as the leading town of a large manufacturing district, he defended it manfully, and he cherished and supported it by every means in his power. It stands to-day substantially as he helped to plan it, stamped with public approval.

While this was his most important achievement on the School Committee, he took at least his full share of its work in other ways. He was often intrusted with the preparation of reports on important questions; as chairman of the committee on music, he carefully watched that department; he gave his time ungrudgingly to the details of school management in his district, winning the respect and affection of the teachers, to whose appeals he always lent a sympathetic ear. In 1884, by an unfortunate application of party politics to the choice of the School Committee, he was not re-elected. This, which to most men would have been a relief, was to him a serious disappointment. It was not that he cared for the position, it was that he missed the work. The loss of an opportunity to perform a laborious duty was to Charles Perkins a misfortune. In his performance of it he exhibited the same qualities which distinguished his historical studies, — thoroughness, perseverance, in short, a singular capacity for taking pains.

The labors I have recounted by no means exhausted his activity. He was ready to take part, and always a vigorous part, in every effort for the advancement of the Fine Arts. He had been one of the projectors of the Boston Music Hall, and had adorned it by the gift of Crawford's noble statue of Beethoven. He was an active member of the Harvard Musical Association. He was for several years the President of the Boston Art Club. But it was especially by his lectures delivered before the Lowell Institute, and before many colleges, schools, and societies, that he sought, not only to give information, but to rouse the public to a keener sense of the need of knowledge and training in the arts. When we recognize the great increase of interest in these subjects within the last twenty years, we must gratefully acknowledge the service given by one who was its most constant and efficient promoter.

Charles Perkins was fortunate in his life. He had never known illness, he had been free from harassing cares, he had given himself to occupations in which he was deeply interested, surrounded in his home by those who were always ready with intelligent sympathy and aid. He had not indeed satisfied his early ambitions, nor even pursued them to the end. He had not been a creator in art. It was not for the task of comparing obscure examples of sculpture and searching in musty archives for forgotten details, it was not for the often wearisome toil of the School Committee, that he had made the long preparation of his early manhood. But he had taken hold of the tasks and the duties which came to his hand to do, and he had found happiness in doing them with all his might. And probably no preparation he could have made would have better fitted him for the work he was to do. But he was more than fortunate. He devoted his life to the increase of knowledge, and to the advancement of his own people along his chosen path; and he so lived that all who knew him were eager to bear witness to his high and delicate sense of honor, the purity of his character, his fidelity in friendship, and the kindness of heart which his charming manner so happily expressed.

On the 25th of August, 1886, at Windsor, Vermont, he was thrown from a carriage and was instantly killed. He left a widow, two sons, and a daughter.

HENRY HOBSON RICHARDSON.

The death of Mr. Richardson on the 26th of April, 1886, took from his profession a great master, and from his friends a man of most noteworthy and interesting character.

He was born at Priestley's Point, St. James Parish, Louisiana, on the 29th of September, 1838. His father, Henry D. Richardson, was a planter of American birth, but his earlier ancestors were Scotchmen, who however had moved to England before the family came to this country. His mother was Catherine Caroline Priestley, who was a daughter of Dr. Priestley, the famous theologian. It is easy to believe that all these circumstances of his origin contributed something which can be recognized in the character of the distinguished architect.

Mr. Richardson received an appointment to West Point from Judah P. Benjamin, who was then a Senator of the United States. He went to the Military Academy and passed his examinations; but the death of his father changed his plans, and his education was transferred to Harvard College, where he entered in 1855, and graduated in the Class of 1859. His college course, so far as one can learn, was marked by no extraordinary signs of promise. Bright, gay, popular, he seems to have indicated no special disposition to the art in which he was destined to make for himself such a brilliant career. Nor is it possible to learn what led him just before his graduation to determine upon architecture as his profession.

It was the years immediately following graduation, — the years from 1859 to 1865, — which brought out the character of Richardson and filled him with enthusiasm for his chosen work. In those years the war was raging. Richardson was studying in Paris. His resources, which had till then been abundant, failed him entirely, and he was obliged to work for his support. The strong pressure of poverty behind him called forth the energy and persistency which were in him, and the fascination of the work before him, which he speedily felt and to which he heartily abandoned himself, quickened a genius before unsuspected by himself or by his friends. He entered the office of a French architect, and made drawings for several public buildings in Paris. Thus he labored for his daily bread while he was eagerly pursuing his studies. These years were the making of the man and of the architect at once.

Mr. Richardson returned to America, and began business for himself in New York on the 1st of January, 1866. He married on the 3d of January, 1867, Julia Gorham Hayden, daughter of Dr. Hayden, of Boston.

The years from 1865 to 1871 were full of steadily increasing work and constant progress towards those characteristics which in his later life gave such broad and noble significance to all he did. His earliest buildings were in Springfield, Massachusetts, where the railroad offices and the Agawam Bank already gave evidence of his great power. The Church of the Unity, however, in the same city, is a Gothic building, and quite unlike the ecclesiastical structures of his later years.

In 1871, Mr. Richardson began to build the Brattle Street Church in Boston. In 1872, he prepared and presented his plans for Trinity Church. About the same time he built the Cheney Buildings, in Hartford, Connecticut. Not much later came the Memorial Library at North Easton, the Public Library at Woburn, and the beginning of his work at the State Capitol at Albany. These buildings, and others which belong to the same period, mark the ripening of his powers, and the development of that strong and masculine style which afterwards was seen in all he built, and which must always make his work recognizable and notable for the best qualities of architecture.

Then came ten years of the most brilliant and exuberant vitality. The place which the successful architect, still a young man, had won at the head of his profession, was recognized with singular cordiality on every side. Students flocked to him for instruction, and his studio at Brookline, where he established his home in 1875, became famous for the inspiration with which he filled it. He was sought out by men from all over the country who wanted greatness and simplicity and strength in any of the fields of architecture in which he had shown his power. These fields were very various. Churches like those in Boston, and like the great cathedral which he designed, but never built, in Albany; great civic buildings, like those in Albany and Cincinnati, and his last great work, which he left unfinished in Pittsburg; memorial halls and libraries, for which he created a type of singular beauty and fitness in North Easton, and Quincy, and Malden, and Burlington; Academic structures, like Sever and Austin Halls at Cambridge; railroad stations, which surprise the traveller with the possibility of what before seemed hopeless; great mercantile houses in Boston, and Hartford, and Chicago; dwellings in Washington, and Boston, and on the sea-shore, and in the country; — these all came in profusion from his brain, which stamped each of them with separate originality and yet gave them all the indubitable mark of his personal character and genius.

To those who knew him well, all the work that he did must seem to have essential relations to the sort of man he was. The style was the man. A solidity and seriousness which yet was always full of vitality and never dull, a love of simplicity which was not an abandonment of richness but a delighted discovery of it in the simplest things, a constant desire to produce impression by great forms and masses and not by pettiness of detail, spontaneity and freshness which were all the more impressive because they carried in themselves the principle of self-restraint, — all these appear in the freely treated Romanesque in which his monumental buildings are constructed, and something corresponding to them is felt, by those who knew him, in all the character and conduct of the man.

His influence upon the architecture of America must be very strong, and cannot be anything but good. He broke the spell which still rested in large degree upon the freedom of his art. He gave it dignity and greatness. He never trifled. He reverenced his profession. He was not afraid of repetition, trusting confidently to the constant diversity of occasions and of needs to make monotony impossible. He will be imitated, of course, in stupid and mechanical fashion; but he will also do what he would have most wished to do; he will inspire men to be real, simple, and sincere. He will make tricks and devices seem unworthy of an art whose greatness he felt and declared in all his buildings.

