THE

AMERICAN JOURNAL

OF

SCIENCE AND ARTS.

CONDUCTED BY

PROFESSORS B. SILLIMAN AND JAMES D. DANA,

IN CONNECTION WITH

PROFESSORS ASA GRAY, AND WOLCOTT GIBBS,
OF CAMBRIDGE,

AND

PROFESSORS S. W. JOHNSON, GEO. J. BRUSH, AND
H. A. NEWTON, OF NEW HAVEN.

SECOND SERIES.

VOL. XLIII.—[WHOLE NUMBER, XCIII.]

NOS. 127, 128, 129;

JANUARY, MARCH, MAY.

NEW HAVEN: EDITORS.
1867.

PRINTED BY E. HAYES, 426 CHAPEL ST.

CONTENTS OF VOLUME XLIII.

NUMBER CXXVII.

SCIENTIFIC INTELLIGENCE.

NUMBER CXXVIII.

SCIENTIFIC INTELLIGENCE.

NUMBER CXXIX.

SCIENTIFIC INTELLIGENCE.

ERRATA.

Vol. xlii, p. 271, l. 1 and 7 from top, for H. St. Claire Deville, read F. Pisani.

In No. CXXVII, page 87, line 25 from top, for $12^h\ 39^m\ 0^s$, read $12^h\ 59^m\ 0^s$.

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[SECOND SERIES.]

ART. I.—*On the construction of a Normal Map of the Solar Spectrum.* An abstract of a memoir read before the National Academy of Sciences, Aug. 7th, 1866; by WOLCOTT GIBBS, M.D., Rumford Professor in Harvard University.

THE extraordinary impulse which has been given to the study of the spectrum by the investigations of Bunsen and Kirchhoff has led to an accumulation of details which have not yet been systematically or even conveniently arranged. To a certain extent at least this has arisen from the want of a standard map of the solar spectrum upon which new lines may be entered with precision as regards their relative places. The well known chart of Kirchhoff, though executed with great care and labor, is not, properly speaking, normal, since it only represents a spectrum formed by four flint glass prisms, the angles of which, it is true, are given, but of which the indices of refraction are not stated. Moreover the prisms were not placed accurately in the positions of least deviation for each of the spectral lines. The scale of millimeters adopted by Kirchhoff is therefore a purely arbitrary one.

A standard or normal map of the spectrum must be wholly independent of peculiarities in the form of apparatus, in the number of prisms, their refractive and dispersive powers and their positions. Such a map can only be based upon the wave lengths of the spectral lines, since these do not, like the indices of refraction, vary with the material of which the prisms are composed.

The diffraction spectrum as obtained by a glass plate ruled with from one to ten thousand lines to the inch gives a nearer approach to a perfectly normal spectrum than any which has hitherto been proposed, and has been employed by Fraunhofer,* Mossotti† and Draper.‡ But even in this case there is a position of least deviation for each line depending upon the angle which the incident beam of light makes with a normal to the plane of the ruled surface, and in addition, it is necessary either to fix upon a standard number of lines to be ruled upon each millimeter of glass surface, or to reduce the positions of the spectral lines to those which would have been obtained with a standard ruled surface.

We avoid all these difficulties by constructing a normal spectrum in such a manner that each spectral line shall be entered according to its wave length, a method first suggested, I believe, by Billet.§

The materials which the present condition of science furnishes for the construction of a chart of the spectrum upon the principle laid down are not very copious. They consist essentially of the older measurements of Fraunhofer‖ of the wave lengths of the lines B, C, D, E, b, F, G and H; of recent and very accurate measurements by Angström;¶ of a still more extended series by Ditscheiner;** of the measurements of Plücker†† for certain lines in the spectra of gaseous media, and of those of Esselbach‡‡ for the ultra-violet rays. In addition we have a small number of isolated measurements by Müller,§§ Mascart,‖‖ Stefan,¶¶ and Ketteler.***

For the construction of the chart which I present herewith to the Academy I have selected the wave lengths determined by Angström as standards. This has been done because both the ruled glass and the measuring apparatus employed by him appear to have been much more perfect than those of other observers—Fraunhofer not excepted. On the other hand, however, all of Angström's measures are not available for the reason that the identification of the lines as produced by particular elements does not appear to be in all cases absolutely certain. As Angström's measurements are in ten-millionths of a Paris inch they have been reduced to millionths of a millimeter by multiplying them by the constant 27·07.

Ditscheiner's measurements agree closely with those of Ang-

* Denkschr. Münch. Acad., Bd. viii, 1821–22.
† Annali delle Univer. Toscane, t. i, 1845; also Pogg. Ann., lxii, p. 509.
‡ L. & E. Phil. Mag., xxvi, 1845.
‖ Loc. cit.
§ Traite d'Optique, vol. i, p. 47.
¶ Pogg. Ann., cxxiii, p. 489.
** Sitzungsberichte der k. k. Akad. der Wiss., Bd l, 1864.
†† Pogg. Ann., cvii, p. 497.
‡‡ Pogg. Ann., xcviii, p. 513.
§§ Pogg. Ann., cxviii, p. 641 and cxxix, p. 637.
‖‖ Pogg. Ann., cxviii, 367.
¶¶ Pogg. Ann., cxxii, p. 634.
*** Pogg. Ann., cxxiv, p. 390.

ström after undergoing a correction which depends upon the value of the wave length of the more refrangible line of D. This value is taken by Ditscheiner as 588·8, the wave length as determined by Fraunhofer. But as, for the reasons above mentioned I consider the results of Angström more reliable, I have taken his value, 589·43, in place of that of Fraunhofer, and have reduced all the measurements of Ditscheiner in accordance with this assumption. The following table will suffice to show the agreement between the two series of measurements.

TABLE I.

Angström.	Ditscheiner.	Diff.	Angström.	Ditscheiner.	Diff.
687·49	687·81	+0·32	527·32	527·42	+0·10
656·76	656·66	−0·11	523·69	523·74	+0·05
619·17	619·72	+0·55	519·63	519·67	+0·04
617·08	617·50	+0·42	518·79	518·73	+0·06
616·33	616·73	+0·40	517·66	517·70	+0·04
614·31	614·24	−0·07	517·15	517·15	0·00
612·34	612·76	+0·42	492·23	492·22	−0·01
610·45	610·82	+0·36	491·41	491·41	0·00
590·04	590·07	+0·03	489·50	489·54	+0·04
589·43	589·43		487·55	487·55	0·00
561·99	561·98	+0·01	486·52	486·49	−0·03
560·70	560·77	+0·07	440·81	440·87	+0·06
559·10	559·13	+0·03	438·63	438·75	+0·12
557·66	557·77	+0·11	434·28	434·34	+0·06
545·97	546·05	+0·08	432·78	432·82	+0·04
545·07	545·08	+0·01	431·03	431·35	+0·32
534·41	534·41	0·00	397·16	397·10	−0·06
533·16	533·29	+0·13	393·59	393·74	+0·15
528·73	528·79	+0·06			

A number of Ditscheiner's measurements refer to lines which cannot certainly be identified with the lines produced by particular elements. These lie between G and H and have been omitted as useless for our present purpose. But in the greater number of cases the wave lengths in his table of results are referred directly to the lines given in Kirchhoff's chart, which not merely enables us to identify them, but permits us to obtain the wave lengths of the intermediate lines by interpolation. The following table gives the corrected values of all the wave lengths measured by Ditscheiner with the exception of those between G and H, and of those of the nine principal lines of Fraunhofer which are given in Table I.* For these I have taken the values given by Angström. I have not ventured to make a further use of Angström's determinations for the reason that it is only through a comparison with the measurements of Ditscheiner that they can be identified with the lines upon Kirchhoff's scale. In every part of the spectrum excepting that between C and D the agreement between the two sets of measurements appears to fall within the limits of the errors of observation.

* Marked in Table II with asterisks.

TABLE II.

Kirchhoff's Line.	Wave Length.	Kirchhoff's Line.	Wave Length.	Kirchhoff's Line.	Wave Length.	Kirchhoff's Line.	Wave Length.
A 404·5	*761·20	1242·6	557·77	1737·7	511·42	2221·7	474·34
B 592·7	*687·49	1280·0	553 27	1750·4	510·30	2233·7	473·36
C 694·1	*656·77	1303·5	551·13	1777·5	508·41	2250·0	472·26
711·4	652·09	1306·7	550·70	1799·0	506·91	2264·3	470·21
719·6	650·05	1324·8	548·13	1834·3	504·55	2309·0	467·07
783·8	634·05	1337·0	546·78	1854·9	503·25	2416·0	460 63
831·0	623 61	1343·5	546·05	1867·1	502·26	2436·5	458·66
849·7	619·72	1351·1	545·08	1873·4	501·67	2457·5	456·81
860·2	617 50	1367·0	543·42	1885·8	501·07	2467 6	455·71
863·9	616·73	1389·4	540 91	1908·5	499·72	2489·4	453·73
874·3	614·74	1410·5	538·79	1920·2	498·78	2537·1	450·56
877·0	614·24	1421·5	537·52	1960·8	496·15	2547·2	450·13
884·9	612·76	1449·4	534·41	1975·7	495 04	2566·3	448·46
894·9	610·82	1463·3	533·29	1983·3	494·34	2606·6	446·00
959·8	598·14	1492·4	530·22	1989·5	493·76	2627·0	444·65
Dβ 1002·8	*590·04	1506·3	528·79	2001·6	492·22	2638·5	443·85
Dγ 1005·0	589·74	1515·5	528·02	2018·5	491·41	2670·0	442·29
Dα 1006·8	*589·43	E 1523·7	*527·38	2041·3	489·54	2686 6	440·87
1029·3	586·26	1541·9	525·98	2058·0	488·18	2721·6	438·75
1096·1	576·72	1569 6	523·74	2067·1	487 55	2734·1	437·80
1102·9	575·78	1577 6	523·09	F 2080·0	*486·52	2775·7	435·67
1135·1	571·51	1589·1	521·97	2103·3	484·63	2796·7	434·34
1155·7	568·70	1601·7	521·32	2119·8	482·81	2822·3	432·82
1174·2	566 33	1622·3	519 67	2148·9	480·56	G 2854·7	*431·03
1200.6	562·97	1634·1	518 73	2157·4	479 55	2869·7	430·37
1207·3	561·98	b 1648·8	517·70	2160·6	479·23	H	*397·16
1217·8	560·77	1655 6	517·15	2187·1	476·93	H′	*393·59
1237·8	559·13	1693·8	514·65	2201·9	475·90		

Table II, embracing determinations of 111 wave lengths, has served as the basis for the construction of the interpolation curves which are herewith submitted to the Academy.

By means of these curves the values of the wave lengths for every tenth line of Kirchhoff's scale from line 694 or C, to line 2854·7 or G, have been determined. These values are given in the following table. Similar relations cannot at present be found for the lines between A and B, or between B and C, on account of the absence of the requisite measurements.

TABLE III.

Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.
700	655 05	2·70	800	630·30	2·20	900	609·72	2·27	1000	590·45	1·65
10	652·35	2·65	10	628·10	2·10	10	607·45	1·95	10	588·80	1·70
20	649·70	2·60	20	626·00	2·10	20	605·50	1·95	20	587·10	1·65
30	647·10	2·50	30	623·90	2·05	30	603·55	1·90	30	586 05	1·50
40	644·60	2·50	40	621·85	2·18	40	601·65	1·85	40	584·55	1·50
50	642·10	2·50	50	619·67	2·20	50	599·80	1·80	50	583·05	1·40
60	639·60	2·40	60	617·47	1·85	60	598·00	2·30	60	581 65	1·40
70	637·20	2·30	70	615·62	1·92	70	595 70	1·85	70	580·25	1·40
80	634 90	2·30	80	613·70	2·01	80	593·85	1·70	80	578·85	1·35
90	632·60	2·30	90	611·69	1·97	90	592·15	1 70	90	577·50	1·30

TABLE III—(continued.)

Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.
1100	576·20	1·45	60	524·25	0·85	10	492·05	0·80	70	455·65	0·85
10	574·75	1·40	70	523·45	0·80	20	491·25	0·75	80	454·80	0·85
20	573·35	1·35	80	522·70	0·75	30	490·50	0·90	90	454·05	0·75
30	572·00	1·35	90	521·95	0·75	40	489·60	0·80	2500	453·30	0·75
40	570·65	1·35	1600	521·20	0·75	50	488·80	0·80	10	452·55	0·75
50	569·30	1·25	10	520·50	0·70	60	488·05	0·75	20	451·80	0·70
60	568·05	1·25	20	519·75	0·75	70	487·30	0·84	30	451·10	0·70
70	566·80	1·30	30	519·05	0·70	80	486·46	0·86	40	450·40	0·65
80	565·50	1·30	40	518·35	0·70	90	485·60	0·75	50	449·75	0·70
90	564·20	1·30	50	517·65	0·70	2100	484·85	0·82	60	449·05	0·65
1200	562·90	1·25	60	516·90	0·75	10	484·03	1·26	70	448·40	0·70
10	561·65	1·20	70	516·15	0·75	20	482·77	1·17	80	447·70	0·65
20	560·45	1·20	80	515·45	0·70	30	481·60	0·60	90	447·05	0·65
30	559·25	1·20	90	514·75	0·70	40	481·00	0·74	2600	446·40	0·65
40	558·05	1·25	1700	514·00	0·75	50	480·26	0·97	10	445·75	0·65
50	556·80	1·20	10	513·30	0·70	60	479·29	1·29	20	445·10	0·65
60	555·60	1·10	20	512·60	0·70	70	478·00	1·13	30	444·45	0·70
70	554·50	1·20	30	511·85	0·75	80	476·87	0·61	40	443·75	0·70
80	553·30	1·05	40	511·15	0·70	90	476·26	0·34	50	443·05	0·60
90	552·25	1·10	50	510·45	0·70	2200	475·92	0·62	60	442·45	0·70
1300	551·15	0·79	60	509·65	0·80	10	475·32	0·82	70	441·75	0·60
10	550·36	1·54	70	508·95	0·70	20	474·50	0·80	80	441·15	0·60
20	548·82	1·35	80	508·25	0·70	30	473·70	0·90	90	440·55	0·60
30	547·47	1·06	90	507·55	0·70	40	472·80	0·80	2700	439·95	0·60
40	546·41	1·31	1800	506·80	0·75	50	472·00	0·85	10	439·35	0·55
50	545·10	1·10	10	506·15	0·65	60	471·15	0·85	20	438·80	0·55
60	544·00	0·83	20	505·50	0·65	70	470·30	0·80	30	438·25	0·55
70	543·17	0·93	30	504·80	0·70	80	469·50	0·80	40	437·70	0·60
80	542·24	1·44	40	504·10	0·70	90	468·70	0·75	50	437·10	0·60
90	540·80	0·70	50	503·45	0·65	2300	467·95	0·75	60	436·50	0·60
1400	540·10	1·15	60	502·75	0·70	10	467·20	0·75	70	435·90	0·60
10	538·83	1·06	70	502·05	0·70	20	466·45	0·65	80	435·30	0·55
20	537·77	1·34	80	501·40	0·65	30	465·80	0·65	90	434·75	0·55
30	536·43	1·20	90	500·80	0·50	40	465·15	0·65	2800	434·20	0·60
40	535·23	0·80	1900	500·20	0·60	50	464·50	0·65	10	433·60	0·60
50	534·43	0·83	10	499·55	0·65	60	463·85	0·60	20	433·00	0·55
60	533·60	0·94	20	498·90	0·65	70	463·25	0·60	30	432·45	0·55
70	532·66	1·16	30	498·25	0·65	80	462·65	0·60	40	431·90	0·60
80	531·50	1·00	40	497·55	0·65	90	462·05	0·55	50	431·30	0·60
90	530·50	0·95	50	496·80	0·75	2400	461·50	0·55	60	430·70	0·60
1500	529·55	0·95	60	496·10	0·70	10	460·95	0·95	70	430·10	
10	528·60	0·95	70	495·40	0·70	20	460·00	0·90			
20	527·65	0·90	80	494·55	0·85	30	459·10	0·85			
30	526·75	0·90	90	493·75	0·80	40	458·25	0·90			
40	525·95	0·85	2000	492·95	0·80	50	457·35	0·85			
50	525·10				0·90	60	456·50				

To find the wave length of any line in Kirchhoff's table, or upon his chart, from Table III, it is only necessary to employ the simple formula $\lambda' = \lambda - \frac{1}{10}(\varkappa' - \varkappa)\,\Delta\lambda$

in which λ' represents the wave length sought and $\varkappa'$ the corresponding line upon Kirchhoff's scale; λ the wave length of the next lower line $\varkappa$ in Table III, and $\Delta\lambda$ the corresponding difference also given in the table. It is not necessary in any case to employ second differences. The following table will serve to show the degree of accuracy attainable by means of the formula above given and the data in Table III.

TABLE IV.

Kirchhoff.	Calcul.	Found.	Diff.	Kirchhoff.	Calcul.	Found.	Diff.	Kirchhoff.	Calcul.	Found.	Diff.
711·4	651·96	652·09	−0·03	1421·5	537·57	537·52	+0·05	2067·1	487·52	487·55	−0·03
719·6	649·81	650·05	−0·24	1449·4	534·48	534·41	+0·07	2080·0	486·46	486·52	−0·06
783·8	634·03	634·05	+0·02	1463·4	533·29	533·29	0·00	2103·3	484·58	484·63	−0·05
831·0	623·69	623·61	+0·08	1492·4	530·28	530·22	+0·06	2119·8	482·80	482·81	−0·01
849·7	619·87	619·72	+0·15	1506·3	528·95	528·79	+0·16	2148·9	480·60	480·56	+0·04
860·2	617·44	617·50	−0·06	1515·5	528·08	528·02	+0·06	2157·4	479·55	479·55	0·00
863·9	616·75	616·73	+0·02	1523·7	527·30	527·38	−0·08	2160·6	479·23	479·23	0·00
874·3	614·80	614·74	+0·06	1541·9	525·80	525·98	−0·18	2187·1	476·44	476·93	−0·49
877·0	614·28	614·24	+0·04	1569·6	523·48	523·74	−0·26	2201·9	475·78	475·90	−0·12
884·9	612·72	612·76	−0·04	1577·6	522·88	523·09	−0·21	2221·7	474·37	474·34	+0·03
894·9	610·73	610·82	−0·09	1589·1	522·02	521·97	+0·05	2233·7	473·37	473·36	+0·01
859·6	598·40	598·14	+0·26	1601·7	521·07	521·32	−0·25	2250·0	472·00	472·26	+0·26
1002·8	589·99	590·04	−0·05	1622·3	519·58	519·67	−0·09	2264·3	470·79	470·71	+0·08
1004·8	589·66	589·74	−0·08	1634·1	518·76	518·73	+0·03	2309·0	467·27	467·07	+0·20
1006·8	589·33	589·43	−0·10	1648·8	517·73	517·70	+0·03	2416·0	460·62	460·63	−0·01
1029·3	586·17	586·26	−0·09	1655·6	517·26	517·15	+0·11	2436·5	459·51	458·66	+0·85
1096·1	576·78	572·72	+0·06	1693·7	514·49	514·65	−0·16	2457·5	456·71	456·81	−0·10
1102·9	575·82	575·78	+0·04	1737·7	511·27	511·42	−0·15	2467·6	455·85	455·71	+0·14
1135·1	571·31	571·51	−0·20	1750·4	510·42	510·30	+0·12	2489·4	453·35	453·73	−0·38
1155·7	568·53	568·70	−0·17	1777·5	508·42	508·41	+0·01	2537·1	450·60	450·56	+0·04
1174·2	566·27	566·33	−0·06	1799·0	506·87	506·91	−0·04	2547·2	449·93	450·13	−0·20
1200·6	562·82	562·97	−0·15	1834·3	504·50	504·55	−0·05	2566·3	448·64	448·46	+0·18
1207·0	561·99	561·98	+0·01	1854·9	503·11	503·25	−0·14	2606·6	445·97	446·00	−0·03
1217·8	560·67	560·77	−0·10	1867·1	502·25	502·26	−0·01	2627·0	444·64	444·66	−0·01
1237·8	558·31	559·13	−0·32	1873·4	501·85	501·67	+0·18	2638·5	443·85	443·85	0·00
1242·6	557·74	557·77	−0·03	1885·8	501·05	501·07	−0·02	2670·0	441·75	442·29	−0·54
1280·0	553·30	553·27	+0·03	1908·5	499·65	499·72	−0·07	2686·6	440·75	440·87	−0·12
1303·5	550·88	551·13	−0·25	1920·2	498·89	498·78	+0·11	2721·6	438·71	438·75	−0·04
1306·7	550·61	550·70	−0·09	1960·8	496·04	496·15	−0·11	2734·1	438·02	437·80	+0·22
1324·8	548·18	548·13	+0·05	1975·7	495·00	495·04	−0·04	2775·7	435·56	435·67	−0·11
1337·0	546·73	546·78	−0·05	1983·3	494·48	494·34	+0·14	2796·7	434·38	434·34	+0·04
1343·5	545·96	546·05	−0·09	1989·5	493·71	493·75	−0·04	2822·3	432·86	432·82	+0·04
1351·1	544·98	545·08	−0·10	2001·6	492·81	492·22	+0·59	2854·7	431·60	431·03	+0·57
1367·0	543·42	543·42	0·00	2018·5	491·37	491·41	−0·04	2869·7	430·08	430·37	−0·21
1389·4	540·89	540·91	−0·02	2041·3	489·50	489·54	−0·04				
1410·5	538·78	538·79	−0·01	2058·0	488·16	488·18	−0·02				

From the above table it will be seen that wave lengths may usually be determined correctly in the first decimal place when the corresponding line upon Kirchhoff's scale is known to the tenth of one millimeter. From Table I it will be seen that wave lengths as determined by two observers differ almost always by several units in the second decimal, and not rarely even in the first, so that Table III will give results within the probable errors of observation. It must however be remarked that the data for the calculation of Table III have not been equally numerous for equal intervals of Kirchhoff's scale, and the table is not therefore *equally* reliable in all its parts. New measurements of wave lengths are needed to give greater precision, especially between the numbers 890—1000 and 1030—1090.

Kirchhoff's measurements have not hitherto been extended beyond the line G. For this portion of the spectrum we possess the beautiful photographic charts of Mr. Rutherfurd extending from b to H′. These charts are not however at present available for the determination of wave lengths, because the lines upon them beyond G have not yet been identified with lines whose wave lengths have been measured.

The very numerous measurements of Mr. Huggins* give the relative positions of a great number of spectral lines characteristic of particular elements. To give these measurements a real value the corresponding wave lengths must be determined as in the case of Kirchhoff's lines. I am not at present able to state to what extent this has been done, or whether it will be possible without a great number of new measurements of wave lengths to reduce the scale-numbers given by Mr. Huggins to the wave standard. If this can be done, we shall be able to fill up the portion of the spectrum beyond the line G not examined by Kirchhoff, and for which Ditscheiner's measurements are not available.†

In any event the tables and formula above given will enable an observer to determine the wave length of any new spectral line by simple comparison with Kirchhoff's chart, provided only that the line lies between B and G. In practice I suggest that this comparison may be readily made directly. Let for example three or four flint glass prisms be used with the spectroscope so as to give an amount of dispersion approximately equal to that of Kirchhoff's apparatus. If now a scale telescope be employed with an object glass of about 18 inches focal length, it will be easy to place Kirchhoff's chart in such a position that the reflected image of any small portion of it shall be in the field of view of the observing telescope at the same time with the direct image of the part of the solar spectrum containing the line the wave length of which is to be determined, which line may then also be brought into the field of view by means of a small prism covering a part of the slit of the collimator in the usual manner. If the scale telescope be provided with a rectangular prism placed at a convenient distance from the object glass and so that the hypothenuse of the prism shall make an angle of 45° with the vertical, the chart may be laid flat upon the table and moved into any convenient position. Finally, the magnitude of the reflected image of the scale may be reduced at pleasure by interposing a concave lens and suitably varying the distance of the scale. When the position of the given line with reference to any two adjacent lines, or to any scale number upon Kirchhoff's

* Philosophical Transactions for 1864; also Pogg. Ann., cxxiv, p. 275.

† Since the above was written I have succeeded, by comparing the lines upon Mr. Huggins' scale with those upon Kirchhoff's scale, in constructing interpolation tables for the former similar to Table III. These I shall hereafter publish in extenso together with the wave lengths of all the elements given by both observers. —W. G. Nov. 1st, 1866.

chart, has been determined, the wave length may be found from Table III.

The determination of wave lengths by the method of comparison which I have explained above, is analogous to the determination of the place of a star by comparison with that of another star whose place is known. It is easy to see that when the wave lengths of a sufficient number of lines have been determined with accuracy for the purposes of comparison, the wave length of a given line may be found with very nearly as much precision as by direct measurement with a ruled glass. For in a large spectroscope with five or six prisms of high dispersive power, the angular separation of two lines differing in wave length by only a single millionth of a millimeter, is so great that the interval may be readily divided into hundredths. Of course the magnitude of this interval for the same system of prisms will differ in different parts of the spectrum, being greatest for the most refrangible rays. But the interval will always be sufficient to give us the advantage of determining a small difference in magnitude by the measure of a considerable distance in space. To the best of my knowledge this method of determining wave lengths is new.

The spectroscope enables us however to determine wave lengths by another method which, though not new in principle, has not received the attention which it deserves, and has been applied in practice only in certain cases. I refer to the employment of the interference bands of Talbot, an application first made by Esselbach* in the measurement of the wave lengths of the ultra-violet rays. The method in question exhibits an extraordinary degree of precision when a spectroscope with several prisms of high dispersive power is employed, since in this case interference plates of considerable thickness may be used so as to produce very numerous dark bands. By measuring the number of bands between the given spectral line and two other spectral lines whose wave lengths are known, the wave length of the line in question may at once be found.† This method possesses the further advantage, that by employing several interference plates of different thicknesses or different kinds of glass, a number of independent measurements may be made, the mean of which may be taken. A number of observations may also be made with a single plate and different pairs of comparison lines.

The chart which is herewith presented to the Academy must be regarded simply as a first approximation to a normal chart of the spectrum. It contains 187 lines, the wave lengths of which have been accurately determined. The chart is drawn to a scale of millimeters, and in entering the lines of the spectrum upon

* Pogg. Ann., xcviii, 513.

† See Müller's Lehrbuch der Physik und Meteorologie, Bd. i, p. 850.

it each millimeter of the chart corresponds to the one-millionth of a millimeter of wave length. The probable error of measurement in determining the wave length does not usually exceed one or two ten-millionths of a millimeter, and the spectral lines have been ruled by a dividing engine upon the copper plate of the engraver so as to be correct in position to about one-tenth of a millimeter upon the chart. The substance generating each line is indicated by a dotted line and symbol as in Kirchhoff's chart, while the seven principal lines of Fraunhofer are denoted by the usual letters. In order to permit a comparison of the lines characteristic of different elements closely related to each other in their chemical properties, or belonging to the same natural groups, several impressions of the scale have also been printed upon a single sheet parallel to each other. Upon these the lines may be entered by hand. Copies of the scale have also been printed at the bottoms of large sheets so as to permit of the construction of dispersion curves. The comparison of the wave lengths of the spectral lines which characterize elements belonging to the same natural family may hereafter lead to interesting results, but at the present time it is difficult to institute such a comparison for the reason that we do not know all the lines which are produced by any one element. For the same reason it would probably be impossible at present to determine whether there is any law governing the wave lengths of the spectral lines belonging to the elements as regards their intervals or distribution over the spectrum. The conviction that precise knowledge of these and similar points must depend upon a knowledge of wave lengths and not merely of indices of refraction, has led me to make this first attempt to form a normal map of the spectrum. As a first attempt merely it is necessarily imperfect, but my object will be fully attained if I shall have succeeded in pointing out the path to be followed in the future discussion of the subject.

My grateful acknowledgments are due to Prof. J. E. Hilgard, under whose superintendence most of the curves which I have employed for interpolation have been drawn in the office of the Coast Survey. To Mr. S. P. Sharples I am also indebted for much assistance in the work of computation.

Cambridge, July, 1866.

Postscript.—Since the above was written I have received a second paper by Ditscheiner* on the wave lengths of the spectral lines, in which the author gives the results of a determination of the absolute value of the interval between two successive lines of the grating or ruled glass surface employed by him. When this value is used the wave lengths of $D\beta$ and $D\alpha$ become

* Sitzungsberichte der kaiserlichen Akad. der Wissenschaften, Band lii, 289.

respectively, as measured by Ditscheiner, 590·53 and 589·89, which are 0·49 and 0·46 higher than those of Angström as given in Table I. Ditscheiner in this second paper has recomputed the table given in his first memoir. The results are much higher than those of Angström or those given in my reduction of Ditscheiner's first measurements, the average difference being about 0·4 of one unit. The close agreement of the two sets of results given in Table I appears to me a sufficient reason for adhering to the values of the wave lengths employed in this paper as data for interpolation.

Cambridge, August, 1866.

Art. II.—*John Francis Encke.**

John Francis Encke, born Sept. 23, 1791, was the youngest son but one of the deacon of the Jacobi Church in Hamburg. Four years after his birth his father died, leaving the care and the education of eight children to his mother, a lady of much worth, and happily possessed of great mental energy.

The first tutor of the boy was Mr. Hipp, a gentleman possessing considerable aptitude for mathematical teaching; and to his honor be it spoken, a man who rendered valuable pecuniary assistance to the orphan and moneyless family. Hipp continued this material encouragement to young Encke even after the time that he entered the College at Hamburg, well known as the Johaneum. At this College, then under the directorship of Gurlitt, who enjoyed a high reputation for classical learning, the boy-student rapidly advanced, and in addition to considerable ability in Latin composition, his knowledge of Greek was sufficient to enable him to translate and enjoy the Lyricks of Pindar. Notwithstanding, however, this early classical training, when the time came for his entrance at the University, Encke resolved henceforth to devote his attention mainly, if not exclusively, to the study of astronomy.

But here came a very formidable impediment; there were ample funds at the disposal of a poor clergyman's son for a theological career, but none for the prosecution of so unusual a study. Nevertheless, such was the acknowledged ability, and so determined was the inclination, of young Encke, that, as is happily not unusual in such cases, all the difficulties yielded at length to perseverance, and to his great joy, in Oct. 1811, he found himself at Göttingen, and a student under the celebrated Gauss.

The very newspapers of Hamburg were at that day compulsorily printed in French; as a condescension, however, or as an insult to the inhabitants, a German translation was added; in a

* From the Monthly Notices of the Astronom. Soc. of London, 1866, p. 129.

like spirit even the university matricula of the old "Georgia Augusta" of Göttingen had the image and superscription of Jerome Buonaparte printed upon it. No wonder then that neither Gauss nor astronomy could retain the young student at his books, but, obeying the impulse which animated the whole heart of Germany, in the spring of 1813 he took up arms and marched to Hamburg for the rescue of his country from the domination of the French. After the re-occupation of Hamburg by the foreigner, Encke entered the Hanseatic Legion, then in process of formation in Holstein and Mecklenburg, and there he served as a sergeant-major in the horse artillery until July, 1814. In the autumn of this year he returned to Göttingen and to his astronomical pursuits, and for nearly twelve months continued a diligent student of subjects far more peaceable, and far more congenial to his turn of mind. Nevertheless the return of Napoleon from Elba once more finds him in a soldier's uniform, but now only for a short period, and, happily, for the last time. Waterloo and its consequences restored peace to France and to Europe, and young Encke, who in peace had no taste for soldiership and a uniform, returned, for the third time, to Göttingen and to Gauss. It was thus in the midst of these stirring and troublesome events, that the spirits of such men as Franz Encke and Wilhelm Struve were disciplined and matured.

While Encke was serving as a lieutenant of artillery in the Prussian fortress of Kolberg, he became acquainted with the celebrated Lindenau, at once astronomer and statesman, and after the completion of his studies under Gauss, he was appointed, by the influence of the former, an sssistant in the Observatory of Seeburg, not far from Gotha. In 1820 he became Vice-director, and in 1822 he was appointed Director, in the place of Lindenau, who returned to his political career.