Mr. Richardson was made a member of this Academy in 1881, of the Archæological Institute of America in 1881, and of the Royal Institute of British Architects in 1886, only three weeks before he died. When this last honor reached him, he said, "If they praise me so for what I have done, what would they say if they saw what I can do." It was the consciousness of unused power. To himself and to his friends he seemed, dying at forty-eight, to be dying young. If he could have had twenty years more of life, no man can say with what work he might have enriched the world. But life had been a fight with death for years. Everything he did had been done for years in pain and sickness. Nothing but a vitality which seemed to have no limit, an enthusiasm and buoyancy and joyousness that never failed, had kept him in this world. At last the ever-advancing illness conquered even them, and his work was over, and he died.

His death took from his friends a character which they must always remember with delight. To know him was to live in a land of wonderful profusion. There was a charm about him which will not submit to be analyzed, and which can never be forgotten. He remains a picture of breadth, openness, simplicity, happiness, and strength. He seemed to enlarge the thought of human nature while he lived, and to leave the world perceptibly more empty when he died.

FOREIGN HONORARY MEMBERS

LEOPOLD VON RANKE.

Heredity is an important element in the making of great men. While this factor alone does not suffice to explain such a phenomenon of historical genius as Leopold von Ranke, it is at least worthy of careful observation. Dr. Oliver Wendell Holmes, in his biography of Emerson, has clearly shown the effect of heredity in the development of the Concord philosopher from a long line of cultivated New England clergymen. In studying the descent of Ranke, one is impressed with a similar fact. For several generations, indeed as far back as his progenitors can be traced, they were liberally educated men; and they were all clergymen with the sole exception of Ranke's father, Gottlob Israel, who at the University of Leipzig changed his course from theology to law; but he afterward repented his choice and urged Leopold, his oldest son, to become a clergyman. In fact, the youth studied theology, in connection with the classics, at Leipzig, and once spoke in his brother Heinrich's church at Frankfurt on the Oder, where the coming historian taught school before his call to Berlin. While one of his brothers actually became a clergyman, Leopold and three others were differentiated from the pastoral stock and became university professors. The historian's son, Otto, reverted to the original type, and is now a pastor in Potsdam.

The best sources of information respecting Ranke's early life and the characteristics of his family are his brother Friedrich Heinrich Ranke's "Jugenderinnerungen," which reveal wonderful powers of exact description, and withal charming glimpses into German homes and German local life; and Ranke's own "Lebenserinnerungen," fragments of which were published in the "Deutsche Rundschau" for April, 1887. Ranke says, "Die Vorfahren, die uns bekannt sind, waren alle Geistliche, meist in der Grafschaft Mansfeld." He sketched his family history from the seventeenth century. The oldest known ancestor was Israel Ranke. "Er lebte ganz seiner Pfarre," says Ranke. Israel had a brother Andreas, who was a clergyman and "ein Gelehrter." He wrote dissertations, and was fond of mingling local history with his sermons; indeed, Ranke says this man's work is quoted to this day as an authority in his parish. Among the great historian's ancestors was a second Israel Ranke, a clergyman of such broad views that he prayed for God's blessing upon his labors in the liberal arts ("auch in den freien Künsten"), so that he might be of service to his fellow-men. Here, perhaps, lay the ancestral germ of that fair humanity which Leopold von Ranke developed in all his writings. The historian's grandfather, Heinrich Israel, was also a clergyman, and lived to the age of fourscore (1719–99).

Longevity appears to have been an hereditary trait in the Ranke family. This trait was strengthened, if not developed, by the regularity and quiet life incident to the clerical profession in country districts. Men have not yet ceased to marvel at the phenomenon of Leopold von Ranke beginning a history of the world in his eighty-fifth year, and continuing the same with unabated mental vigor until past the age of ninety; but that phenomenon has a physical basis laid by generations of long-lived, earnest, intellectual men. Nothing is so wonderful in the life of Ranke as his persistent, indomitable activity, or what the Germans call "rastlose Thätigkeit"; and yet this tireless energy was but an intensified, highly specialized form of that systematic, almost religious devotion to work and duty which has characterized German pastors since the days of the Reformation. Superadded to this habit of methodic toil, characteristic indeed of all German scholars and of most professional men, was the equally methodic habit of rest and recreation, in which matters the Germans surpass their Anglo-American kinsmen.

In early years Ranke was fond of horseback riding and of athletics. With his brother Heinrich at Frankfurt, he was a follower of Father Jahn, from whom our modern gymnastics and first gymnasia came. Through all his later years Ranke was devoted to long and pleasant walks in the open air and sunshine. Thus he cultivated perpetual health, and maintained that serenity of mind and heart which illuminates all his works. To these same physical facts of open-air exercise and regularity of life are due in great measure the vigorous longevity of America's oldest historian, Mr. George Bancroft, who at the age of eighty-seven is quietly preparing to continue in outline his History of the United States through the present century. To the same simple German regimen of work and recreation we may perhaps ascribe other kindred phenomena; for example, Schlosser writing world history in Heidelberg at the age of eighty-five, and Alexander von Humboldt completing his "Cosmos" at the age of ninety. Good habits and a good constitution were the foundation of Ranke's longevity. His brothers also were long-lived. The youngest, a Professor of Theology in the University of Marburg, is still living.

If heredity had its influence upon Leopold von Ranke, history and education finished the product. He was born in a revolutionary epoch, in a time of war and political commotion. The little town of Wiehe, in the so-called Golden Aue of Saxon Thuringia, was his birthplace, and the 21st of December, 1795, was his birthday. That very year the armies of the French Republic began their successful inroads upon Germany, and that year Prussia, by secret treaty, gave up to France the left bank of the Rhine. It was the beginning of the end of the old German Empire and of the political reconstruction of feudal Europe by Napoleon Bonaparte. Ranke when a boy saw the march of French invaders past the doors of his school. He heard the distant cannon of the French at Jena and Auerstädt. His lessons in reading and writing were Napoleon's bulletins from the Spanish peninsula. The word "insurgents" first came into his vocabulary from the published accounts of the Spanish uprising, prelude to the larger movement of Russia and Prussia for the liberation of Europe. When the news of the retreat of the grand army from Moscow began to penetrate Germany, young Ranke was reading the Agricola of Tacitus. The speech of the British Queen Boadicea, animating her subjects to repel the Roman invader, acquired a new meaning to Ranke as the thought of casting off the French yoke began to penetrate the patriotic German mind. "There," says Ranke himself, "within cloister walls and in the midst of classical studies, the modern world first came into my head."

The Napoleonic wars were, then, the historical influence which led Ranke, the favorite classical pupil at Schulpforte, through the gates of modern history. He was early drawn to historical studies by the fact that one of his classical instructors gave him subjects for Latin verse drawn from the local history of Saxon Thuringia. "Besonders war es sächsische und thüringische Geschichte die dann durch die nahen historischen Plätze einen besonderen Reiz für die Jugend bekam." Although at the University of Leipzig Ranke continued with great zest his classical studies, he remained an essentially modern spirit. He was a great admirer of Goethe, who was at that time introducing "eine moderne Classicität" into German life and studies. Luther, however, was his favorite character. His earliest historical ambition appears to have been to prepare a literary memorial of the great German Reformer, to be published in 1817, on the occasion of the three hundredth anniversary of the nailing of the ninety-five theses upon the church door at Wittenberg. That same year, 1817, Ranke took his doctor's degree. From that date his student purpose began to widen. From the idea of a new biography of Luther sprang the larger thought of the reconstruction of modern European history, from the time of the German Reformation.