It was at Seeberg that Encke commenced and completed his important work on the "Transits of Venus in 1761 and 1769," published at Gotha in 1822 and 1824. He also matured his investigation of the comet of 1680, and of the remarkable comet of short period which bears his name. Zach's Correspondence and Lindenau's Zeitschrift, about this period, contain many evidences of his talents and his industry. During his directorship of the Observatory at Seeberg he was elected an Honorary Associate of the Royal Astronomical Society, and at the time of his decease was the oldest foreign member on our list. In 1824 the Council of our Society awarded to Encke their gold medal for what Mr. Colebrooke, the President of that day, properly designated as "the greatest step that had been made in the astronomy of comets since the verification of Halley's Comet in 1759." Encke had long been on the track of his comet. In 1818 he had succeeded in identifying it with the Comet of Mechain and Messier in 1786, and again with the comet discovered by Miss Herschel in 1795, and with the comet of Pons in 1805. The result of his investigations was, that this comet, which astronomers have agreed to designate as "Encke's Comet" (although he himself always modestly calls it the Comet of Pons), would make its appearance again in 1822, although it would not then be visible in Europe. Accordingly our Society had the gratification of presenting to Mr. Rümker their medal for its discovery at Paramatta in 1822, on the same day when they bestowed a similar mark of approbation, as we have already stated, on Encke himself, for its prediction.

It was in these Memoirs, that Encke signalized himself by his systematic and most successful application of the *principle of least squares* to a number of astronomical observations. For the method itself we are mainly indebted to Legendre and to Gauss, but for the first exhibition of its vast practical value, we are indebted to the example of Encke. His mind, indeed, seems to have been preëminently arithmetical, delighting in the orderly and systematic development of what otherwise and to many would seem an inextricable maze of figures. Those who knew him best consider that he probably injured the generality of his mathematical analysis by the fastidious care which he bestowed upon its symmetrical arrangement.

In 1825, at the recommendation of Bessel, Encke was appointed to the Directorship of the Observatory at Berlin; the Observatory itself was both improperly situated, and inadequately supplied with instruments, but ultimately, at the suggestion of Humboldt, a new Observatory was erected at the expense of the Prussian government, Encke superintending personally both its construction and its interior arrangements. And here, for eight or ten years after its completion, he continued with much assiduity to observe both with the Transit Circle and the Equatorial; but his natural tastes did not lie in instrumental observations, and after the discovery of numerous small planets by various observers, he devoted himself with much success to the investigation of planetary disturbances.

The labors of Encke in reference to the comet which bears his name have already been referred to. Having carefully taken into account the perturbing action of the planets on this comet during several successive periods, he established the remarkable fact that there is some extraneous cause in operation which continually diminishes the comet's periodic time. This is evidently the effect which would be produced if the comet suffered a resistance from moving in a very rare ethereal medium, and accordingly this is the explanation proposed by Encke, and at present generally accepted by astronomers.

Encke has also, as already mentioned, devoted special attention to the subject of the perturbations of the Minor Planets.

In the Appendix to the *Berliner Jahrbuch* for 1837 and 1838, he expounds in detail the method of calculating these perturbations which had been long used by himself and other German astronomers, and which was originally given by Gauss. In this method the perturbations of the six elements of the orbit are computed for successive equal intervals of time by means of mechanical quadratures, and from the values of the elements thus found for any given time, the co-ordinates of the body at that time are determined.

Now this method, although a very beautiful one in theory, is attended with the disadvantage of requiring the determination of double the number of unknown quantities that are really wanted, and the calculations which must be gone through consequently become excessively long.

As the number of the known minor planets became larger, the want of a readier method of computing their perturbations became more and more pressing.

Encke was thus impelled to devise a mode of applying the method of integration by quadratures directly to the differential equations of motion of the disturbed body, and he published an account of this new method in the Proceedings of the Berlin Academy for 1851. In this Memoir he refers the place of the body to rectangular co-ordinates, and he determines the perturbations of its movements during successive short intervals of time by a direct computation of the changes produced in the three co-ordinates by the action of the disturbing planet.

He estimates that the labor of computation is reduced by the new method to less than one-half of that required by the method previously employed.

It should be remarked that Prof. G. P. Bond, in a paper which was communicated to the American Academy of Arts and Sciences in 1849, had already briefly explained a method of calculating perturbations exactly similar in principle to that of Prof. Encke, but the latter was totally unaware of the existence of this paper when he published his own Memoir, which enters much more fully into the practical details of the method, and gives greater prominence to the importance of it as applied to the case of the minor planets.

By astronomers of the present day it is possible that Encke may be most highly estimated for the vast improvements which he introduced into the Berlin Ephemeris. The history of astronomical ephemerides is not a little varied and curious; a concise account of it will be found in the fourth volume of the Memoirs of the Royal Astronomical Society, on the occasion of the council of the Society presenting Encke, through their President, with a gold medal, for the part which he had taken in the improvement of the Berlin Ephemeris. Our own Nautical Almanac, at that day, viz. in 1830, had fallen or had remained greatly behind the requirements of astronomers; but in speaking of the merits of the foreign Ephemeris, the report of the Council runs as follows: "A gold medal has been voted to Professor Encke for the superb *Ephemeris of Berlin*. It would be superfluous to dwell upon the merits of this well-known work, which, far outstripping all rivalry, must be considered as the only Ephemeris on a level with the present wants of the sciences." On presenting the medal, Sir James South, the President, adds, "With the *Berlin Ephemeris*, an observatory scarcely wants a single book; without it, every one." It would, however, be disloyal, though in any other aspect it may be needless, not to add that what has just been said of the Berlin Ephemeris of 1830, may with equal truth be predicated of the Nautical Almanacs from 1834 to the present date; nevertheless the first impulse came from Encke and Berlin.

Many other labors of Encke may also be found in the Memoirs and Monthly Reports of the Berlin Academy, in the Astronomische Nachrichten, and in four volumes of the Berlin Observations. He is also well known by the publication of several excellent speeches, and especially for a memorable *éloge* on the celebrated Bessel.

Encke visited England in the autumn of 1840, in order to be present at the meeting of the British Association, and for the purpose of inspecting the English Observatories. His account of that journey is a testimony of the deep and pleasing impression which his hearty reception in England left upon his memory.

In 1859 Encke suffered from an apoplectic fit, and foreseeing the commencement of disease of the brain, he obtained leave of absence from his Observatory in the spring of 1863. In the autumn of the same year, finding a recurrence of the same symptoms, and knowing what they implied, with a brave heart, the now aged man explained his forebodings to a physician, and at once placed himself under his care in an institution for diseases of the brain at Kiel. At the commencment of 1864 he requested permission to be relieved from all astronomical work, and until the time of his decease, continued to live in a quiet, happy state of mind, in the midst of his family, at Spandau, near Berlin.

Encke, during the forty years of his professorship at Berlin, impressed the form and bent of his mind upon many pupils, who have ably contributed their share in the progress of astronomical knowledge. There is no greater proof of the real worth of a teacher, than when his pupils speak well and lovingly of him. They see the man in his weakness and in his strength. So it fared with Encke. They bear strong and uniform testimony to his eminent frankness and truthfulness; his labors, they say, were incessant, his recreations few; he was simple in his manners, and in all his habits temperate. Towards his coadjutors and assistants he showed a severe judgment, but he set them a severer example. A man such as this, absorbed in his work, and shutting himself away from the outer world, was likely to be sometimes abrupt, or laconic, or even incautious, in his utterances; these utterances, from their bluntness or their truthfulness, occasionally gave offense, and involved Encke in trouble. As age, however, grew upon him he became more gentle in his manners, and softer in his address; and in the presence of those whom he knew and trusted, the old man would sometimes review his own life, and urge his favorite pupils to draw from his own experience lessons of moderation and self-restraint, both in passing their judgments on the labors of others, and in the amount of labor which they felt it their duty to exact from themselves.

There occurs but one more question regarding this great and venerable man; the writer of this memoir gladly adopts this language, *great and venerable*, because they are the very words selected by men who served him long and who knew him well, and who are themselves doing good public service in their own day. It is well known that great theological activity, not to say theological strife, surrounded Encke and every other intellectual thinker in Germany; it may not, perhaps, concern us, simply as students in Astronomy, but it cannot fail to interest us as men, to know what effect this independence of thought and boldness of expression had upon the spirit of a man, whose name will for ever be associated with some of the noblest and furthest-reaching efforts of the human mind. In reply to this question, we are told by those who knew him intimately, that Encke retained through life the strength and simplicity of his early faith; and we also learn that he was heard repeatedly to say, that one of the greatest pleasures of his life was derived from the fact, that one of his sons had become a minister of the Gospel. C. P.

ART. III.—*Sketch of the Geology of Northeastern Dakota, with a notice of a short visit to the celebrated Pipestone Quarry;* by F. V. HAYDEN.

THE object of this note is simply to record some observations on the geology of Northeastern Dakota, made by me in October last, together with an account of a short visit to the celebrated Pipestone quarry. No positive inference is drawn as to the age of the rocks in which the pipestone layer is located, from the fact that no well-defined organic remains could be found. Therefore certain facts are noted down with the hope that they may hereafter aid in the solution of the problem of their age, inasmuch as their geographical distribution seems to be quite extended.

In October last, after my return from a tour of exploration to the "Mauvaises Terres" or "Bad Lands" of White river, I took advantage of an opportunity that presented itself to visit some portions of Dakota Territory on the north side of the Missouri river not hitherto examined by me. I there made my starting point the village of Yankton, the capital of Dakota Territory, located on the Missouri, about twelve miles above the mouth of the James. At this point we observed a large exposure of the yellow calcareous marl beds of No. 3, Niobrara Division, forming along the river nearly vertical bluffs, extending sometimes several miles. The rock varies in texture from a nearly white, soft chalk, much like our chalk of commerce, to a somewhat compact limestone which is used for burning into lime and for building purposes. Thick beds of this chalk present a marked rust color from the presence of a greater or less amount of the peroxyd of iron; otherwise it could hardly be distinguished from the chalk of Europe, and without doubt would serve the same economical purposes. The organic remains found here are not very numerous in species. The most abundant shell is the *Ostrea congesta* Conrad, which seems to have been as gregarious and to have aggregated together much in the same way as the little oyster which is exposed when the tide recedes along the shores of the Sea Islands of South Carolina. Near the base of No. 3, there are layers of rock several feet in thickness, made up almost entirely of one or more species of *Inoceramus*, one of which has been identified as *I. problematicus*. The fish remains are quite numerous, diffused throughout the rock. Fragments, consisting of jaws, ribs and scales, are found in the greatest abundance, and Mr. Propper, a resident of Yankton has succeeded in securing some nearly perfect specimens (undescribed) from the quarries there. This group of rocks extends for four hundred miles along the Missouri river, and I am convinced that when carefully studied, it will be found to represent the White Chalk beds of Europe, and be employed for similar economical purposes.

The Cretaceous rocks of the Missouri river have been numbered in the order of superposition, Nos. 1, 2, 3, 4, 5, and all of these divisions have been located in the geological scale by the unmistakable evidence of their organic remains. We find therefore that this portion of Dakota is occupied exclusively, or nearly so, by the middle member of the Cretaceous series. The soft and yielding nature of No. 3 is well shown by the topographical features of the country, where all the slopes are gentle in their descent, and for the most part covered with a thick growth of grass; for the soil which is composed of the eroded materials of this group is quite fertile, and in ordinary seasons produces excellent crops, and is especially adapted to the growth of cereals.

From Yankton our course was nearly north, up the west side of James river. Our path led over a gently rolling prairie for sixty-five miles, with not a tree or a bush to greet the eye. There were no cut bluffs along the little streams over which we passed; the sides of the hills bordering the valleys sloping at a very moderate angle, and being covered with a thick growth of grass. No rocks were seen in place until we arrived at Fort James, about twelve miles below the mouth of Firesteel creek, a branch of James river. Erratic rocks of all sizes and texture were visible on the surface everywhere, more especially in the valley of James river and its tributaries.

At this point on James river, uncovered by the scooping out of the valley, is a large exposure of reddish variegated quartzites, differing somewhat in structure and appearance from any rocks hitherto observed by me on the Upper Missouri. They cover a considerable area in the valley of the James at certain localities, but nowhere are they exposed at a thickness of more than twenty or thirty feet. Indeed they have been much worn by water, so that they project above the surface in large square masses, suggesting to one in the distance a village of log houses.

The rocks are mostly reddish and flesh-colored quartzites, so compact that the lines of stratification are nearly obliterated. They also appear to be metamorphic. There is, however, a horizontal as well as a vertical fracture, and the horizontal fracture breaks across what appear to be original laminæ of deposition. These lines or bands are seldom horizontal; but much waved and inclined, as if the materials had been deposited in shoal or troubled waters. The illustrations of ripple or wave markings in these rocks are very numerous and beautiful. There is considerable variety in the texture of the rock; some of it is a very fine, close-grained quartzite, so that when worn by water it presents a smooth glistening surface like glass. Again it is filled with small water-worn pebbles, forming a fine pudding stone; again there are layers of siliceous sandstone, which separate into slabs varying from one fourth of an inch to several inches in thickness. This rock is very useful for building purposes, and has been employed at this point by the U. S. army officers in erecting the numerous buildings that constitute the fort. I looked diligently wherever the rock had been quarried, for some traces of organic remains, but none were visible. Resting upon the quartzite at this locality, is a bed of black plastic clay, precisely like No. 2 Cretaceous, as seen along the Missouri river near the mouth of the Vermilion. I found no fossils in this rock, but there were numerous specimens of selenite in crystals, which characterize it in other localities. Resting on No. 2 is the Chalky marl of No. 3, not differing in structure from the same rock before described as occurring at Yankton on the Missouri river. It here contains an abundance of its characteristic fossil, *Ostrea congesta.* The thickness exposed is about fifty feet, but from an examination of the slope above, I estimated its entire thickness at this point at from 80 to 100 feet.

The formations at this locality, in descending order, are as follows: *a.* Yellow chalky marl No. 3; *b.* Black plastic clay with selenite crystals, undoubtedly No. 2; *c.* Reddish and rose-colored quartzites.

From Fort James we again proceeded across the undulating prairie, in a direction a little south of east, about 65 miles, to Fort Dakota, at Sioux Falls, on the Big Sioux river. Nothing of especial interest, in a geological point of view, met our eye except a small exposure of the reddish quartzite in the valley of Vermilion river. The soil of the prairie over which we passed, and also the superficial deposits as shown along the streams, gave unmistakable evidence that the surface features of all this region are due to the wearing away of the Cretaceous rocks Nos. 2 and 3, and that they are the immediate underlying formations. The most characteristic features which met the eye everywhere, were the boulders which cover large areas so thickly as to render cultivation impossible until they are removed. These rocks, however, will be found to be very useful to future settlers for building and other economical purposes.

At Sioux Falls there is a remarkable exhibition of the same red and variegated quartzites described at James river. They are here exposed only in the valley of the river by the removal of the superincumbent Cretaceous rocks. The falls are five or six in number, extending a distance of half a mile, and have a descent of 110 feet in all, forming the most valuable water power I have ever seen in the west. About ten feet from the top of the rocks as seen at this locality, is a layer of steatitic material, mottled, gray and cream-color, very soft, about 12 inches thick, which is used sometimes for the manufacture of pipes and other Indian ornaments. When the quartzites have been subjected to the attrition of water, they present the same smooth glassy surface as before mentioned. There are also beds of pudding stone, and the most beautiful illustrations of wave and ripple markings that I have ever observed in my geological explorations.

I was unable to discover any well defined fossils, but wherever the surfaces of the rocks had been made smooth by the attrition of water, quite distinct rounded outlines of what appeared to be bivalve shells could be seen, so numerous that the rocks must have been charged with them. The matrix is so close grained and hard, that on breaking the rock no trace of the fossil could be found. I am confident, however, that the rock is filled with organic remains, but they cannot now be separated from the matrix so as to be identified.

From Sioux Falls to the celebrated Pipestone quarry, the distance is just 40 miles, measured with an odometer. Direction a little east of north. We passed over a similar undulating prairie, with but one small tree along the route, and but one rock exposure, and that occurs about four miles south of the quarry. The rock is a very hard quartzite, composed largely of water-worn pebbles, quartz, jasper, small clay nodules, chalcedony; some of the rock is a quartzose sandstone, other portions are fine grained siliceous rock. It lies in regular layers or beds, dipping at an angle of about 5°, 30° S. of E.*

On reaching the source of the Pipestone creek, in the valley of which the Pipestone bed is located, I was surprised to see how inconspicuous a place it is. Indeed, had I not known of the existence of a rock in this locality so celebrated in this region, I should have passed it by almost unnoticed. A single glance at the red quartzites here, assured me that these rocks were of the same age with those before mentioned at James and Vermilion rivers, and at Sioux Falls. The layer of Pipestone is about the lowest rock that can be seen. It rests upon a gray quartzite, and there are about five feet of the same gray quartzite above it, which have to be removed with great labor before the Pipestone can be secured. About 300 yards from the Pipestone exposure is an escarpment, or nearly vertical wall of variegated quartzite, extending directly across the valley. Each end of the wall passes from view beneath the superficial covering of the prairie. It is about half a mile in length. About a quarter of a mile farther up the valley there is another small escarpment, so that the entire thickness of the rock exposed at this point is about 50 feet. Not a tree can be seen; only a few small bushes growing among the rocks. There is a little stream of clear, pure water flowing from the rocks, with a perpendicular fall of about 30 feet, forming a beautiful cascade. The evidences of erosion were very marked, and the question arose—how could all the materials which must once have existed here joined on to these walls, have been removed, except by a stream much larger and more powerful in its erosive action than the one at present flowing here? There is a slight inclination of the beds from 1° to 3°, about 15° S. of E.

About 200 yards southeast of the quarry are five massive boulders, composed of a very coarse flesh-colored feldspathic granite, very much like that which forms the nucleus of the Black Hills.

* I am greatly indebted to Col. Knox, commandant of Fort Dakota, at Sioux Falls, for important facilities in my examinations.

The first detailed account of the Pipestone quarry that I have been able to find, is that of Catlin, in this Journal, [1], xxxviii. In Nicollet's excellent report there is a much more careful and accurate description of the rock and the locality, but neither of these gentlemen hint at the probable geological age. The first attempt to determine the age of the rocks in which the Pipestone is located, was made by Prof. Hall, in a paper read before the American Philosophical Society not long since. In that paper he regards them as of the same age with the Huronian rocks of Canada and Lake Superior.

At the time Mr. Catlin made his visit to the quarry he sent a portion of the pipestone to Prof. C. T. Jackson, of Boston, for analysis. Prof. J. gave it the name of Catlinite, with the following composition:

Water,	8·4
Silica,	48·2
Alumina,	28·2
Magnesia,	6·0
Peroxyd of iron,	5·0
Oxyd of manganese,	0·6
Carbonate of lime,	2·6
Loss (probably magnesia),	1·0
	100

The Pipestone layer, as seen at this point, is about 11 inches in thickness, only about 2¼ inches of which are used for manufacturing pipes and other ornaments. The remainder is too impure, slaty, fragile, &c. This rock possesses almost every color and texture, from a light cream to a deep red, depending upon the amount of peroxyd of iron. Some portions of it are soft, with a soapy feel, like steatite, others slaty, breaking into thin flakes; others mottled with red and gray. A ditch from four to six feet wide and about 500 yards in length, extending partly across the valley of Pipestone creek, reveals what has thus far been done in excavating the rock. There are indications of an unusual amount of labor on the part of the Indians in former years to secure the precious material.

This rock has been used for many years past by the Indians of the Northwest for the manufacture of pipes, and it was formerly the custom of some of the tribes to make the locality an annual visit to secure a portion of the precious material. They placed a higher value on the rock, because, while being so firm in texture it is so easily wrought, and because they could make far more beautiful and showy pipes than from any other material known to them. Besides, this was and is now, the only locality from whence the true pipestone can be obtained, and the labor is so great in throwing off the five feet of solid quartzite that rests upon it, that the rock has always been rare. For a mile or two before reaching the quarry the prairie is strewed with fragments that have been cast away by pilgrims.

Nearly all of our writers on Indian history have invested this place with a number of legends or myths. They have represented the locality as having been known to the Indians from remote antiquity. All these notions, I am convinced, will disappear defore the light of a careful investigation of the facts. It is quite probable that the rock has not been known to the Indians more than eighty or one hundred years, and perhaps not even as long a period. I could not find a trace of a stone implement in the vicinity, nor could I hear that any had ever been found; and indeed nothing could be seen that would lead one to suppose that the place had been visited for a longer period than fifty years. All the excavations could have been made within that time. There are many rude iron tools scattered about, and some of them were taken out of the ditch last summer in a complete state of oxydation.

Again, it does not appear that in the mounds which have been opened in the Mississippi valley so extensively, any trace of this rock has ever been found. It is well known that the pipe is the most important of the dead man's possessions and is almost invariably buried with the body, and if a knowledge of this rock had extended back into the stone age, it is almost certain that some indications of it would have been brought to light in the vast number of mounds that have been opened in the valley of the Mississippi. Pipes and other ornaments, made from steatite, have been in use among Indians from the earliest indications of their history, and they are still manufactured from this material on the Pacific coast.

Now the question arises as to the age of the rocks we have attempted to describe and which include the pipestone layer. Owing to the absence of well defined organic remains, the problem becomes a difficult one. Their exceedingly close-grained, compact, apparently metamorphic character, would direct one's attention to the older rocks, perhaps some member of the Azoic series; but if the impressions seen at Sioux Falls are those of bivalve shells, we must look higher in the scale. But in order that we may arrive at an approximate conclusion, let us look at the geology of the surrounding country.

We already know that the limestones of the upper Coal Measures are exposed at Omaha City, and continue up the Missouri river to a point near De Soto, almost twenty miles farther, where they pass from view beneath the bed of the river. Overlapping them is a coarse sandstone composed of an aggregation of particles of quartz cemented with the peroxyd of iron. This assumes every color from a deep dull red to a nearly white. The layers of deposition are very much inclined and distorted. Near Blackbird hill numerous dicotyledonous leaves have been found, and many of these plants occur in a quartzite so close-grained that the lines of stratification are nearly or quite obliterated, yet the impressions are distinct. This quartzite forms a valuable quarry near Sioux City. The coal seam included in this formation, (Lower Cretaceous, No. 1) crops out forty miles up the Big Sioux, or within sixty miles of Sioux Falls. Between Sioux City and Yankton we have at least three members of the Cretaceous series. Near Fort James we find that two members of the Cretaceous series (Nos. 2 and 3) rest upon the quartzites. The surface features of the whole country, with the soil and drift, indicate that the immediate underlying rocks are of Cretaceous age. Is it not possible therefore, that the quartzites that include the pipestone bed, belong to the supra-carboniferous, Triassic perhaps, or even to an extension downward of Cretaceous No. 1?

Prof. Hall, in an interesting geological memoir, read recently before the American Philosophical Society, gives an account of a tour into Western Minnesota, and many of the rock exposures which he describes must be of the same age with those noticed in this paper. He seems to have proceeded west from St. Paul to St. Peters and Fort Ridgely on the Minnesota river. From Fort Ridgely he continued west to Lake Shetek, which is not more than forty miles from the pipestone bed. Prof. Hall describes a wall of red quartzite at this locality, which he thinks is of the same age and character with that at Pipestone creek. I am convinced that not only the rock at Lake Shetek, but at many other localities which he describes with great care, are of the same age. I was informed by intelligent land surveyors in Dakota and Minnesota, that these red quartzite exposures extend very far to the north. Prof. Hall regards these quartzites as of the age of the Huronian series. His opportunities for tracing these rocks from the north and east were excellent, and his opinion is entitled to great weight.

Acad. Nat. Sci. Philadelphia, Nov. 10, 1866.

Art. IV.—*New Classification of Meteorites, with an Enumeration of Meteoric Species*; by Charles Upham Shepard.

The arrangement here proposed differs so widely from the two formerly put forth by me, as to be really new. The changes introduced will, I trust, appear as flowing naturally from the recent progress of the study. The localities by which the system is illustrated are such as are represented in my collection, now deposited in Amherst College. A number of localities found on my previous lists as well as upon those of others, are omitted, either because a degree of doubt hangs over their meteoric origin, or for the reason that they have suffered artificial alteration, or been too largely exposed to terrestrial decomposition.

Classification of Meteorites.

Class	Sub-Class	Orders
CLASS I. **LITHOLITES.** Stoney. (Λίθος, *a stone.*)	Sub-Class I. Eucritic. *Crystalline: earthy individuals distinct.* (Ευκρίτος, *distinct.*)	Ord. 1st. *Feldspathic.* Contains one or more species of feldspar. Ord. 2nd. *Augitic.* Contains augite.
	Sub-Class II. Dyscritic. *Earthy individuals indistinct.* (Δύσκρῖτος, *indistinct.*)	Ord. 1st. *Psammitic.* (Ψάμμος, *sand.*) Has the structure of sandstone. Ord. 2nd. *Howardic.* Compactly massive. Ord. 3rd. *Oolitic.* With oolitic grains. Ord. 4th. *Porphyritic.* Sub-porphyritic. Ord. 5th. *Basaltic.* Trappean.
	Sub-Class III. Anthracic. *Black.* (Ανθραξ, *coal.*)	Ord. 1st. *Atalene.* (Ατᾶλός, *soft.*). Friable. Ord. 2nd. *Anatalene.* (α, *privative* and ατᾶλός, *firm.*) Firm.
CLASS II. **LITHOSIDERITES.** Stone and iron, mixed. (Λιθος & Σιδηρος, iron.)	Sub Class I. Pleiolithic. *More than half stoney.* (Πλείων, *more.*)	Ord. 1st. *Stigmatic.* (Στίγμα, *a spot.*) Iron in round spots.
	Sub-Class II. Meiolithic. *Less than half stoney.* (Μείων, *less.*)	Ord. 1st. *Mignumic.* (Μίγνῦμί, *to mix.*) Stone and iron much mixed.
CLASS III. **SIDERITES.** Chiefly iron.	Sub-Class I. Psatharic. *Brittle.* (Ψαθαρός, *brittle.*)	Ord. 1st. *Chalyptic.* (Χάλυψ, *steel.*) Steel-like.
	Sub-Class II. Apsatharic. *Tough.* (Αψαθαρός, *tough.*)	Ord. 1st. *Agrammic.* Without lines when etched. Ord. 2nd. *Sporagrammic.* With scattered lines. Ord. 3rd. *Microgrammic.* Lines very small. Ord. 4th. *Eugrammic.* Lines distinct. Ord. 5th. *Megagrammic.* Lines coarse. Ord. 6th. *Tæniastic.* (Ταινία, *a riband.*) Banded. Ord. 7th. *Nephelic.* (Νεφέλη, *a cloud.*) Clouded.

CLASS I. LITHOLITES.

Sub-class I. Eucritic.

Order 1st. *Feldspathic.*

1. Stannern, Moravia, May 22, 1808.
2. Juvenas, France, June 15, 1821.
3. Jonzac, France, June 13, 1819.
4. Mässing, Bavaria, Dec. 13, 1803.
5. Petersburg, Tenn., U. S. A., Aug. 5, 1855.
6. Bialistock, Poland, Oct. 17, 1827.
7. Nobleboro, Maine, U. S. A., Aug. 7, 1823.
8. Manegaon, July 26, 1843.
9. Luotolaks, Finland, Dec. 13, 1813.

Order 2d. *Augitic.*

1. Chassigny, France, Oct. 3, 1815.
2. Bishopsville, S. Carolina, U. S. A., March 25, 1843.
3. Ensisheim, France, Nov. 7, 1492.
4. Shalka, India, Nov. 30, 1850.

Sub-class. II. Dyscritic.

Order 1st. *Psammitic.*

1. Erxleben, Prussia, April 15, 1815.
2. Bethlehem, New York, U. S. A., Aug. 11, 1859.
3. Kleinwenden, Prussia, Sept. 16, 1843.
4. Simbirsk, Russia.
5. Pillistfer, Russia, Aug. 8, 1862.
6. Klein Menow, Mechlenburg, Oct. 7, 1861.

Order 2nd. *Howardic.*

1. Paulograd, Russia, May 19, 1826.
2. Zaborzika, Russia, April 10, 1818.
3. Mauerkirchen, Austria, Nov. 20, 1768.
4. Oesel, Baltic Sea, May 13, 1855.
5. Charkow, Russia, Oct. 13, 1787.
6. Linum, Prussia, Sept. 5, 1854.
7. Castine, Maine, U. S. A., May 20, 1848.
8. Alboreto, Italy, July, 1766.
9. Futtehpur, India, Nov. 30, 1822.
10. Kakova, Hungary, May 19, 1858.
11. Aumières, France, June 4, 1842
12. Utrecht, Holland, June 2, 1843
13. Lucé, France, Sept. 13, 1768.
14. Milena, Croatia, April 26, 1842
15. Slobodka, Russia, Aug. 10, 1818.
16. New Concord, Ohio, U. S. A., May 1, 1860.
17. Girgenti, Sicily, Feb. 10, 1853.
18. Uden, Holland, June 12, 1840.
19. Buschof, Russia, June 2, 1863.
20. Angers, France, June 3, 1822.
21. Kuleschofka, Russia, Mar. 12–13, 1811.
22. Lissa, Bohemia, Sept. 3, 1808.
23. Bachmut, Russia, Sept. 15, 1814.
24. St. Denis, Belgium, June 7, 1855.
25. Apt, France, Oct. 8, 1803.
26. Linn, Iowa, U. S. A., Feb. 25, 1847.
27. Politz, Russian Germany, Oct. 13, 1819.
28. Nashville, Tenn., U. S. A., May, 9, 1827.
29. Forsyth, Georgia, U. S. A., May, 8, 1829.
30. Deal, New Jersey, U. S. A., Aug. 14, 1829.
31. Tirlemont, Belgium, Dec 7, 1863.
32. High Possil, Scotland, April 5, 1804.
33. Moradabad, India, Feb. 1808.
34. Durala, India, Feb. 18, 1815.
35. Yorkshire, Eng., Dec. 13, 1795.
36. Darmstadt, Hessia, 1815.

37. Nerft, Russia, April 12, 1864.
38. Macerata, Italy, May 8, 1846.
39. Dhurmsala, India, July 14, 1860.
40. Wessely, Moravia, Sept. 9, 1831.
41. Sales, France, March 8, 1798.
42. Favars, France, Oct. 21, 1844.
43. Heredia, Costa Rica, Apr. 1, 1857.
44. Vouillé, France, May 13, 1831.
45. Toulouse, France, April 10, 1812.
46. Constantinople, Turkey, June, 1805.
47. Grüneberg, Silesia, Prussia, Mar. 22, 1841.
48. Charsonville, France, Nov. 23, 1810.
49. Aigle (L'Aigle), France, April 26, 1803.
50. Charwallas, India, June 12, 1834.
51. Berlanguillas, Spain, July 8, 1811.
52. Goruckpore, India, May 12, 1861.
53. Macao, Brazil, Nov. 11, 1836.
54. Eichstadt, Bavaria, Feb. 19, 1785.
55. Agen, France, Sept. 5, 1814.
56. Château-Renard, France, June 12, 1841.
57. Doroninsk, Russia, Apr. 10, 1805.
58. Killeter, Ireland, April 29, 1844.
59. Shytal, India, Aug. 11, 1863.
60. Lixna, Russia, July 12, 1820.
61. Honolulu, Sandwich Isl'ds, Sept. 14, 1825.
62. Allessandria, Piedmont, Feb. 2, 1860.

ORDER 3rd. *Oolitic.*

1. Gutersloh, Prussia, April 17, 1851.
2. Nanjemoy, Maryland, U. S. A., Feb. 10, 1825.
3. Benares, India, Dec. 13, 1798.
4. Pulaski, Missouri, U. S. A., Feb. 13, 1839.
5. Nellore, India, Jan. 23, 1852.
6. Ausson, France, Dec. 9, 1858.
7. Timochin, Russia, March 13–25, 1807.
8. Trenzano, Italy, Nov. 12, 1856.
9. Pegu, India, Dec. 27, 1857.
10. Cereseto, Piedmont, July 17, 1840.
11. Esnaude, France, Aug. 1837.
12. Poltawa, Russia, anterior to 1838.
13. Zebrak, Bohemia, Oct. 14, 1824.
14. Ohaba, Transylvania, Oct. 10–11, 1857.
15. Casignano, Parma, Italy, April 19, 1808.