Of all the men who influenced Ranke's development, Luther undoubtedly stood first. Next to him were Thucydides and Niebuhr. From the one Ranke took his pregnant artistic style; from the other, his critical method. The lessons derived from a careful study of ancient history were applied to modern history. Ranke himself says that Niebuhr's History of Rome exercised the greatest influence upon his own historical studies. "It was the first German historical book which made an impression upon me." Ranke, however, developed Niebuhr's critical method, and eliminated certain faults. While an admirable critic of sources, Niebuhr read into his version of Roman history a variety of moral and philosophical views unwarranted by the existing evidence; while undermining ancient traditions, he built up new structures upon unsafe foundations. From fragments of truth he undertook to construct the whole truth by a somewhat fanciful and imaginative process. Ranke, on the other hand, determined to hold strictly to the facts of history, to preach no sermon, to point no moral, to adorn no tale, but to tell the simple historic truth. His sole ambition was to narrate things as they really were, "wie es eigentlich gewesen." Truth and objectivity were Ranke's highest aims. In his view, history is not for entertainment or edification, but for instruction. He would not tolerate inventions, and mere fancies or assumptions. He did not believe it the historian's province to point out divine providences in human history, still less to proclaim that history is a *Weltgericht.* Without presuming to be a moral censor, Ranke tried to bring historic truth in its purity before the world. He cultivated withal an artistic style, always choosing a form of expression which rose above the trivial and the commonplace. In this respect he was influenced not merely by classical models, but by the style of Johannes von Müller. To avoid such false coloring as had been given to history by Sir Walter Scott and writers of the Romantic School, was one of Ranke's favorite ideas. Thus the weakness as well as the strength of other men were educating influences in the development of Leopold von Ranke.

His first book was written at Frankfurt on the Oder, whither he was called in 1818, to be a teacher in the Frankfurt Gymnasium, or classical school. The book was published in 1824, when Ranke was twenty-nine years old. It is the best introduction to a study of Ranke's writings, for, as the writer himself said in later life, it constitutes the foreground of modern history and contains a preparation for most of the later work of the author. His principles of historical criticism and his ideas of history are there clearly stated, and the book is still regarded in Germany as the best general exposition of Ranke's method.

His book was called a "History of the Latin and Teutonic Nations." The narrative portion has been translated into English since Ranke's death by Ashworth, the translator of Gneist. The work is accessible to any English reader in Bohn's Standard Library, although the critical appendix to the original work, Ranke's "Kritik neuerer Geschichtsschreiber," is unfortunately omitted. In this critique, Ranke examined the literary foundations of early modern history. He considered with great care the work of Machiavelli and Guicciardini, two representative Italian historians; also two German historians; and one Spanish and one French authority. In each case Ranke's object was to discover how far the writer's statements were original and trustworthy. Ranke was one of the first scholars to vindicate the character of Machiavelli. On the other hand, he was the first to expose Guicciardini, whose history was shown to have no solid foundations and to be written for romantic effect.

In his own narrative Ranke begins by sketching, in a few bold and striking lines, the great facts which mark the essential unity of the Latin and Teutonic nations; on the one hand, the Italian, French, and Spanish, and on the other, the German, English, and Scandinavian. Ranke shows that these six peoples have all passed through the same phases of internal history, and have all been borne along by the same great current of external experience. The chief tributaries of European history are seen to flow together into the great modern stream which issues in a new world. Three connected events are pointed out: 1. the migrations; 2. the Crusades, begun by the Normans, who ended the Teutonic invasion of Italy; and 3. the colonization of new countries, a movement still in progress, but sprung from crusading enterprise. These three great facts, says Ranke, connect both the times and the peoples. "They are, if I may so speak, three great respirations of this incomparable union." Another expression of the essential unity of Latin and Teutonic nations Ranke saw in the Spanish monarchy of the House of Hapsburg, against which France revolted at the time Northern Europe threw off the yoke of the Papacy. The resultant struggles constitute the chief interest of modern history. Ranke's introductory work covers the brief period from 1494 to 1514. Modern political history is shown to begin with the French invasion of Italy by Charles VIII. In the resultant wars, the leagues and counter leagues, which ended in the expulsion of the French from Italy, as they were afterward expelled from Germany, one can almost see prefigured the modern struggle of European states. It was no chance which led Leopold von Ranke, after the German War for Liberation, to turn back to the Italian beginnings of this long contest for supremacy.

Ranke's first book was an immediate success. Scholars recognized at once that the author was a *Weltgeist*, discerning vast unities where other men had seen only infinite particulars. Through the influence of Altenstein, the Prussian Minister, Ranke was called to the University of Berlin in 1825, although he was not made full Professor until 1836. Ranke had borrowed the literary materials for his first book from the Berlin collections. Indeed, it was jocosely said, before his call, that it would be necessary either to invite Ranke to Berlin or to remove the royal library to Frankfurt. It may be confidently asserted that the literary environment of the University made Ranke's historical work a possibility. In Frankfurt he had used only printed books. In Berlin, following the track of Johannes von Müller, he came upon the manuscript relations of the Venetian ambassadors, in forty folio volumes. They were not originals, but transcripts. It was once the fashion with princes and nobles to secure copies of state papers and diplomatic correspondence for their private libraries. Venetian despatches were always prized, because they were the best and fullest. Venice had the best diplomatic system in Europe. She sent her ambassadors in rotation to Rome, Madrid, Paris, Vienna, and Constantinople; she had representatives in the chief courts and centres of trade. She required diplomatic reports every fortnight, and these were read to the Senate, which contained many diplomats who had retired from foreign service after years of experience. Consequently Venetian ambassadors took great pains to be accurate in their observations and sound in their judgments; otherwise they would have fallen into disrepute with the home government.

Respecting this new source of modern European history which Ranke rediscovered in the royal library at Berlin he said, "Whatever be the event upon which one may wish information in this great period of history, here he will usually find carefully prepared reports, with exact details, almost always suited to help solve the problem." Ranke went through the entire Berlin collection of forty folio volumes, and afterwards found a dozen volumes more at Gotha. One he acquired for himself. In this connection, it may be worthy of note that eight folio volumes of copied Venetian manuscripts from the Greystoke Library, England, were not long ago offered by special letter to the American Historical Association for something over $1500. Like those manuscripts found by Ranke, they are transcripts from the original despatches of Venetian ambassadors at the various European courts, and were executed for a private library under the superintendence of an English diplomatist accredited to Venice.

Upon the basis of such novel materials Ranke entered upon his great career as the historian of modern European states. In 1827 was published his "Princes and Peoples of Southern Europe in the

Sixteenth and Seventeenth Centuries," the first volume relating to the Ottoman Turks and the Spanish monarchy. From 1827 until 1831 he was allowed a four years' leave of absence for the study of foreign archives. He visited the libraries of Vienna, Rome, Florence, and Venice, everywhere making valuable discoveries of fresh materials for modern European history. Ranke's researches in Italy have been compared to Humboldt's observations in the New World. Libraries and archives are for the historian what laboratories and nature are to students of natural science. Ranke's work in Italian, especially Venetian archives, marks an epoch in the study of modern history. Before his time, historians had been content with printed books and other men's opinions. Ranke went to the primal sources of political information, to state papers, diplomatic correspondence, and original documents. With regard to such rummaging in archives, Ranke once said: "He needs no pity who busies himself with these apparently dry studies, and renounces for their sake the pleasure of many joyful days. These are dead papers, it is true; but they are memorials of a life which slowly rises again before the mind's eye." Ranke saw in history the immortality of the past.