ORDER 4th. *Porphyritic.*

1. Assam, India. Found 1846 ?
2. Mëzo-Madaras, Transylvania, Sept. 4, 1852.
3. Chandakapoor, India, June 6, 1838.
4. Weston, Conn., U. S. A., Dec. 14, 1807.
5. Agra, India, March 28, 1860.
6. Siena, Tuscany, Italy, June 16, 1794.
7. Harrison, Kentucky, U.S. A., Mar. 26, 1859.
8. Richmond, Virginia, U.S.A., June 14, 1829.
9. Limerick, Ireland, Sept. 10, 1813.
10. Parnallee, India, Feb. 28, 1857.
11. Nulles, Spain, Nov. 5, 1851.
12. Abkurpore, India, April 18, 1838.
13. Cabarrus, N. Car., U. S. A., Oct. 31, 1849.
14. Okniny, Russia, Dec. 27, 1833.
15. Tabor, Bohemia, July 3, 1753.
16. Blansko, Moravia, Nov. 25, 1833.
17. Seres, Turkey, June, 1818.
18. Lupounas, France, Sept. 7, 1753.
19. Barbotan, France, July 24, 1790.
20. Tipperary, Ireland, Aug. 1810.
21. Bremevörde, Hannover, May 13, 1855.

ORDER 5th. *Basaltic.*

1. Chantonnay, France, Aug. 5, 1812.
2. Renazzo, Italy, Jan. 15, 1824.
3. Segowlee, India, March 6, 1853.
4. Mainz, Hessia. Found in 1852.

Sub-Class III. Anthracic.

Order 1st. *Atalene.*

1. Alais, France, March 15, 1806.
2. Orguiel, France, May 14, 1864.
3. Charleston, S. C., U. S. A., Nov. 16, 1857.

Order 2d. *Anatalene.*

1. Cold Bokkeveldt, Africa, Oct. 13, 1838.
2. Kaba, Hungary, April 15, 1857.
3. Grosnja, Caucasus, Russia, June 16, 1861.
4. Simonod, (Ain) France, Nov. 13, 1835.

CLASS II. LITHOSIDERITES.

Sub-Class I. Pleiolithic.

Order 1st. *Stigmatic.*

1. Hainholz, Westphalia. Found 1856.
2. Sierra de Chaco, Atacama, S. A. Found in 1862.

Sub-Class II. Meiolithic.

Order 1st. *Mignumic.*

1. Atacama, S. A. Found 1827.
2. Rittersgrün, Saxony. Found 1861.
3. Steinbach, Saxony. Found 1751
4. Krasnojarsk, Siberia. Found 1776.
5. Taney, Missouri, U. S. A. Found in 1856.
6. Newton, Ark., U. S. A. Found in 1860.

CLASS III. SIDERITES.

Sub-Class I. Psatharic.

Order 1st. *Chalyptic.*

1. Rutherford, N. Car., U. S. A. Found in 1856.
2. Niakornak, Greenland.
3. Newstead, Roxburgshire, Scotland. Found in 1861.
4. Otsego, N. Y., U. S. A. Found in 1845.

Sub-Class II. Apsatharic.

Order 1st. *Agrammic.*

1. Scriba, N. York, U. S. A. Found 1814.
2. Babb's Mill, Tenn., U. S. A. Found 1842.
3. Smithland, Kentucky, U. S. A. Found 1840.
4. Botetourt, Virginia, U.S.A. Found anterior to 1845.
5. Oktibbeha, Miss., U. S. A. Found in an Indian mound in 1856.
6. Wöhler's unknown locality.
7. Tuczon, Sonora. Found 1850.

Order 2d. *Sporagrammic.*

1. Chester, S. Car., U. S. A. Found 1847.
2. Walker, Alabama, U. S. A. Found [in 1832.
3. Dacotah, U. S. A. Found 1833.
4. Rasgata, New Granada. Found 1823.

ORDER 3rd. *Microgrammic.*

1. Santa Rosa, (Coahuila) Saltillo, Mex. Found 1850.
2. Tocavita, near Tunga, New Grenada. Found 1823.
3. Braunau, Bohemia. Fell July 14, 1847.
4. Salt River, Kentucky, U. S. A. Found 1850.
5. Senegal, Africa. Found 1763.
6. Tucuman, Otumpa, Arg. Rep., S. A. Found 1788.
7. Bitburg, (Eifel) Prussia. Found 1814.
8. Bonanza, Mexico. Found 1865.

ORDER 4th. *Eugrammic.*

1. Oxtlahuaca, Mex. Found 1784.
2. Toluca, Mexico. Found 1784.
3. Mani (Toluca valley). Wöhler's 19 lb. mass.)
4. Ruff's Mountain, S. Car., U. S. A. Found 1850.
5. Marshall, Kentucky, U. S. A. Found 1856.
6. Schwetz, Prussia. Found 1850.
7. Cranbourne, Australia. Found 1861.
8. Robertson, Tenn., U.S.A. Found 1860.
9. Seneca Falls, N. York, U. S. A. Found 1850.
10. Orange River, Africa. Found 1856.
11. Oaxaca, Mexico. Found 1843.
12. Burlington, N. York, U. S. A. Found 1819.
13. Tula, Russia. Found 1846.
14. Wayne, Ohio, U. S. A. Found 1849.
15. Lenarto, Hungary. Found 1815.
16. Bohumilitz, Bohemia. Found 1829.
17. Texas (Red River), U.S.A. Found 1814.
18. Madoc, Canada. Found 1854.
19. Caillé, France. Found 1828.
20. Nebraska, U. S. A. Found 1856.
21. Lockport, N. York, U.S.A. Found 1818.
22. Oldham, Kentucky, U. S. A. Found 1860.
23. Durango, Mexico. Found 1811.
24. Carthage, Tenn., U. S. A. Found 1845.
25. Oregon, U. S. A. Found 1845.
26. Bahia, (Bendigo) Brazil.
27. Agram, Croatia. Fell May 26, 1751.
28. Ellogen, Bohemia. Found 1811.
29. Lion River, Africa. Found 1853.
30. Putnam, Georgia, U.S.A. Found 1839.
31. Aeriotopos,* near Denver City, Colorado. Found in 1866.
32. Asheville, N. Car., U.S.A. Found in 1839.
33. Guildford, N. Car., U.S.A. Found in 1828.
34. Tazewell, Tenn., U. S. A. Found in 1853.
35. Oberrkirchen, Nassau. Found in 1863.
36. Dickson, Tenn., U. S. A, Fell July 30, 1835.

ORDER 5th. *Megagrammic.*

1. Arva, Hungary. Found 1844.
2. Sarepta, Russia. Found 1854.
3. Zaccatécas, Mexico. Found 1792.
4. DeKalb, Tenn. Found 1845.
5. Cocke, (Sevier) Tenn., U. S. A. Found 184).
6. Heywood, N. Car., U.S.A. Found 1854.

* Αηριος, *lofty* and τοπος, *place*, from its being found over 8,000 feet above the sea.

ORDER 6th. *Tæniastic.*

1. Cape of Good Hope, Africa. Found 1801.

ORDER 7th. *Nephelic.*

1. Black Mountain, S. Car., U. S. A. Found 1835.
2. Seeläsgen, Prussia. Found 1847.
3. Nelson, Kentucky, U. S. A. Found 1856.
4. Union, Georgia, U. S. A. Found 1853.
5. Pittsburg, Penn., U. S. A. Found 1850.
6. Tabarz, Thuringia. Found 1854.

APPENDIX TO SUB-CLASS II. Markings not ascertained.

1. Savisavik, Greenland. Found 1850?
2. Benton, Texas, U. S. A. Found 1856.
3. Brazos, Texas, U. S. A. Found 1856.

Total number of localities in the collection, 211.

METEORIC MINERALS.*

1. CHAMASITE, (*Reichenbach.*) Fe, or variable mixtures of Fe and Ni up to 23 p. c. of the latter.
2. TÆNITE, (*Reichenbach.*) $Fe^x Ni^x$. ($Fe^4 Ni^3$. ?)†
3. OKTIBBEHITE, (*Shepard.*) Fe Ni.
4. SCHREIBERSITE, (*Haidinger.*) $Fe^x Ni^x P^x$ ($Fe^4 Ni^2 P$. ?)‡
5. RHABDITE, (*Reichenbach.*) $Fe^x Ni^x P^x$.
6. CHALYPITE, (*Shepard.*) $Fe^x C^x$. Forchhammer obtained as a leading constituent of the Niakornak Iron a hard, brittle, cast-iron like compound of iron and carbon in proportions of from 7·23 to 11·06 p. c. of carbon, which would indicate the formula of Fe^2C for this species.
7. FERROSILICITE, (*Shepard*). Fe^6 Si (Si being 22).
8. TROILITE, (*Reichenbach*). $Fe^7 S^8$ (or Fe 62·07, S 37·93).
9. GRAPHITOID, (*Shepard*). $Fe^x C^x$ (nearly pure C).
10. KABAITE, (*Shepard*). $C^x H^x O^x$ (meteoric petroleum).
11. CHROMITE. $\dot{Fe}\,\bar{\dddot{Cr}}$ (with traces of $\dot{Mg}$).
12. QUARTZ. $\dddot{Si}$.
13. OLIVINE. $\dot{Fe}^2\dddot{Si}+9\dot{Mg}^2\dddot{Si}$ (=$\dddot{Si}$ 41·3, $\dot{Mg}$ 47·, $\dot{Fe}$ 10).
14. AUGITE OR ENSTATITE. $\dot{Mg}\dddot{Si}$ (=$\dddot{Si}$ 59·71, $\dot{Mg}$ 40·29).
15. PIDDINGTONITE, (*Haidinger*). $\dot{R}\dddot{Si}+\dot{R}^2\dddot{Si}^3$ (=$\dddot{Si}$ 57·66, $\dot{Fe}$ 20·65, $\dot{Mg}$ 19·, $\dot{Ca}$ 1·5).
16. SHEPARDITE, (*Rose*). $\dot{Mg}^3\dddot{Si}^3$ (=$\dddot{Si}$ 68·91, $\dot{Mg}$ 31·02.
17. ANORTHITE. $\dot{R}\bar{\dddot{Al}}\dddot{Si}^3$ ($\dot{R}$ being mostly $\dot{Ca}$, with a little $\dot{Mg}$, $\dot{Na}$ and $\dot{K}$. Taking $\dot{R}$ as wholly $\dot{Ca}$, composition would be $\dddot{Si}$ 45·8, $\bar{\dddot{Al}}$ 25·00 and $\dot{Ca}$ 18·00.)
18. LABRADORITE. $\dot{R}\bar{\dddot{Al}}\dddot{Si}^3$. ($\dot{R}$ chiefly $\dot{Ca}\dot{Na}$ and $\dot{K}$. Composition nearly $\dddot{Si}$ 53·09, $\bar{\dddot{Al}}$ 30·39, $\dot{Ca}$ 16·52.)

* Only those species are enumerated which are supposed to have existed in meteorites anterior to their arrival within our atmosphere.

† I have observed in a single instance among the iron and nickel *matte* of the produce of the dipyrite mine at Gap, Penn., thin laminæ of an alloy of Fe and Ni precisely resembling the Tænite of meteoric iron, which consisted of Fe 56·11 and Ni 43·89.

‡ An artificial compound having this composition was produced by Deville.

Amherst College, Sept. 29, 1866.

ART. V.—*On the Tertiary Formations of Mississippi and Alabama;* by EUG. W. HILGARD, Ph.D., State Geologist of Mississippi.

PORTIONS of the Tertiary formations of Mississippi and Alabama have formed the subject of study of various observers, from time to time, during the past thirty-five years; and the relative age and characteristic fossils of three of the most important divisions, have been determined by the labors of Morton, Conrad, Lea, Lyell, Tuomey and others. Most of these observations, however, have been confined to a few localities, or to such as were situated at short distances from each other in the direction of the strike, though sometimes affording complete sections in that of the dip of the strata.

It is my object in the present paper, to review the general results of my own observations, as combined and collated with those of other scientific observers to whose writings I have been able to refer. If in so doing I am led to controvert the opinions of some, it is in the interest of science, my opportunities for observation having afforded fuller data for reaching correct conclusions. No one can appreciate more than I do, how much American geology owes to the indefatigable research of Conrad, especially. Had he been less active in promoting our systematic knowledge of the Tertiary, I should have had fewer objections to offer to his opinions, and certainly fewer results to science.

Among the sections best adapted to the study of the Alabama Tertiary, are those afforded along the course of the Alabama and Tombigby rivers, by the well-known exposures of Claiborne and St. Stephens, where Sir Charles Lyell first definitively settled the question of the age of the so-called Nummulite, more properly Orbitoides, limestone; and observed the fact, ignored again by some subsequent writers on the subject, that the matrix of Zeuglodon bones always lies below the true Orbitoides limestone.

The Vicksburg and Jackson groups.—In most respects, the Claiborne and the St. Stephens sections agree so closely, that their character was naturally considered as the type of the Southwestern Tertiary, until Conrad's examination of the Vicksburg bluff showed the *Orbitoides* to be there associated with a fauna distinct from, yet equalling in variety and peculiarity, that of the Claiborne sand. In view of the coincidence of leading fossils, nevertheless, Conrad at once considered the part of the Vicksburg profile first examined by him (No. 5 of Sec. 31, p. 141 of my Miss. Report) as the near congener of the Orbitoides limestone of St. Stephens. Yet he seems to have retained doubts as to the precise equivalence of the two divisions, which have lately found expression in the separation attempted by him, of the Vicksburg marl and blue limestone from the Orbitoides limestone proper, and the transfer of the latter to the Jackson group. (This Jour., Jan., 1866.)

The collection of shells upon which Conrad based his determination of the latter group (Trans. Acad. Nat. Sci., 1855, p. 257) was unfortunately a selected one.* It led him to the conclusion that the Jackson beds contained no species in common with those of Vicksburg, and a very few with those of Claiborne. Had he been on the spot he would have found, as I did a few years afterwards, that not only do the Jackson beds contain a goodly proportion of recognized Vicksburg fossils, but that the same fauna (though in an indifferent state of preservation) occurs in the marlstone strata overlying the sandy shell-bed, associated with *Zeuglodon* bones, *Laganum Rogersi* and *Scutella Lyelli.* Moreover, the oyster occurring on top of the Jackson beds, as stated in a previous paper is not *O. Georgiana*, but a *Gryphaea* everywhere accompanying the *Zeuglodon;* but also occurring in the Vicksburg marl and limestone. Nowhere in Mississippi has a single Orbitoid been found associated with either the Zeuglodon, or any of the characteristic fossils of the Jackson group. It is quite possible that in Alabama, Zeuglodon bones may have been picked up in company with Orbitoids, equally as well as with drift pebbles. There, the same ravine often cuts into the strata of both groups, and of course commingles their fossils. In Mississippi, I have found this direct superposition only in a single instance; elsewhere, the regions in which the several groups crop out are so far separated geographically, (in consequence of the intercalation of lignitic strata,) as to leave the observer no legitimate chance of error in reference to fossils.

Notwithstanding the defectiveness of his materials, Conrad assigned to the Jackson group its proper place, between that represented by the Claiborne sands and the Orbitoides limestone. He still, however (*l. c.*) thought it most probable that the *Zeuglodon* was referable to the same age as the latter.

A great deal of the obscurity in which the relative age of the Southwestern Tertiary has been involved, is owing to too great a reliance placed by most observers on lithological characters,

* It is impossible to avoid erroneous inferences from the examination of fossils sent for determination by amateurs, and rarely collected with a view to completeness, or general results. From the collection of Jackson fossils submitted to Mr. Conrad, any one would infer that this rich fauna had been totally extinguished by some cataclysm, before the deposition of the Vicksburg strata; whereas in fact, probably more than one-fifth of the former fauna is represented in the latter.

The same has happened with reference to the superior Cretaceous of Mississippi and Alabama, the Ripley group of Conrad, whose fossils as described by him from a *selected* collection forwarded to him, would seem to constitute an isolated group, almost unconnected specifically, with the lower members of the Cretaceous of the Southwest and elsewhere; whereas in reality it shares the leading fossils of the latter, and is connected with the Rotten Limestone group especially, by transitions both lithological and paleontological, as ascertained by myself a year previous. (Miss. Rep., pp. 79, 84.)

differences as well as resemblances. The "white limestone of Alabama" has so long been quoted as the matrix of the *Zeuglodon* as well as of the *Orbitoides*, that no one seemed to question their being contemporaries. Yet in examining all the records of the occurrence of Zeuglodon bones which I have been able to collect, I have no where found a distinct statement that the Orbitoids have been found associated with them *in situ*. The Orbitoides limestone is mentioned as forming knolls, hill-tops—the *Zeuglodon* as being found in level fields, or in ravines.

The true position of the Zeuglodon bed did not, however, escape the glance of Lyell (On the Nummulite Limestone of Alabama; this Jour. [2], vol. iv); for he distinctly identifies the upper "Rotten limestone" bed of the Claiborne bluff with that which, at Bettis' Hill, contains *Aturea Alabamensis* and *Zeuglodon*, and underlies the Orbitoides rock. The only other observer who seems to have recognized the same fact. is C. S. Hale (this Jour., [2] vol. vi, p. 354). Tuomey, otherwise so accurate in his field observations, ignores it, and speaks only of the "white limestone" in general.

Nowhere has the geologist more need of divesting himself of reliance upon lithological characters, than in the study of the Mississippi Eocene. Not only do the materials of the different groups often bear a most extraordinary resemblance to each other, but their character varies incessantly *in one and the same stratum*, within short distances. Hale (*l. c.*) remarks that in Mississippi, the Orbitoides limestone seems to be represented by blue marlstone, and so it is—sometimes. But while on the one hand we see the hard limestone of the Vicksburg bluff passing into blue marl (Byram, Marshall's quarry), we on the other hand find it passing equally into a rock undistinguishable from that of St. Stephens (Brandon, Wayne county); the varied fossils described by Conrad disappearing almost entirely, to be replaced by millions of Orbitoids imbedded in a semi-indurate mass of carbonate of lime, interspersed at times with similarly constituted conglomeratic masses of *Pecten Poulsoni*.

I cannot therefore, with the lights before me, agree to the propriety of distinguishing as separate divisions the Orbitoides limestone and the Vicksburg group of fossils. Even the occurrence of a different species of Orbitoides (*O. nupera* Con.) at Vicksburg cannot alter the case, for the undoubted *O. Mantelli* occurs there also, in the solid rock. And there are few of the characteristic fossils of the Vicksburg profile, which I have not on some occasions found side by side with the *O. Mantelli* and its companions, the *Pecten Poulsoni* and *Ostrea Vicksburgensis*.

Of course, the coral had its favorite haunts—the mollusks theirs. There is nothing surprising in the fact that where the one abounds the others are usually scarce, or *vice versâ*.

The Red Bluff group.—In a late paper, above referred to, Conrad proposed to distinguish the lowest fossiliferous stratum ordinarily visible at Vicksburg, and subsequently studied by him (No. 4 of my Vicksburg section, *ut supra*), as a separate group, which he considers as characterized by the occurrence of *Ostrea Georgiana*, and for which he proposes the name of Shell Bluff group. I have elsewhere (this Jour., July, 1866) explained my reasons for dissenting from Conrad as to the position between the Claiborne and Jackson groups, which he assigns to this new division. To the propriety of distinguishing it, however, as a sub-group of the Vicksburg age, I fully agree, though doubting that of giving it the name of a locality from which, as Conrad remarks, but one coincident fossil is known—*O. Georgiana*—while another also occurring there—*O. sellæformis*—in Mississippi and Alabama is confined to the Claiborne group. In a profile of 80 feet, as occurring at Shell Bluff, loose data like those extant regarding this locality, cannot fairly be made a ground of conclusions contrary to the order elsewhere elaborately observed. For aught that is on record, the whole Jackson group may be represented between the beds in which *O. Georgiana* and *O. sellæformis* respectively occur at that place, if (as seems probable from its non-occurrence in the Jackson group of Mississippi and Alabama) the former shell should be so restricted in its range as Conrad supposes.

I believe the white limestone (No. 1 of my Vicksburg section) which underlies the lignite at Vicksburg, but is visible only at extraordinarily low stages of water, to be of the Jackson age, both from its stratigraphical position and the lithological character of the specimens I have seen. But whether it is or not, there can be no reasonable doubt that the usual Jackson strata, which are largely developed on the Yazoo above Vicksburg, underlie at Vicksburg, as well as on Pearl river and Chickasawhay, the Vicksburg group.

The Georgiana bed at Vicksburg is preëminently the habitat of a shell common to the Jackson and Vicksburg stages, but most abundant in the former, viz., *Meretrix Sobrina* Con.; of the two Madrepores described by Conrad, and of *Fulgoraria Mississip.*, all occurring, more or less, in the Vicksburg stage proper. Of the fossil first mentioned, I have after a freshet found hundreds washed out, mingled with numerous masses of Madrepores, sometimes of several pounds weight, with *Fulgoraria*, *Natica? Vicksburgensis*, *Ostrea Georgiana*, etc. The bed has therefore affinities both above and below, and moreover occupies precisely the stratigraphical position of the bed at Red Bluff (Miss. Rept., p. 135). Here the fossils are much more numerous and the affinities in both directions are therefore better expressed. Characteristic and abundant above all, however, is a *Plagiostoma*, which I cannot distinguish from figures and descriptions of *P. dumosum*, but hesitate to refer to that species, since it has not been found in the underlying Jackson strata. Lyell mentions the occurrence of *P. dumosum* in the lower portion of the Orbitoides limestone at Bettis' Hill; the same is mentioned by Tuomey, moreover, as occupying a corresponding position in the St. Stephens profile, associated with Orbitoids, and even his description of the lithological character of the bed tallies with that of the Red Bluff deposit. Hale, likewise, mentions *P. dumosum* as one of the prominent fossils of the "white limestone."

The Red Bluff bed seems, therefore, to be more or less coëxtensive with the Vicksburg group, and regularly associated with it as a subordinate feature. Its inconsiderable thickness readily explains its entire absence at many points where, stratigraphically, it ought to appear. Unfortunately, the fossils accompanying *O. Georgiana* at the only locality, other than Vicksburg, where it has been found in Mississippi, have not been observed.

The Claiborne group proper.—That the beds of blue marl and white marlstone, which in my Report I have designated as the "Calcareous Claiborne" group, are strictly equivalent to the typical fossiliferous sand at Claiborne, with underlying limestone bed, is probable both from their stratigraphical position and the correspondence of all the fossils thus far observed; though from the indifferent state of preservation in which the latter are found in the Mississippi stratum, these are few in number. *Ostrea sellæformis* Con. and *O. divaricata* Lea, are the leading shells; I have also recognized *Corbula gibbosa* Lea and *Voluta petrosa* Con. These beds possess fewer good exposures in Mississippi than either of the preceding groups, and may possess many unobserved features. Since publishing my Report, I have received evidence that it extends somewhat farther westward, between the territory of the Jackson and Siliceous Claiborne groups, than it appears on the map. Nor is the division between it and latter groups very well defined, inasmuch as the transition from siliceous to calcareous materials is a gradual one, through strata often very rich in *Scutella Lyelli*, *Pecten Lyelli*, *Ostrea divaricata* and *O. Alabamensis* Tuo.? I am not aware of the existence of any lignite bed in the dark colored clays which immediately underlie the blue marl.

Siliceous Claiborne, or Buhrstone group.—The precise Alabamian equivalents of my "Siliceous Claiborne" group are not nearly so obvious. The extreme variability of its strata both in Mississippi and Alabama (see Tuomey's first Report, and C. S. Hale, *l. c.*), which it seems natural should carry with it a corresponding variation at least in the *predominance* of fossils, and the comparative scarcity and ill preservation of the latter, render its study doubly difficult. I think that, as Tuomey intimates (ibid., p. 146) and Conrad more decidedly avers (this Jour., Sept. 1865, p. 266), there is a lower division to be distinguished, which represents the fauna of the Great Lignite epoch, while the upper one seems clearly to be the equivalent of the Buhrstone formation of Georgia and South Carolina. That here as elsewhere in the Mississippi Eocene, lignitic beds should intervene where there is a direct superposition in Alabama, need not surprise us.

Since publishing my Report, I have had some opportunity of examining more closely the southern portion of Newton and Lauderdale counties. I have ascertained that the facies of the white siliceous claystone, so remarkable for its lightness (Miss. Rep., p. 124), is much more extensively developed than I had anticipated; that though often showing lithological transitions into chert and sandstone, it is on the whole characteristic of the superior part of the siliceous division, whose lower portion is represented by the soft yellow sandstone of South Neshoba and North Newton, its lowest probably by the hard, buhrstone-like rock with chalcedonized shells, of the Marion ridge. (Ibid., *l. c.*) All this tallies very closely with Tuomey's observations in Alabama where the "chalk hills" are also a matter of popular remark.

Lower Lignite—Great Lignite group?—The fauna of the lower division, which has never been studied as yet, I conceive to be represented in the small fossiliferous sandstone deposits skirting the Cretaceous in Tippah and Pontotoc (Miss. Rep., pp. 109–112); in the isolated patch of ferruginous green sand of Shongalo, in Carroll, Holmes, Attala and Choctaw counties, Miss., which seems to have been struck again at 415 feet in the bored well at Jackson. (Ibid., pp. 121–123.) As regards this deposit, I will call attention to the fact that it contains *Aturea Alabamensis*, claimed by Conrad as a leading fossil of the Great Lignite, and moreover closely resembles in its lithological characters, the Shark river beds described by Meek and Hayden.

Finally, in Alabama, this era, as Conrad observes, is probably represented in the Bashia creek section of Tuomey's first Report; which, since it is said to contain abundance of well preserved fossils, is well worthy of especial study.

But from this point, Conrad, Hale and others have been led by lithological appearances to extend the limits of the Great Lignite to the southward and westward, to deposits far above it, and even, probably, beyond the limits of the Tertiary.

Conrad (this Jour., Sept., 1865) inclines to refer to this group the buried forest containing tree palms (Miss. Rep., 153), observed jointly by Harper and myself in 1855. The "Nipadites and Cycadites" of that locality, so far as any determination of specimens goes, were "all in the eye" of one of the observers. At all events, the bed lies above the Orbitoides limestone, and within the Grand Gulf group of my Report; and the "large oyster" overlying marl and limestone, mentioned in the same place, is not *O. Georgiana*, but the *Gryphœa* repeatedly referred to. As for the Vicksburg lignite, it is but one of the many lignitic seams constantly found intercalated between the marine stages of the Mississippi Tertiary. Finally the Port Hudson strata, observed by Carpenter and Lyell, are either the highest of the Grand Gulf group, or form part of the (probably Post-pliocene) formation underlying the Mississippi delta—the "Coast Pliocene" of my Report.

Hale (this Jour., [2], vol. vi, p. 356) goes so far as to identify with the Bashia creek lignite, beds occurring near Natchitoches, and on the Trinity, Colorado and Brazos rivers, in Texas.

I shall not here reiterate the reasons and data given in my Report (p. 109) in support of my opinion that the whole of my "Northern Lignitic" is of the lowest Eocene age, having nothing new to add to what is said there on the subject, and by Dana. (Manual of Geology, p. 510.) In a late letter, Lesquereux informs me that according to the specimens he has examined, there must be a considerable difference of age between the Winston strata marked *c* in my general section (Miss. Rep., p. 108) and those marked *a* in Tippah, and that the former appear to be newer, probably Pliocene. Had the conclusion been the reverse, it might have been more readily reconciled with stratigraphical evidence. Winston county adjoins Neshoba, where, as in Lauderdale, the Lignitic unequivocally dips beneath the siliceous Claiborne strata, and the locality *c* is on the same parallel with the marine outlier of the Claiborne age, in Caroll and Attala. Between locality *c* and the edge of the siliceous Claiborne strata in Neshoba and Lauderdale, the outcrops continue in unbroken succession and uniformity of character; there is nothing to indicate the superimposition of a limited Pliocene basin upon the most ancient Eocene, *here*, any more than between loc. *a* in Tippah and *b* in Lafayette county, which latter Lesquereux is also inclined to consider of later age.

I hope to be able, hereafter, to submit to the experienced hands of Lesquereux more complete sets of specimens from these and other localities situated nearer to the recognized Eocene, with a view to the solution of the interesting problem regarding the correspondence of ancient and modern floras on the two continents.

It is the continuation of these lowest lignite beds of Lauderdale which, in the map accompanying Tuomey's first Alabama Report, is intended to be represented by a narrow band of brown tint, skirting the Cretaceous on the south, across the state. Tuomey was not certain of its eastward limit, and it would appear from the notes of Mr. Thornton, appended to Tuomey's second

Report, that on the line between the Cretaceous and Tertiary in Barbour county, Ala., no similar strata occur.

Stratigraphical conformation of the Tertiary.—I now turn to the consideration of some of the general stratigraphical phenomena of the Mississippi and Alabama Tertiary, which have given rise to misapprehensions regarding its dip and general arrangement.

I have stated (Miss. Rept., p. 107) that the general dip of the Tertiary strata of Mississippi seems to conform to that of the Cretaceous strata—westward in the northern part of the state, and southward, or nearly so, in the southern. The westward dip of the old Lignitic does not appear to be much greater than the fall of the rivers, from the fact that on the waters of the Tallahatchie and Yallabusha, the same strata appear in the beds of streams for miles, before giving place to higher ones. I do not think the dip can exceed four or five feet per mile; but the variability of materials and small extent of outcrops (which often exhibit local dislocations) render direct observations extremely difficult. As we approach the region of southward dip, however, the inclination becomes more decided and can be observed even in limited outcrops, on streams or railroad cuts trending southward. On Pearl river below Jackson, and on the Chickasawhay, there is no difficulty in recognizing the fact; but yet it is by no means easy to determine correctly the amount of dip, unless by regular leveling operations; the variability of the materials and thickness of the strata, as well as their irregular surface, rendering all the usual pocket instruments unreliable. According to the best observations I have been able to make by reference to the river level, the dip of the Vicksburg strata at Byram (Miss. Rep., p. 145) and of the Jackson strata near Trotter's plantation (ibid., p. 135) amounts to from 10 to 12 feet per mile, S. by W. But this is by no means the maximum or minimum observed, but refers to points where the great regularity of succession for a considerable distance seemed to indicate a normal configuration.

If this estimate be correct (and I do not believe it will hereafter be found to differ materially from the truth), it would go to prove that the upheaval which caused this dip as well as that of the Cretaceous system in Mississippi and Alabama, was a slow one. For the artesian borings on the territory of the former formation, have shown the dip to be about double the above, or 25 feet per mile, in Monroe and Lowndes counties, Miss., and the adjoining portions of Alabama. On the other hand, the strata of the formation overlying the marine Tertiary in south Mississippi possess so slight a dip as, at first, to render its very existence doubtful.

In the general (north and south) section accompanying Tuomey's geological maps of Alabama, the Tertiary strata are represented as dipping southward, conformably with those of the Cretaceous. Nevertheless, in the section from Baker's bluff to the lower Salt Works on the Tombigby, he finds the white limestone (= Jackson and Vicksburg groups) occupying "a trough-like depression in the Buhrstone formation." In conversations with me, a few months prior to his death, he expressed his belief that such was the general disposition of the Tertiary strata, and that on close examination it would turn out that the strata passed over in going southward from the border of the Cretaceous, would be again passed over in reversed order, still farther south. My report of the existence in Mississippi, of a lignitiferous formation (the Grand Gulf group) southward of the marine Tertiary, seemed to confirm this view.

My subsequent examination of the Mississippi Tertiary has proved that in Mississippi at least, the disposition is such as first conceived by Tuomey, and laid down on his map; affording a strong presumption that the same is the case in Alabama But at the same time I found, in two different meridians, a similar anomalous reappearance of older strata which had sunk out of view farther northward.

One of these cases is noticed in my Report (p. 128). From Jackson to Canton, a distance of twenty-five miles N. and S., the same clay marl stratum with *Zeuglodon* bones and *Gryphœa* continues on the surface, overlying conformably, as it seems, the lignitic strata, which appear in the bed of Pearl river, just above Jackson, overlaid by the shell-bed. But thence they sink out of view rapidly, and are followed in regular succession by the Jackson and Vicksburg strata. It will be remarked that here there is a singular elbow interrupting the regular E. by S. course of the strike.

The other case occurs on the Chickasawhay, contrary to the statement in my Report (*l. c.*), in making which I overlooked some specimens and notes of 1855, then mislaid.