The most notable result of Ranke's Italian studies is his famous "History of the Popes of Rome in Church and State in the Sixteenth and Seventeenth Centuries." This work, which some critics regard as Ranke's masterpiece, and which was introduced to English readers by Macaulay's famous essay, is a continuation, in the ecclesiastical field, of the "Princes and Peoples of Southern Europe." It reviews, however, the entire history of the mediæval Church, and is perhaps for the general reader the most interesting of all his early works.

While in Italy, Ranke met a Servian refugee named Wuk, and drew from him a narrative of the Servian revolution, which is one of his best minor writings. Niebuhr said it was the best book in literature upon a contemporary event, and one whereof Germany might well be proud. In this connection, it may be said that, in general, Ranke was strongly opposed to writing history with a political tendency. His inaugural address, upon assuming the duties of a full Professor in Berlin, in 1836, was upon the relation and difference between history and politics. Therein Ranke states the true view when he says: "A knowledge of the past is imperfect without an acquaintance with the present; there is no understanding of the present without a knowledge of earlier times. The one gives to the other its hand; neither can exist or be perfect without the other."

Ranke was by nature and associations a conservative in politics.

From 1828 to 1836 he and Savigny edited the "Historische-politische Zeitschrift," which was distinctly opposed to the liberal and democratic spirit of the age. Ranke lived in a period of political reaction. Cautious statesmen were turning away in distrust from the revolutionary spirit begotten by France. Scholars were urged to strengthen the foundations of existing society by reviving a knowledge of an illustrious past. It was a period most favorable to historical studies, although not to political progress in popular ways. By conservative methods of reconstruction, scholars and statesmen hoped to build up Germany anew. Eichhorn studied early Germanic law and institutions. The Grimm brothers studied Germanic folk-lore. Savigny investigated the history of Roman law in the Middle Ages. Niebuhr wrote his Roman history, and Ranke carried Niebuhr's idea into the history of modern Europe, with a specifically German impulse proceeding from Luther and the German Reformation. At the patriotic instance of Baron vom Stein, an historical society was founded at Frankfurt on the Main in 1818, for the reconstruction of German history from the very foundations. By Stein's recommendation George Pertz was engaged to edit the original sources of German history, now well developed in a magnificent series of volumes called the "Monumenta Germaniæ Historica." Pertz was also put in charge of the royal library at Berlin, which became the centre of historical activity for all Germany, as it is now the centre of politics for the new German Empire. The conservatives were perhaps wiser than the radicals in that slow historical upbuilding of now reunited Germany.

Into this process of peaceful, scientific reconstruction not only of Germany, but of modern Europe, Ranke entered heart and soul. He was pre-eminently the man who taught Young Germany how to utilize the historical materials which Pertz was beginning to collect and publish. Ranke early instituted at the University of Berlin an historical seminary, or, as it was then called, historical exercises, for the critical use of the original sources of mediæval history. While his own work was for many years in the modern field, he preferred to keep his students upon mediæval ground, where materials could be better mastered. A little company of advanced students met once a week in Ranke's own library, and learned, under his direction, to apply the critical method. This was the origin of the famous Ranke school of historians, of which Germany is now full. Three generations of historical scholars have been trained under his direct or indirect influence. Dr. Jastrow, of Berlin, from whom the writer obtained some materials for the present sketch, says there is not a single professor of history at any German university to-day who is not a product of the Ranke school.

By the use of this term "school," it is not meant that all of Ranke's students were cast in one mould. On the contrary, the great historian took special care to develop the individual talent and peculiar strength of all his pupils. The marvellous variety of men and work that have issued from Ranke's historical laboratory is the best proof of the broad views of its director. Among Ranke's pupils are such widely different specialists as George Waitz, author of the Constitutional History of Germany, and Pertz's most illustrious successor in editing the Monumenta; Heinrich von Sybel, editor of the "Historische Zeitschrift," and author of the best German work upon the period of the French Revolution; Wilhelm von Giesebrecht, the historian of the German Emperors; Max Duncker, author of the best German History of Antiquity, particularly of the Orient; and Wattenbach, the historian of the Papacy and author of "Deutschlands Geschichtsquellen." Ranke's influence is not confined to Germany. A recent article upon Ranke, by Hans Prutz, says that in Ranke's school were trained those men who to-day in France and England are pursuing the most scholarly investigations in history. M. Gabriel Monod and Bishop Stubbs are cases in point. According to Ranke's method, the best historians of newly awakened Italy are now working. Prutz says that the newly founded American Historical Association signified its obligations to Ranke in extending to him, when he was ninety years old, through its President, George Bancroft, an election to honorary membership.

Ranke's success as a university professor was of the highest kind, for he not only made remarkable contributions to his chosen science, but trained up a generation of historians who have extended his critical methods far and wide. As an academic lecturer he was never popular. President Andrew D. White, in "The Forum" for February, 1887, has given a graphic and amusing picture of Ranke in his lecture-room: "He had a habit of becoming so absorbed in his subject as to slip down in his chair, hold his finger up toward the ceiling, and then, with his eye fastened on the tip of it, go mumbling through a kind of rhapsody, which most of my German fellow students confessed they could not understand. It was a comical sight: half a dozen students crowding around his desk listening to the Professor, as priests might listen to the Sibyl on her tripod, the other students being scattered through the room in various stages of discouragement." This description is confirmed by the testimony of many of Ranke's German pupils. Alfred Stern says Ranke never had what men call a good delivery. Leaning carelessly back upon his chair, his great blue eyes looking toward the ceiling as though he saw rising there the shadows of the past, he ran together in a feeble voice sentences that were often hardly intelligible, until suddenly a striking word, a brilliant comparison, a grand thought of universal significance, thrown out with lively gestures, seemed to break through the chain of mysterious oracular sayings like a flash of lightning. At first, continues Stern, Ranke was not attractive to young students. The historical exercises in which, as instructor in a private and select circle, he enjoyed his greatest triumphs, did not establish a reputation until later.

Ranke's chief activity continued to be in the line of original contributions to modern history. From 1839 to 1847 was published his "History of Germany in the Period of the Reformation," in six volumes. Fresh materials for this great work were found at Frankfurt on the Main, in the proceedings of the German Diet from 1414 to 1613, in ninety-six folio volumes. These archives proved almost as important as the relations of the Venetian ambassadors. Sixty-four folio volumes of records and reports were digested by Ranke for his German History. With remarkable liberality, the authorities at Frankfurt allowed Ranke to take selections from this great collection to Berlin for use in his own library. Other municipal archives were opened to his researches; for example, the records at Weimar. The royal archives of Prussia and Saxony were likewise placed at his service. By this generosity a vast collection of absolutely new material was accumulated by Ranke for his work. New contributions drawn from fresh sources of information were always Ranke's aim in writing history. It was a maxim with him not to relate things which everybody knew already. These ideas have borne rich fruit, not only in Ranke's own contributions to European history, but in those made by his students, who, like their master, have widened the domains of historical science.