I find that on the very southern edge of the Vicksburg territory in Wayne county, at Dr. E. A. Miller's (p. 146), I collected *Gastridum vetustum*, *Morio Petersoni*, *Laganum Rogersi* and other Jackson fossils, from a blue sandy marl directly underlying the St. Stephens limestone teeming with Orbitoids. North of this locality, the Vicksburg strata alone are seen outcropping until we reach Red Bluff, where the Jackson strata disappear beneath those of the Red Bluff group. Within this distance of about ten miles, not only have the Jackson strata "dipped up" again, but the Red Bluff group, with its concomitant green clays and stiff clay marls (nearly a 100 feet in thickness altogether) has vanished from between them and the Vicksburg strata proper. It might therefore be suspected that the whole formation was here thinning out, and that we were near the edge of a basin.

So far, I have been unable to observe the marine Tertiary in juxtaposition with the Grand Gulf group on the Chickasawhay, and cannot positively assert that the former dips under the latter at all. In Hinds, Rankin and Smith counties, their relative age is clearly exhibited, but it is possible that they do not overlap very far, so that, were a portion of the superior formation removed by denudation, the edge of the marine basin might be laid bare. Yet from the fact that at the very locality mentioned, the Vicksburg strata proper possess approximately the same aggregate thickness as elsewhere observed, we should not conclude that the stratum is about to run out. Nor is it easy to reconcile such a supposition with the grand scale on which these marine strata are developed in the direction of their strike, through the states of Alabama, Mississippi and Arkansas, and their relations to the Great Lignite. It would seem more natural to suppose that they form part of the deposits of a tertiary Gulf of Mexico, and now (either themselves or their deep sea equivalents) underlie that gulf. Under this point of view, they might possibly be expected to reappear in Yucatan, along the foot of the Mexican plateau, in Texas, and forming a tongue, as it were, in the direction of the long cretaceous Mediterranean, and tertiary freshwater sea which is marked by the Great Lignite of the upper Missouri.

In view of the slight dip of the Mississippi Tertiary, the anomalies mentioned may find their explanation in undulations of the sea-bottom upon which these strata were deposited. A dip of ten feet per mile does not differ very sensibly from the horizontal, and a stratum deposited on such a slope would not necessarily, on that account, vary much in thickness. If at the time of the deposition of the Jackson group, a northward slope to that extent existed between Jackson and Canton, a subsequent general upheaval to the northward would render that slope a horizontal plain, while the strata heretofore horizontal would acquire a southward dip to the same extent. Similarly, if between Baker's bluff and the Salt Works on the Tombigby, or between Dr. Miller's and Red Bluff on the Chickasawhay, the sea bottom had a slight trough-shaped undulation (such as the ocean beds of our time frequently exhibit), the existing state of things would result. Artesian borings lower down on the Tombigby river may hereafter inform us whether or not the white limestone underlies there, as by analogy with the Pearl river beds it might be expected.

While, however, the general features and position of the Tertiary as well as of the Cretaceous strata of Alabama correspond closely with those observed in Mississippi, it seems, contrary to what one would expect, that the absolute amount of southward dip is somewhat less in the former state. No numerical data regarding this point are given, but from the great breadth of country upon which outcrops of one and the same group of the Tertiary occur in Alabama, the fact is apparent enough as concerns the latter. Whether the same is true of any part of the Cretaceous, is doubtful; unless the great north and south width of the Ripley group, as exhibited on Chunnenugga ridge in Macon and Barbour counties (according to Tuomey's and Thornton's observations combined), should thus find its explanation. It seems doubtful, in fact, whether the true Rotten Limestone (if it exist there) comes to the surface at all. This is the more remarkable from the near proximity of the primary and metamorphic rocks of that portion of the state, whose original upthrusting would thus be proved to ante-date greatly the general Allegheny upheaval.

The Grand Gulf group.—I have considered the older and well-defined eocene Tertiary apart from the two other groups described in my Report, whose age is doubtful and whose relation to the former is not well recognized. A glance at the map nevertheless shows that so far as extent is concerned, the Grand Gulf group is perhaps the most important of the formations of the state of Mississippi, and that, judging by the trend of its outlines on the Mississippi river, it must be still more so in Louisiana; while in Alabama it rapidly contracts, and attracts so little attention that I find but two observers who, *passim*, advert to anything resembling this formation as it exists in Mississippi.

Conrad (this Jour., [2], vol. ii, 210) states that the bluffs of Vicksburg, Grand Gulf, Rodney and Natchez, have a similar geological origin; that their lower portion is of marine origin, and a member of the Eocene.

I am unable to refer to a prior publication, mentioned by Conrad, for the data upon which this determination is based, so far as the bluffs below Vicksburg are concerned. I have made detailed examinations of the profiles at Grand Gulf and at Fort Adams, at the extreme limits of the formation in Mississippi, and I may say, of all the important outcrops in the interior; but thus far, have failed to find even a trace of a marine fossil, and in fact, but a single specimen—a bone fragment as I take it—likely to prove of zoogene origin. Vestiges of vegetation are common, but only in one instance, so far, have I found any specimens likely to admit of exact determination. I refer to the deposit on the Chickasawhay, already referred to, which exhibits the trunks, stumps and roots of an ancient forest, inhabited, among other trees, by tree palms. But even here, scarcely anything beyond the most general outlines of a few leaves can be traced. It may be that in proximity to the (rare) lignite beds of this formation, better success might be had—as has been the case in the Lower Lignitic. In the sand- and claystones belonging to this group, neither Wailes, who resided amongst them and gave the name of "Davion rock" to one variety of the former; nor myself who have delved in scores of exposures, have ever found a trace of any fossil whatsoever.

The Natchez bluff I have not visited; but Wailes, who resided within six miles of it, must have done so, and he is silent on the subject of any but the Loess fossils, although he mentions all other fossiliferous rocks occurring in the State. Thus, while I have seen mentioned in various places "marine strata at the foot of Natchez bluff," I cannot trace the report to any authentic source. I shall endeavor to settle the point as soon as possible, but meanwhile observe, that according to reliable information given me, the Rodney bluff is essentially a counterpart of that at Grand Gulf; a detailed profile of which, obtained at a medium stage of the river, is given in my Report (p. 148).

The extreme scarcity of fossils in this formation is the more remarkable, as from the regularity of its stratification it is manifest that it has been formed in quiet water, and it contains a great variety of materials suitable for the preservation of either fauna or flora. Even the strata containing carbonate of lime, however, seem to have had nothing to fossilize, save in the solitary instance of a doubtful fragment of cellular bone already mentioned. In some portions of it, we might imagine that the abundance of soluble salts (which pervade more or less the entire deposit) indicated the former existence of bitter lakes, incapable of harboring life; but this could by no means apply to the formation as a whole.

The only probable presumption in favor of referring it to the Eocene, so far as I know, arises from the lithological resemblance and transition of its strata, at its northern limit, to those of the Vicksburg group. The upper division of the latter group in the neighborhood of Brandon is undistinguishable from the materials of the Grand Gulf group at many points, and I so referred them until I found them overlaid by a string of limestone nodules containing *Orbitoides*, about forty-five feet above the uppermost sands of the Vicksburg group. (See section, Miss. Rep., p. 140.) At a level about forty feet higher, the characteristic soft white sandstone of the Grand Gulf group crops out.

This, however, amounts to mere conjecture; and, *per contra*, toward the sea-coast the lithological transition into the materials of the "Coast pliocene" seems about equally cogent. The mere fact that tree palms are found in the formation, amounts to nothing, inasmuch as these grow at the present time in the same latitude in South Carolina.

The existence of this formation in Alabama appears from Mr. Thornton's notes (2d Rep. Ala., Appendix), in which he mentions similar materials as overlying the (Vicksburg) marine Tertiary at its southern limits. Moreover, Bigelow (this Jour., ii, 419) describes a sandstone formation in Baldwin county, Ala., which impresses me as though it might be Grand Gulf sandstone overlaid by the ferruginous sandstone with tubes, of the Orange Sand group (Miss. Rep., p. 9), "filled with variously colored sand." Bigelow states that in the lowest portion of this rock he has seen obscure impressions of shells; which, if my conjecture be correct, might offer an opportunity of determining the age of the group. The same rock is said to occur at Pensacola.

The "blue clay bottom" of the Coast—"Coast Pleiocene."—Finally, as regards the imperfectly known black clay formation of the coast (Miss. Rep., p. 154, ff.), a comparison of specimens of shells and borings obtained from the New Orleans artesian well,* in 1854, seems to show that it underlies the whole of the delta, perhaps as high up as Port Hudson, whose subterranean Cypress swamps, observed by Carpenter and by Lyell, may belong to this formation. No Eocene fossils have been brought up by the augur, even from the lowest shell-bed found, at the depth of 570 feet, (the greatest depth was 630); while from among the shells of the first bed struck, at 41 feet, I have thus far determined eighteen marine species, all now living in the Gulf. At 153 feet a trunk of cypress, with bark, was found. At 256 feet, some extinct, or if living, undescribed shells seem to occur; and at 480 a Gnathodon bed. I hope to be able to determine by microscopic comparison whether or not the Grand Gulf group has been passed through or reached in this bore, which from present appearances has penetrated both Post-pleiocene and Pleiocene marine deposits. This would parallelize more closely the Tertiary of the Atlantic coast and of the Gulf; though so far as I know, nothing apparently corresponding to the Grand Gulf era has been observed in the former series. Should the chain of the Antilles, after the close of the Eocene epoch have for some time cut off the Gulf of Mexico from the Atlantic, it seems possible that the deposits of the former might have changed their character to the extent required by the facts observed. A strong influx of fresh water—perhaps that pertaining to the Great Lignite era—from the continent might for the time being have extinguished the Eocene marine fauna without replacing it by another sufficiently numerous to be readily detected in the deposits of the period, which might thus correspond to the Atlantic Miocene. Upon the subsequent irruption of the Gulf stream through the Antilles chain, the formation of normal marine deposits along the margin of the Gulf would be resumed.

University of Mississippi, July 26, 1866.

* These specimens were furnished by Drs. Copes and S. S. Riddell, of New Orleans, to Maj. Gen. A. A. Humphreys, and by him referred to me for examination; which, however, is not yet completed.

Art. VI.—*Evidences of the existence of ancient Local Glaciers in the White Mountain Valleys;* by A. S. Packard, Jr., M.D.

The following observations were made during the past autumn in the valleys of the tributaries of the Saco, and Androscoggin rivers. At Jackson, N. H., on Thorn mountain, which lies just south of Tin mountain, there are some well marked glacial scratches which point directly toward Mt. Washington, which stands at the head of the valley of the Ellis river; their course being N. 25° W. These were first noticed on quartz veins running over the ledges which have been polished smooth as porcelain and finely grooved. At other places on the same mountain part way up, and also upon the summit, upon removing the soil, similar striæ occurred running in the same direction. On this mountain and the neighboring hills occurred occasional boulders of a peculiar mica slate, enclosing crystals of staurotide, which had evidently been transported from near the summit of Mount Washington. The summit of Mt. Kearsage we found moulded by ice. Dr. C. T. Jackson in his report on the Geology of New Hampshire states that the drift scratches one half way up Mount Kearsage run N. 30° W. He also states that on Mount Chicorua they run N. 35° W. (S. 35° E.), which is the course of the Ossipee valley just below it.

On a hill just east of Goodrich's falls on the Ellis river are very distinct ice-marks, on polished surfaces, with striæ running N. 30° W., and lunoid furrows with their horns pointing up the valley in the same general direction as the grooves.

Crossing over the mountains into Chatham, and Stowe, Maine, into the valley of the Cold river, another tributary of the Saco, we find another set of striæ. The broad summit of Speckled mountain, opposite Mt. Royce, which two mountains guard the southern entrance of Evans' Notch, is glaciated both on the N.W. and N.E. flanks. Here also is a "col," down which the ice must have moved in both directions. Near the summit the grooves and lunoid furrows run N. 15° E., following the course of the valley at this place, and aiming at a higher peak to the north and east. On Mt. Baldface, 3600 feet high, three or four miles southward, the grooves are very clearly indicated both below and directly upon the summit. Here they run N. 10° W., and it might be mentioned that the Cold river valley turns more to the southeast at this point. On a shoulder of the mountain, perhaps 300 feet below the summit, the lunoid furrows are especially abundant.

On the summit of this mountain, which is made up of a light colored fine syenite, were a few boulders of a peculiar porphyritic syenite, with oblong crystals of albite. Following the N. 10° W. course, less than a quarter of a mile, we traced them to the parent rock composing Peaked mountain, which is somewhat lower than Baldface, at least 100 feet.

Again, crossing the high range of mountains over into Gilead in the Androscoggin valley, glacial marks directed N.W. occurred on a high ledge near the river, indicating that the ice moved from the northwest, pursuing the general course of the valley at this point.

Here, then, are good proofs of distinct systems of glaciers radiating from a central *mer de glace* which capped the White mountains. This dome of ice must, so far as our slight observations show, have been soon subdivided into local glaciers which pursued their route down the different valleys to the sea. Thus following down the Androscoggin river, at Lewiston, the ice-marks run nearly north and south, the course of the valley at that place, as we are informed by Mr. G. J. Varney of that town; and at Brunswick, on the seashore, there are deep furrows running in a N.W. direction, being the ancient course of the river where it undoubtedly entered the sea, up to a late period of the Terrace epoch.

ART. VII.—*Experiments on the Electro-motive Force and the Resistance of a Galvanic Circuit;* by HERMANN HAUG.

[Concluded from vol. xlii, p. 389.]

NATURALLY I first inquired whether or not the experiments of other observers would exhibit peculiarities of a similar character. I am not fortunate enough now to have a great choice of material at hand. But the experiments of J. Müller, cited on page 384, with six cells of Daniell's, if every possible combination of two different intensities is calculated, show decidedly a similar great increase of the internal resistance with the decrease of the combined intensities, viz:

For cell	No. 1,	from	2·85	to	5·19
"	" 2	"	3·41	"	4·76
"	" 3	"	3·02	"	4·07
"	" 4	"	3·19	"	4·07
"	" 5	"	3·08	"	4·73
"	" 6	"	3·68	"	4·19

As I have every reason to believe that in these experiments the circuit was really opened every time a greater resistance was to be introduced, I considered this circumstance, or the reverse, as not of any great account, and tried to determine at least the general character of its influence upon the results of all the other circumstances which may be regarded as important.

With this object in view, I preferred to exchange the nitric acid for a properly acidulated solution of bichromate of potash, since a battery with this liquid, after having been used for some time, possesses much less reliability as regards constancy than the Bunsen battery. The results of this series of experiments are recorded in table VI. They are very irregular, from errors of observation, and from what are called the fluctuations of the electro-motive force. For every external resistance two mean values of the internal resistance are calculated, one from the first half, the other from the second half of the single observations. These mean values are:

For centim. of platinum in the circuit.	First mean value.	Second mean value.	For centim. of platinum in the circuit.	First mean value.	Second mean value.
2	25·69	25·00	30	37·33	34·37
4	36·5	28·42	40	34·72	36·09
6	33·34	31·08	60	41·37	39·76
8	33·44	31·69	120	41·85	39·57
10	31·36	31·75	200	41·54	40·09
20	35·27	34·66			

In nine out of eleven cases the mean values of the first observations are greater than the mean values of the last observations. From this fact I thought myself warranted to believe that all those circumstances together which may be considered as influential upon the results, generally tend to diminish the ratio of increase, or at least, that in my experiments they would not increase this ratio. I therefore considered the results of my experiments reliable enough, as far as the fact of the great increase of internal resistance was concerned, and I changed only the manner of determining the intensity by observing the deflections of the swinging needle, both ways, and taking the mean, instead of waiting for the resting of the needle. In this way I made two series of observations, the results of which are given in tables VII and VIII. The battery was Bunsen's, the acids having been used once before.

Since the heating of the thin platinum wire of the reochord prevented me from observing higher intensities (those above tan. = 0·6), and calculating upon them, and since I was aware that the influence of temperature upon the resistance of conductors would probably be, and has been, considered as sufficient to explain the increase of internal resistance, as proceeding from the common method of calculation, I prepared myself a rather imperfect reochord with copper wire, because this metal becomes heated but very little, and would afford me to compare the results of very different intensities. Table VII contains the results of experiments with this copper wire rheochord. All resistances are expressed in centimeters of this copper wire. Experiments of table VIII are made with the platinum wire rheochord, besides which the circuit constantly contained 200 centimeters of thin copper wire. As to the calculation of the internal resistance I have to make the following statements.