Ranke's German History was followed by his "Nine Books of Prussian History," a work afterwards extended to twelve books. This special contribution was partly due to the fact that, in 1846, Ranke was made historiographer of Prussia, an office which he held until his death, and which doubtless suggested further Prussian contributions. From Germany, the idea of national history during the period of the Reformation was extended by Ranke to France and England. His work on the History of France is based upon original studies in French archives. It embraces the period of the religious wars and the full development of French absolutism. Ranke's French studies threw new light upon such characters as Catherine de' Medici, Henry IV., Richelieu, Mazarin, and Louis XIV. Ranke's History of England, covering the period of the Stuarts and of both Revolutions, in nine volumes, appeared in the years from 1859 to 1861. Like all his previous work, this also was based upon original studies. Ranke betook himself to the British Museum, and to the Record Office in London. The English reader may be quite sure that he will find in Ranke's History of England facts and deductions which no previous historian had reached. Lord Acton, who is said to be the best-read man in England, in his brilliant article on "German Schools of History," published in the first number of the English Historical Review, says that Ranke "alone among writers of prose has furnished a masterpiece to every country."

The completion of the History of England marks the completion of a grand circuit of European history by Leopold von Ranke. He had passed in historical review the great states of modern times. He was now nearly seventy years of age. He was raised to the rank of the nobility on the occasion of his seventieth birthday. He enjoyed the admiration of all Germany and the appreciation of the learned world. The fiftieth anniversary of his doctor's degree was celebrated by enthusiastic pupils, and the event was marked by a new and complete edition of his writings. Thus crowned with honors and with years, he might well have thought of retiring from further labor; but Ranke's activity suffered no diminution. He was indeed relieved from the responsibility of further lecturing at the Berlin University. His name was retained in the catalogue for twenty years longer, and students read after that famous name the words *liesst nicht.* During this period of pensioned leisure, accorded to Ranke by the Prussian government, he produced in quick succession that wonderful series of contributions to German history: 1. German History from the Religious Peace to the Thirty Years' War; 2. History of Wallenstein; 3. Origin of the Seven Years' War; 4. History of Austria and Prussia between the Peace of Aix la Chapelle and Hubertsburg; 5. The German States and the League of Princes; 6. Origin and Beginning of the Revolutionary Wars of 1791–92; 7. Memoirs of Hardenberg, which, like the Memoirs of Metternich, were kept back for half a century; and 8. Life of Frederick William IV. The last named of these writings brings Prussian history down to the time of the present King. Such a brilliant series of contributions by an historian who had long passed the allotted term of human life seemed to the world nothing short of marvellous.

A greater surprise was that in 1880, when it was rumored that Leopold von Ranke, now eighty-five years old, was writing a History of the World. Dr. George Winter, one of Ranke's private secretaries at this period, narrates in his charming "Erinnerungen" how Ranke first made known to him this new project. Ranke had taken a fortnight's vacation, the only one on record in the latter part of his life. He had been to visit General Manteuffel at his country seat. To the astonishment of his friends Ranke took no books with him upon the journey. He said he was going for recreation, and meant to talk with Manteuffel. Upon his return, Ranke handed his secretary a manuscript biography of Frederick the Great, dictated during the two weeks' absence without consulting a single book. That wonderful sketch, thrown off apparently for historical amusement, may be found in the "Allgemeine Deutsche Biographie," of which Ranke was the founder. This biography of Frederick the Great was, however, a trifling surprise compared with Ranke's announcement that he had made up his mind at General Manteuffel's to write a History of the World. At first Dr. Winter thought Ranke meant perhaps a brief philosophy of history, but he soon found that the old historian had in mind something much more elaborate than a philosophical sketch. He meant a fresh study of universal history from original sources. He proposed a Weltgeschichte in a series of volumes.

This vast undertaking was the crowning glory of Ranke's life. All his previous writings were but a scientific preparation for this final task. "History," said Ranke in his inaugural address, "is in its very nature universal." It has been said with truth that Ranke never wrote anything except universal history. He treated individual countries, England, France, and Germany, not as isolated phenomena, but as illustrations of world-historic ideas expressed in individual European states. For Ranke, as for Abelard, the universal always lay in the particular. Ranke's very first book, on the History of the Latin and Teutonic Nations, was really a contribution to universal history. There is a perfect unity, therefore, between the beginning and end of Ranke's life-work. His "Weltgeschichte" was but the natural supplement of all that had gone before.

A basis for the proposed history had been laid in a course of lectures by Ranke to King Maximilian of Bavaria, upon "Weltgeschichte." These lectures, says Dr. Winter, still existed in manuscript, and were taken as an outline of the new work. Ranke entered with his secretary upon a fresh study of the ancient historians. The original texts were read aloud, for Ranke could no longer use his eyes for studious work. Copious extracts, with critical observations by Ranke, were collected in great folio volumes, which he called his timber. Although for sixty years the man had devoted chief attention to modern history, he returned now to the classical studies of his youth with almost boyish enthusiasm. He recognized with profound gratitude his debt to that old cloister school of Schulpforte, reformed by Melancthon and the German humanists. Classical culture was the fountain-head of Ranke's historical learning, and it now came into full play.

Ranke was eighty-five years old when the first volume of his "Weltgeschichte" was published. He had begun the work in secret with Dr. Winter some time before. From the appearance of the first volume, the work advanced with great rapidity. "I am an old tree," wrote Ranke to the Empress, "but every year I bear my fruit (*und ich bringe doch alle Jahre meine Frucht*)." Alfred Stern, writing of this wonderful productivity, says, "We all remember still how every year, at regular intervals, appeared one part after another of Ranke's 'Cosmos,' until his narrative reached the greatest imperial personage of the Saxon dynasty, — the Emperor who sprang from the very region of Ranke's narrow home, by the rushing Unstrut, where the Palatinate once flourished at Memleben." Thus Ranke's life-work, having compassed the history of many nations, ended where it began, in Saxon Thuringia, whose stirring local history had first quickened his poetic imagination when he was a boy at school. Ranke's Weltgeschichte was left unfinished, but it connects with all his earlier studies in modern history, the beginnings of which he always sought far back in the Middle Ages. An American once asked Ranke if he really expected to finish his Weltgeschichte. "Lieber Freund," said Ranke, "ich glaube, und wenn Gott will, dass ich mein Werk vollende, so werde ich es vollenden." To other persons he once said, "I have made a compact with God; he must still give me five or six years for the work, then I will gladly go."

Ranke's last labors upon his Weltgeschichte were heroic. Suffering from old age and bodily infirmity, he resolutely subdued himself each day, saying to his secretary, "Now we must forget these pains, and devote ourselves entirely to the Muse." He worked night and day, Sundays and holidays included. He took only one day's vacation in the entire year, and that was not from choice, but simply because his secretaries positively refused to work on Christmas. He wore out daily the best energies of two young men in collecting materials and in writing from rapid dictation. Although Ranke had what Kaulbach called the eyes of old Fritz, they could not be used for reading or writing. He worked under obstacles that would have appalled younger men. To attempt a critical study of the sources of universal history without the use of one's eyes would have dismayed any one except Ranke. His wonderful memory for details, — a characteristic of his family, — and his unerring instinct for truth, were the qualities which, in spite of all hindrance, made his work advance rapidly and surely.

His habits of toil were most systematic. He rose at nine o'clock in the morning, and, after a simple German breakfast, worked steadily until two in the afternoon, when he received visitors for a brief interval, and then walked for an hour or two in the Berlin Park, or Thiergarten, enjoying the sunshine and fresh air. The only thing which annoyed him in that attractive place was the sight of men smoking. He had a most unconquerable aversion to tobacco. He said he never could understand why sensible men could walk abroad in God's free, beautiful nature with a cigar in the mouth. Returning home at four o'clock, Ranke dined and indulged in a comfortable after-dinner nap, after which he was again to be seen by his friends. At seven o'clock in the evening he was ready for his second secretary, with whom he worked continuously until past midnight. From eight to ten hours' work was Ranke's daily habit for many years. It may afford a trifling solace to the friends of early rising and the enemies of night-work to learn that Ranke was informed in his ninety-first year by his physician that he must change his mode of life and give up late hours. Ranke's method of quiet, uninterrupted, continuous work, sustained by sufficient sleep, simple diet, and regular exercise, goes far toward the explanation of his phenomenal energy. It has been suggested that the congenial nature of his occupation recruited his strength and prolonged his life. Work was certainly his only delight. His motto was *Labor ipse voluptas.*

In spite of Ranke's unremitting habits of toil, he was a genial, companionable man, beloved by all his friends and students. His early life in Berlin and Italy was eminently social and *gemüthlich.* Von Reumont has given a pleasing picture of Ranke and his Italian days (Historisches Jahrbuch, Band. VII. 4 Heft). He was a great favorite in Berlin society, and was a personal friend of King William IV., as well as of the great scholars of his time, — Alexander von Humboldt, Savigny, Eichhorn, Boeck, Ritter, Hegel, Neander, Niebuhr, and Goethe. Although he remained a bachelor until the age of fifty, he was always fond of the society of cultivated women.

Indeed, his name is somewhat romantically associated with Bettina von Arnim and Rahel Varnhagen von Ense, both of whose conversational powers and *bel esprit* he much admired. He married at last, in 1845, an attractive Englishwoman, to whom he was truly devoted, and whom he survived by many years. Two sons and one married daughter are now living. One of his sons, Otto, is a clergyman, and therefore perpetuates the theological instinct of the Ranke line of pastors. It was through this theological connection that the sale of Ranke's private library was negotiated for the benefit of an American institution. The historian himself was a man of deeply religious nature, although he never attempted, like Bunsen, to determine special providences in human history. Ranke always gave the facts.

In personal appearance Ranke was extraordinary. The historian of the world was not much over five feet in stature. But his head was "finely chiselled, with a great arched forehead, exceedingly mobile lips (covered only during the last few years of his life by a long white beard), and very bright eyes, with an incessantly inquiring and keenly interested look." A photograph which the writer has recently received from Berlin was taken in Ranke's extreme old age, but the historian looks younger and fresher than most men at the age of seventy. The face is plump and round; the hair abundant, the eyes bright; and the whole expression noble and majestic. He is pictured sitting in his *Schlafrock*, or gown, in which, like many German scholars, Ranke did his literary work, and in which he was sometimes forced, much against his will, to receive the Crown Prince of Prussia, one of his most admiring friends.

In his old age Ranke continued to be the favorite of princes and scholars. The best and noblest came to see him in his simple, unpretentious home, in the second flat of Luisen Strasse, No. 24 A, in the old and quiet part of Berlin, north of Unter den Linden. Here, in the selfsame apartment, Ranke lived for more than forty years, in fact from the time he was married. A most charming glimpse of Ranke at home, and apparently in good health, only three weeks before his death, is that given by Sophie Weisse, daughter of a German exile and a resident of Eton, England. "Her father," said Ranke humorously, when introducing her to his friends, "took a somewhat lively interest in the movement of 1848, and so left Berlin." When his English visitor remonstrated with him for working so hard, Ranke replied, with charming *naïveté*, "Aus Faulheit, aus Faulheit; ich arbeite aus Faulheit; ich habe ja weiter nichts mehr zu thun!" And thus this cheery, charming, wonderful old man worked on until the very last. He once said of his work, "It is my life; I live to work; as long as I live, I shall work." When overtaken by his last illness, and forbidden by his physician to leave his bedroom, he persisted in working. His study table was brought near his bed and sofa, and he continued to dictate to his secretary. A fortnight before he died, he rose from his sick-bed, without the knowledge of his attendant, and made his way into his library. Lost in thought, he stumbled and fell. This accident is thought to have hastened his death; but on that fatal day, as Ranke himself told his daughter, Frau von Kotze, his mind seemed as it were inspired with thoughts of such grandeur and sublimity as he had never before enjoyed in all his life. The morning after the accident he said to his secretary, "What a pity you were not here during the night! We should have completed the last chapter of the seventh volume; I had the whole in my head." But Ranke knew now that his world history was ended, and he calmly prepared for the world beyond. He died on the evening of the 23d of May, 1886. Of him Goethe's words are a fitting epitaph:—

"Edel war der Mensch
Hülfreich und gut!
Unermüdet schafft' er
Das Nützliche, Rechte,
War uns ein Vorbild
Jener geahnten Wesen."

Since the last Report, the Academy has received an accession of twenty-two members; viz., ten Resident Fellows, and twelve Associate Fellows. The list of the Academy, corrected to June 15, 1887, is hereto added. It includes 181 Resident Fellows, 100 Associate Fellows, and 69 Foreign Honorary Members.

LIST

OF THE FELLOWS AND FOREIGN HONORARY MEMBERS.

RESIDENT FELLOWS. — 181.

(Number limited to two hundred.)

CLASS I. — *Mathematical and Physical Sciences.* — 75.

SECTION I. — 6.

Mathematics.

Gustavus Hay,	Boston.
Benjamin O. Peirce,	Cambridge.
James M. Peirce,	Cambridge.
John D. Runkle,	Brookline.
Edwin P. Seaver,	Newton.
T. H. Safford,	Williamstown.

SECTION II. — 13.

Practical Astronomy and Geodesy.

J. Ingersoll Bowditch,	Boston.
Seth C. Chandler, Jr.,	Cambridge.
Alvan Clark,	Cambridgeport.
Alvan G. Clark,	Cambridgeport.
George B. Clark,	Cambridgeport.
J. Rayner Edmands,	Cambridge.
Henry Mitchell,	Boston.
Edward C. Pickering,	Cambridge.
John Ritchie, Jr.,	Boston.
William A. Rogers,	Cambridge.
Edwin F. Sawyer,	Cambridge.
Arthur Searle,	Cambridge.
O. C. Wendell,	Cambridge.

SECTION III. — 42.

Physics and Chemistry.

A. Graham Bell,	Cambridge.
Clarence J. Blake,	Boston.
Francis Blake,	Weston.
John H. Blake,	Boston.
Thos. Edwards Clark,	Williamstown.
Josiah P. Cooke,	Cambridge.
James M. Crafts,	Boston.
Charles R. Cross,	Boston.
William P. Dexter,	Roxbury.
Amos E. Dolbear,	Somerville.
Thos. M. Drown,	Boston.
Charles W. Eliot,	Cambridge.
Moses G. Farmer,	Eliot, Me.
Thomas Gaffield,	Boston.
Wolcott Gibbs,	Cambridge.
Frank A. Gooch,	New Haven.
Edwin H. Hall,	Cambridge.
Henry B. Hill,	Cambridge.
N. D. C. Hodges,	Salem.
Silas W. Holman,	Boston.
William L. Hooper,	Somerville.
Eben N. Horsford,	Cambridge.
T. Sterry Hunt,	Montreal.
Charles L. Jackson,	Cambridge.
William W. Jacques,	Newtonville.
Alonzo S. Kimball,	Worcester.
Leonard P. Kinnicutt,	Worcester.
Joseph Lovering,	Cambridge.
Charles F. Mabery,	Cambridge.
Alfred Michael,	Boston.
Lewis M. Norton,	Newton.
John M. Ordway,	Boston.
William H. Pickering,	Boston.
Robert H. Richards,	Boston.
Edward S. Ritchie,	Brookline.
Stephen P. Sharples,	Cambridge.
Francis H. Storer,	Boston.
John Trowbridge,	Cambridge.
Cyrus M. Warren,	Brookline.
Harold Whiting,	Cambridge.
Charles H. Wing,	Boston.
Edward S. Wood,	Cambridge.

SECTION IV. — 14.

Technology and Engineering.

George R. Baldwin,	Woburn.
John M. Batchelder,	Cambridge.
Chas. O. Boutelle,	Washington, D.C.
Winfield S. Chaplin,	Cambridge.
Eliot C. Clarke,	Boston.
James B. Francis,	Lowell.
Gaetano Lanza,	Boston.
E. D. Leavitt, Jr.,	Cambridge.
William R. Lee,	Roxbury.
Hiram F. Mills,	Lawrence.
Alfred P. Rockwell,	Boston.
Charles S. Storrow,	Boston.
William Watson,	Boston.
Morrill Wyman,	Cambridge.

CLASS II. — *Natural and Physiological Sciences.* — 52.

SECTION I. — 8.

Geology, Mineralogy, and Physics of the Globe.

Thomas T. Bouvé,	Boston.
Algernon Coolidge,	Boston.
William O. Crosby,	Boston.
William M. Davis,	Cambridge.
O. W. Huntington,	Cambridge.
Jules Marcou,	Cambridge.
William H. Niles,	Cambridge.
Nathaniel S. Shaler,	Cambridge.

SECTION II. — 7.

Botany.

William G. Farlow,	Cambridge.
George L. Goodale,	Cambridge.
Asa Gray,	Cambridge.
H. H. Hunnewell,	Wellesley.
Charles S. Sargent,	Brookline.
Charles J. Sprague,	Boston.
Sereno Watson,	Cambridge.

SECTION III. — 20.

Zoölogy and Physiology.

Alex. E. R. Agassiz,	Cambridge.
Robert Amory,	Brookline.
James M. Barnard,	Boston.
Henry P. Bowditch,	Boston.
Edward Burgess,	Boston.
John Dean,	Waltham.
J. W. Fewkes,	Cambridge.
Hermann A. Hagen,	Cambridge.
Alpheus Hyatt,	Cambridge.
Samuel Kneeland,	Boston.
Theodore Lyman,	Brookline.
Edward L. Mark,	Cambridge.
Charles S. Minot,	Boston.
Edward S. Morse,	Salem.
James J. Putnam,	Boston.
Samuel H. Scudder,	Cambridge
William T. Sedgwick,	Boston.
D. Humphreys Storer,	Boston.
Henry Wheatland,	Salem.
James C. White,	Boston.

SECTION IV. — 17.

Medicine and Surgery.

Samuel L. Abbot,	Boston.
Henry J. Bigelow,	Boston.
Henry I. Bowditch,	Boston.
Benjamin E. Cotting,	Roxbury.
Frank W. Draper,	Boston.
Thomas Dwight,	Boston.
Charles F. Folsom,	Boston.
Richard M. Hodges,	Boston.
Oliver W. Holmes,	Boston.
Alfred Hosmer,	Watertown.
Francis Minot,	Boston.

Wm. L. Richardson,	Boston.
George C. Shattuck,	Boston.
J. Baxter Upham,	Boston.
Charles E. Ware,	Boston.
John C. Warren,	Boston.
Henry W. Williams,	Boston.

CLASS III. — *Moral and Political Sciences.* — 54.

SECTION I. — 11.

Philosophy and Jurisprudence.

James B. Ames,	Cambridge.
Charles S. Bradley,	Providence.
Phillips Brooks,	Boston.
Charles C. Everett,	Cambridge.
Horace Gray,	Boston.
John C. Gray,	Boston.
Laurens P. Hickock,	Northampton.
Mark Hopkins,	Williamstown.
John Lowell,	Newton.
Henry W. Paine,	Cambridge.
James B. Thayer,	Cambridge.

SECTION II. — 16.

Philology and Archæology.

William S. Appleton,	Boston.
William P. Atkinson,	Boston.
Lucien Carr,	Boston.
Joseph T. Clarke,	Boston.
Henry G. Denny,	Boston.
Epes S. Dixwell,	Cambridge.
William Everett,	Quincy.
William W. Goodwin,	Cambridge.
Henry W. Haynes,	Boston.
David G. Lyon,	Cambridge.
Bennett H. Nash,	Boston.
Frederick W. Putnam,	Cambridge.
Joseph H. Thayer,	Cambridge.
John W. White,	Cambridge.
Justin Winsor,	Cambridge.
Edward J. Young,	Cambridge.

SECTION III. — 18.

Political Economy and History.

Chas. F. Adams, Jr.,	Quincy.
Edward Atkinson,	Boston.
John Cummings,	Woburn.
Charles Deane,	Cambridge.
Charles F. Dunbar,	Cambridge.
Samuel Eliot,	Boston.
George E. Ellis,	Boston.
Edwin L. Godkin,	New York.
Henry C. Lodge,	Boston.
Augustus Lowell,	Boston.
Edward J. Lowell,	Boston.
Francis Parkman,	Boston.
Andrew P. Peabody,	Cambridge.
John C. Ropes,	Boston.
Denman W. Ross,	Cambridge.
Henry W. Torrey,	Cambridge.
Francis A. Walker,	Boston.
Robert C. Winthrop,	Boston.

SECTION IV. — 9.

Literature and the Fine Arts.

Martin Brimmer	Boston.
George S. Boutwell,	Groton.
J. Elliot Cabot,	Brookline.
Francis J. Child,	Cambridge.
Charles G. Loring,	Boston.
James Russell Lowell,	Cambridge.
Charles Eliot Norton,	Cambridge.
Thomas W. Parsons,	Boston.
John G. Whittier,	Amesbury.

ASSOCIATE FELLOWS. — 100.

(Number limited to one hundred.)

Class I. — *Mathematical and Physical Sciences.* — 39.

Section I. — 7.

Mathematics.

E. B. Elliott,	Washington, D.C.
William Ferrel,	Washington, D.C.
Thomas Hill,	Portland, Me.
Simon Newcomb,	Washington, D.C.
H. A. Newton,	New Haven, Conn.
James E. Oliver,	Ithaca, N.Y.
Wm. E. Story,	Baltimore, Md.

Section II. — 14.

Practical Astronomy and Geodesy

W. H. C. Bartlett,	Yonkers, N.Y.
J. H. C. Coffin,	Washington, D.C.
Geo. Davidson,	San Francisco.
Wm. H. Emory,	Washington, D.C.
Asaph Hall,	Washington, D.C.
J. E. Hilgard,	Washington, D.C.
George W. Hill,	Nyack, N.Y.
E. S. Holden,	Berkeley, Cal.
Sam. P. Langley,	Allegheny, Pa.
Elias Loomis,	New Haven, Conn.
Maria Mitchell,	Poughkeepsie, N.Y.
C. H. F. Peters,	Clinton, N.Y.
George M. Searle,	New York.
Chas. A. Young,	Princeton, N.J.

Section III. — 11.

Physics and Chemistry.

F. A. P. Barnard,	New York.
J. Willard Gibbs,	New Haven, Conn.
S. W. Johnson,	New Haven, Conn.
M. C. Lea,	Philadelphia.
John Le Conte,	Berkeley, Cal.
J. W. Mallet,	Charlottesville, Va.
A. M. Mayer,	Hoboken, N. J.
Albert A. Michelson,	Cleveland, O.
Ogden N. Rood,	New York.
H. A. Rowland,	Baltimore.
L. M. Rutherfurd,	New York.

Section IV. — 7.

Technology and Engineering.

Henry L. Abbot,	New York.
Geo. W. Cullum,	New York.
Geo. S. Morison,	New York.
John Newton,	New York.
William Sellers,	Philadelphia.
George Talcott,	Albany, N.Y.
W. P. Trowbridge,	New Haven, Conn.

Class II. — *Natural and Physiological Sciences.* — 32.

Section I. — 15.

Geology, Mineralogy, and Physics of the Globe.

Cleveland Abbe,	Washington, D.C.
George J. Brush,	New Haven, Conn.
James D. Dana,	New Haven, Conn.
J. W. Dawson,	Montreal, Canada.
J. C. Fremont,	New York.
F. A. Genth,	Philadelphia.
James Hall,	Albany, N.Y.
F. S. Holmes,	Charleston, S.C.
Clarence King,	Washington, D.C.
Joseph Le Conte,	Berkeley, Cal.
J. Peter Lesley,	Philadelphia.
J. S. Newberry,	New York.
R. Pumpelly,	Newport, R.I.
J. W. Powell,	Washington.
Geo. C. Swallow,	Columbia, Mo.

Section II. — 3.

Botany.

A. W. Chapman, Apalachicola, Fla.
D. C. Eaton, New Haven.
Leo Lesquereux, Columbus, Ohio.

Section III. — 8.

Zoölogy and Physiology.

Joel A. Allen, New York.
S. F. Baird, Washington, D.C.
J. C. Dalton, New York.
Joseph Leidy, Philadelphia.
O. C. Marsh, New Haven, Conn.
S. Weir Mitchell, Philadelphia.
A. S. Packard, Providence.
A. E. Verrill, New Haven.

Section IV. — 6.

Medicine and Surgery.

Fordyce Barker, New York.
John S. Billings, Washington, D.C.
Jacob M. Da Costa, Philadelphia.
W. A. Hammond, New York.
Alfred Stillé, Philadelphia.
H. C. Wood, Philadelphia.

Class III. — *Moral and Political Sciences.* — 29.

Section I. — 9.

Philosophy and Jurisprudence.

D. R. Goodwin, Philadelphia.
A. G. Haygood, Oxford, Ga.
R. G. Hazard, Peacedale, R.I.
Nathaniel Holmes, Cambridge.
James McCosh, Princeton, N.J.
Charles S. Peirce, New York.
Noah Porter, New Haven, Conn.
E. G. Robinson, Providence.
Jeremiah Smith, Dover, N.H.
W. D. Whitney, New Haven, Conn.
T. D. Woolsey, New Haven, Conn.

Section II. — 7.

Philology and Archæology.

A. N. Arnold, Pawtuxet, R.I.
D. C. Gilman, Baltimore.
A. C. Kendrick, Rochester, N.Y.
E. E. Salisbury, New Haven, Conn.
A. D. White, Ithaca, N.Y.

Section III. — 7.

Political Economy and History.

Henry Adams, Washington, D.C.
George Bancroft, Washington, D.C.
S. G. Brown, Hanover, N.H.
Henry C. Lea, Philadelphia.
J. H. Trumbull, Hartford, Conn.
M. F. Force, Cincinnati.
W. G. Sumner, New Haven, Conn.

Section IV. — 6.

Literature and the Fine Arts.

James B. Angell, Ann Arbor, Mich.
L. P. di Cesnola, New York.
F. E. Church, New York.
R. S. Greenough, Florence.
William W. Story, Rome.
Wm. R. Ware, New York.

FOREIGN HONORARY MEMBERS. — 69.

(Appointed as vacancies occur.)

Class I. — *Mathematical and Physical Sciences.* — 24.

Section I. — 6.

Mathematics.

John C. Adams,	Cambridge.
Sir George B. Airy,	Greenwich.
Francesco Brioschi,	Milan.
Arthur Cayley,	Cambridge.
Charles Hermite,	Paris.
J. J. Sylvester,	Oxford.

Section II. — 5.

Practical Astronomy and Geodesy.

Arthur Auwers,	Berlin.
J. H. W. Döllen,	Pulkowa.
H. A. E. A. Faye,	Paris.
Eduard Schönfeld,	Bonn.
Otto Struve,	Pulkowa.

Section III. — 10.

Physics and Chemistry.

Adolf Baeyer,	Munich.
Marcellin Berthelot,	Paris.
R. Bunsen,	Heidelberg.
M. E. Chevreul,	Paris.
H. Helmholtz,	Berlin.
A. W. Hofmann,	Berlin.
G. Kirchhoff,	Berlin.
Balfour Stewart,	Manchester.
G. G. Stokes,	Cambridge.
Julius Thomsen,	Copenhagen.

Section IV. — 3.

Technology and Engineering.

R. Clausius,	Bonn.
F. M. de Lesseps,	Paris.
Sir Wm. Thomson,	Glasgow.

Class II. — *Natural and Physiological Sciences.* — 26.

Section I. — 6.

Geology, Mineralogy, and Physics of the Globe.

H. Ernst Beyrich,	Berlin.
Alfred Des Cloizeaux,	Paris.
James Prescott Joule,	Manchester.
C. F. Rammelsberg,	Berlin.
A. C. Ramsay,	London.
Heinrich Wild,	St. Petersburg.

Section II. — 6.

Botany.

J. G. Agardh,	Lund.
Alphonse de Candolle,	Geneva.
Sir Joseph D. Hooker,	London.
Carl Nägeli,	Munich.
Julius Sachs,	Würzburg.
Marquis de Saporta,	Aix.

SECTION III. — 10.

Zoölogy and Physiology.

Van Beneden,	Louvain.
Du Bois-Reymond,	Berlin.
Thomas H. Huxley,	London.
Albrecht Kölliker,	Würzburg.
Lacaze-Duthiers,	Paris.
Rudolph Leuckart,	Leipsic.
C. F. W. Ludwig,	Leipsic.
Sir Richard Owen,	London.
Louis Pasteur,	Paris.
J. J. S. Steenstrup,	Copenhagen.

SECTION IV. — 4.

Medicine and Surgery.

C. E. Brown-Séquard,	Paris.
F. C. Donders,	Utrecht.
Sir James Paget,	London.
Robert Virchow,	Berlin.

CLASS III. — *Moral and Political Sciences.* — 19.

SECTION I. — 3.

Philosophy and Jurisprudence.

Sir Henry Sumner Maine,	London.
James Martineau,	London.
Sir James F. Stephen,	London.

SECTION II. — 6.

Philology and Archæology.

Pascual de Gayangos,	Madrid.
Benjamin Jowett,	Oxford.
G. C. C. Maspero,	Paris ?
Max Müller,	Oxford.
H. A. J. Munro,	Cambridge.
Sir H. C. Rawlinson,	London.

SECTION III. — 6.

Political Economy and History.

Ernst Curtius,	Berlin.
W. Ewart Gladstone,	London.
Charles Merivale,	Ely.
Theodor Mommsen,	Berlin.
Jules Simon,	Paris.
William Stubbs,	Chester.

SECTION IV. — 4.

Literature and the Fine Arts.

Matthew Arnold,	London.
Jean Léon Gérôme,	Paris.
John Ruskin,	Coniston.
Lord Tennyson,	Isle of Wight.

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Synonyms and incidental references under Carex are printed in Italics.

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