The vertical columns (a) of both tables exhibit this resistance when calculated after the common rule, viz: combining the direct intensity with every lower intensity.

In table VII, the column (a) gives an increase of internal resistance, if only the mean values of the first, and last, five observations are taken, from 103·95 to 128·51, or from 1 to 1·24. In table VIII, the corresponding column (a) gives, from the first and last, three values, an increase from 6·5 to 10·55, or from 1 to 1·61. For the whole range of intensities, between the limits 1·982 and 0·7844, the increase of resistance therefore is as 1 to 1·24×1·61, or as 1 to 1·996. The two centimeters of platinum wire were far from being red hot, yet it is difficult to decide, whether or not, this increase can be explained simply by the influence of temperature, the latter not being determined. I thus failed to get a direct proof that the increase of internal resistance, as visible after this way of calculation, is decidedly greater than the temperature of the measuring wire could account for.

But thinking the matter over I found why this way of calculation is wrong. The first direct observation belongs to a circuit, with high intensity, and where there is no part of it heated considerably. With this observation there are to be combined, first, the observation of an intensity somewhat lower, but the measuring part of the circuit heated very much; second, the observation of a low intensity within a circuit heated but very little. It seems evident both as regards the influence of temperature, and as regards the supposed influence of the intensity of the current, upon the internal resistance, that in this way matters become rather mixed up, and mean results are arrived at, instead of the extreme values sought after. To study the influence of temperature, of intensity of the current, upon the internal resistance, requires therefore to combine with each other, first, two observations of high intensities in circuits, with the measuring unit of resistance heated considerably; and second, two observations of low intensities at which this unit of resistance is heated but very little. Estimating then the ratio of increase, due to the difference of temperature of the unit of resistance, the quotient of it into the actual ratio of increase will give the ratio of increase of the internal resistance, due to the difference of intensity of the current. Of course, it would be much better to provide means for keeping the unit of resistance at constant temperature, but I refer to the method of determining the constants of the battery as commonly practiced.

In order to eliminate as much as possible, the errors of observation I preferred to calculate upon the combination of every two intensities. The results are contained in the vertical columns to the right of columns (*a*), of tables VII and VIII. In table VII, I further calculated the mean of the last five values of each vertical column from (*a*) to (*b*); and the mean value of all the other figures. The table shows unmistakably a general and great increase of the internal resistance with decrease of observed intensities. Comparing now the mean of the first five values of column (*a*), not with the mean of column (*b*) which may be too high, but with the mean of all the last figures, which is still less than the mean of 171·6 and 198·9; we get a ratio of increase of from 103·91 to 183·6; or 1 to 1·77; and this for a reduction of intensity from 1·982 to ·7844, or from 2·53 to 1; and for a reduction of temperature of the unit of copper wire which I should not think at all sufficient to explain that ratio.

In table VIII, calculated in the same way, the mean values at the foot of it embrace only the last three figures of each column. Comparing here the mean of the first three figures of column (*a*) with the mean of the last two mean values, viz: $\frac{15{\cdot}81+18{\cdot}35}{2}=17{\cdot}08$, in order to avoid any overrating, we get an increase of from 6·5 to 17·08, or from 1 to 2·63, which again cannot be accounted for solely by the difference of temperature of the unit of resistance. This ratio is therefore partly due to the ratio of decrease of intensity of the current which amounts to $\frac{\cdot 7844}{\cdot 091}$, equal 8·62 to 1.

In table VII, with the copper wire rheochord, a reduction of intensity to $\frac{1}{2{\cdot}53}$, and of temperature of the rheochord wire to an unknown extent, are attended with an increase of internal resistance from 1 to 1·77. In table VIII, with the platinum wire rheochord, a reduction of intensity to $\frac{1}{8{\cdot}62}$, and of temperature of the rheochord wire to an extent much greater, I have no doubt, than in case of the copper wire, is followed by an increase of internal resistance not more than from 1 to 2·63, being less, in proportion, than in case of table VII. It therefore seems that the increase of internal resistance, as proceeding from difference of intensities, is greater at high intensities than at low intensities of the current. And combining now the results of both tables, we find an increase of internal resistance from 1 to $1{\cdot}77\times 2{\cdot}63$, or from 1 to 4·655, this increase being due first to the reduction of intensity from 1·982 to ·091, and second to the difference of temperature of the unit of resistance, which however could not produce half that ratio, I should think.

In computing these figures I made use of the values of columns (*a*), after having raised objections against them. But it seems to me that I thereby did not unduly increase the results, attributing them as I do to the full difference of intensities, and to the difference of temperature as proceeding from the second intensity and the lowest. Considering this circumstance as chiefly affecting the results of columns (*a*), it appears also evident that the increase of resistance within this column is not so much the result of difference of temperature, as of difference of intensity, since the influence of intensity starts from 1·982 in table VII, and 0·7844 in table VIII, while the influence of temperature starts in correspondence with intensity 1·8008 in table VII, and 0·6063 in table VIII.

There is another circumstance connected with table VIII, the experiments having been made with a circuit containing constantly 200 centimeters of thin copper wire, as an addition to the internal resistance. If the resistance of this copper wire, and the true internal resistance are calculated separately, by means of combining the two first intensities with each of the following ones, there result values contained in columns (Cu) and (R). Both of them show the same ratio of increase as column (*a*), confirming the fact as exhibited in table V. Thus far, the addition of the 200 centimeters of copper wire to the internal resistance proper, does not seem to modify the ratio of increase.

The experiments for tables VII and VIII, still were rather unsatisfactory, showing too great irregularities. To avoid them, if possible, and with a view to get a clue to the understanding of the matter, I undertook another series of experiments, with as much care as I could afford, and the instruments at my command would allow. I made four pairs of observations, two for each end of the swinging needle alternately, and took the mean value of them. The battery was a Bunsen's; the diluted sulphuric acid containing rather much sulphate of zinc, and the nitric acid having been used for a short time. Using such acids my object was plainly to get results about facts of ordinary occurrence. I tried the battery first without any unnecessary addition of other resistances than the platinum rheochord, and afterwards with an addition of 25, 50, 100, 150, 200 centimeters of thin copper wire. The results of these observations, calculated in the same way as explained for tables VII and VIII, are recorded in tables IX to XIV. I did not succeed, the results remaining irregular, probably partly from constant faults of the instruments, and of the location of the tangent compass within about 15 feet distance from an iron stove, and within about five feet distance from about five pounds of iron which could not be removed. I therefore had to content myself with these results, and to use them with caution.

In table IX, the mean of the first three values of column (*a*) is 3·21; the mean of the last three values of the same column is 6·34. The increase is in the ratio of 1 to 1·975. Leaving out the value of column (*b*), as too low, but taking the mean of the six mean values to the left of column (*b*), from 17·31 to 23·03 there being three small and three large values, we get an increase of internal resistance from 3·21 to 18·51, or from 1 to 5·77. This increase is due to the reduction of intensity from 1·3422 to 0·0581, and to the reduction of temperature of the unit of resistance, from dark red heat of the 6 cm. of platinum wire, to about the temperature of the air.

It may be well to examine with some detail this series of observations. The battery was in such a state that the direct intensity decreased rapidly during the short time necessary for 4 pairs of observations of the needle. The intensity with any length of platinum wire in the circuit, was variable too, becoming diminished with short length, and increased with great length of the wire. The examination of the following figures will give an idea of the amount of this variation of intensity. They are the mean values for the first, respectively for the second two pairs of observations:

Cent. of plat. wire in the circuit.	Intensities. First.	Intensities. Later.	Cent. of plát. wire in the circuit.	Intensities. First.	Intensities. Later.
0	1·5039	1·3605	50	·1437	·1441
6	·4679	·4665	60	·1267	·1259
8	·4119	·4097	70	·1118	·1130
10	·3721	·3729	80	·1000	·1016
12	·3402	·3424	90	·0898	·0919
14	·3177	·3153	100	·0814	·0840
16	·2929	·2934	110	·0748	·0774
18	·2762	·2783	120	·0705	·0726
20	·2594	·2596	130	·0652	·0677
30	·2052	·2048	140	·0608	·0634
40	·1674	·1700	150	·0567	·0585

Owing to this change of intensity, it would be necessary to calculate upon the first observations rather than upon any later ones, or upon some mean values. If I do so, I get in column (*a*), 3·01 and 5·89 as mean values, with an increase from 1 to 1·957; instead of the above values 3·21 and 6·34, with an increase from 1 to 1·975. The true ratio of increase is therefore somewhat less than calculated from the table, and this holds good for the whole ratio of increase.

On the other hand, if the decrease of intensity with the time, is mainly to be assigned, as probably will be maintained, to some polarization having taken place, which, from the high direct intensity to the next with 6 cm. of platinum wire in the circuit, will be kept for some time near its maximum; then the intensity with 6 cm. of rheochord wire is lower than it would be, had the circuit not been closed, directly and constantly, previous to the observation with 6 cm. of platinum wire, since this low intensity cannot possibly produce the maximum of polarization. Assuming therefore the intensities with 6, 8 and 10 cm. of platinum wire too low, the mean value in column (*a*) would become yet smaller than 3·01, and the ratio of increase of resistance therefore greater than 1·957, if not greater than 1·975. And this again holds good for the whole ratio of increase.

Considering all these circumstances, I think that my discussion of the combined results, from table VI, is not much at variance with the truth, and that my figures do not exaggerate the facts in any high degree.

There is an other point to be considered. The decrease of intensity with 6, 8 and 10 cm. of rheochord wire in the circuit amounts to a mean of 0·0013. When the circuit is closed directly, this decrease of intensity, for about the same time, amounts to 0·1434, that is, to many times more than the difference of intensities amounts to. The intensity 1·5039 within the circuit closed directly, is the mean value of two pairs of observations, one for each end of the needle, being respectively 1·5845 and 1·4233, with a decrease of 0·1612. This rapid decrease of intensity would justify starting the calculation of column (*a*) from the direct intensity 1·5845 instead of from any later intensity, or from any mean value. If I do so, and compare this intensity with the first intensities given above, the mean values for the first and for the last three figures of column (*a*) become 2·80, respectively 5·58, the ratio of increase being 1·993 against 1·975 from the table. And the whole ratio of increase of resistance would become $\frac{3 \cdot 21}{2 \cdot 80} = 1 \cdot 1465$ times greater than was resulting from the table. This increase, due to the greater direct intensity started from, exemplifies however the intensive degree of influence of the intensity of the current upon the internal resistance, as compared with the influence of the temperature of the unit of resistance.

I suppose, after all, that one may possibly consider the great ratio of increase of internal resistance as figured from table IX, to be the consequence, to a great extent of polarization to which any inconstancy of a battery is usually assigned, and the battery was in fact rather inconstant. But apart from my above reasoning to the contrary, I can refer to table I, the experiments for this table having been made with a battery the acids of which had been used for but a very short time. The degree of constancy of this battery may be judged from the fact that the compass needle was at 60·8° at the beginning of the experiments and at 60·2° one hour later, during which time the battery had been in use, except for very few minutes. Now, if I combine the intensities for several great resistances in the circuit, and take the mean of three consecutive values, I get 15·65, 19·46, 24·97, 17·92, as internal resistances. The mean value of all of them is 19·5, and the internal resistance as calculated from the direct intensity, and that with 8 cm. of platinum wire in the circuit, being 3·48, there results an increase from 1 to 5·604, without the platinum being red hot, against 5·77 of table IX, with the platinum wire red hot indeed. At any rate the polarization cannot play a great part in the results of my experiments.

Comparing the results of tables IX to XIV, I get from the mean values the following

Table of ratio of increase of Internal Resistance, with constant addition of different lengths of copper wire in the circuit.

Length of copper wire in the circuit.	Resistances of columns (*a*) Lowest.	Higher.	Ratio of increase.	Mean highest resistances.	Total ratio of increase.
0	3·21	6·34	1·975	18·51	5·77
25 cm.	3·88	7·77	2·003*	20·17	5·20
50 "	4·33	8·49	1·961	20·67	4·77
100 "	5·02	9·79	1·95	21·30	4·24
150 "	6·61	11·66	1·764	22·24	3·36
200 "	7·65	12·94	1·691	23·44	3·06

The table illustrates the dependence of the ratio of increase on the manner the directly closed circuit is built up, on the greater or less intimacy of the contact, etc.

In tables X to XIV, column (Cu) contains the resistances of the respective lengths of copper wire. The increase of resistance maintains the same ratio as in the respective columns (*a*). Using mean values, I derive, from comparing all five tables, the following results.

Length of copper wire.	Resistance at high intensity.	Respective resistance of 25 cm. length	Resistance at low intensity.	Respective resistance of 25 cm length.
25 cm.	·50	·50	·993	·993
50 "	·85	·425	1·666	·833
100 "	1·66	·415	3·237	·809
150 "	2·76	·46	4·877	·813
200 "	3·62	·452	6·12	·765

The resistance of 25 cm. of copper wire, expressed in centimeters of platinum wire, at high intensity, is rather irregular, the first value in particular being too great. It is, however, in agreement with all other facts, safe to say that the resistance of a given length of copper wire, or the specific resistance, appears the greater the longer the measured wire is. This is contrary to what may be expected from the different influence of temperature upon the resistances of copper and platinum, exemplifying again the supposition that there is some other reason for the increase of resistance in columns (*a*), overruling the influence of difference of temperature. At low intensities, the specific re-

* The observation with 25 cm. of copper and 4 cm. of platinum wire in the circuit, gives a ratio of increase comparatively too great, on account of this length of platinum wire having been hotter than in any other case.

sistance of the copper is actually decreasing with the length of the measured wire, and this seems to indicate that at low intensities, the influence of temperature upon the resistance of conductors prevails over any other reason which, in a galvanic battery, and with this method of determination and calculation, may modify the resistances, actually or apparently.

It was desirable to determine the resistance of the copper wire at low intensities, without any interference on the part of high intensities. The last observation of each of the tables XII to XIV, each with 100 cm. of platinum but with no copper wire in the circuit, enabled me to do so. From

$$I_1=\frac{E}{W+C+P_1};\ I_2=\frac{E}{W+C+P_2}\ \text{and}\ I_3=\frac{E}{W+P_3},\ \text{there follows}$$

$$C=\frac{P_3I_3(I_1-I_2)-P_2I_2(I_1-I_3)+P_1I_1(I_2-I_3)}{I_3(I_1-I_2)}.$$

Putting $I_1=0{\cdot}1900$, $P_1=30$; $I_3=0{\cdot}0832$, $P_3=100$, and afterwards
" $=0{\cdot}1580$, " $=40$; " = " " = " all from table XII, and combining them successively with each of the observations with from 50 to 100 cm. of platinum, and 100 cm. of copper wire in the circuit, as per table XII; and further calculating, after the same manner, with the corresponding figures of tables XIII and XIV, there result, as the mean values from 12 single ones, the following resistances:

Length of copper wire.	Resistance.	Resistance of 25 cm. length.
100	4·465	1·116
150	5·128	0·855
200	5·125	0·641

It becomes here more evident that at low intensities the specific resistance of the copper wire appears to increase with the intensity, respectively with the temperature produced by it.

Of course the above figures cannot be compared with those given on page 50, since the latter values were derived from the highest direct intensity. In order to connect the results of both calculations, I combined first, the intensities 0·8865 and 0·0832, and afterwards the intensities 0·373 and 0·0832, with each of the six observations before the last, all of table XII. The values resulting therefrom, in columns 1 and 2 of the following table, com-

1.	2.	3.	4.
12·3	7·74	4·84	3·53
9·74	6·62	4·73	4·19
7·13	5·02	3·66	3·25
6·35	5·81	5·27	5·19
5·08	4·73	4·53	4·49
4·49	4·78	4·93	4·95
	Mean,	4·66	4·27

pared with those in columns 3 and 4, which the above mean value (4·465) is derived from, go again to show a general decrease of resistance of the copper wire with decrease of observed intensities, the last horizontal row of figures making the only exception, if one and the same low intensity is considered. The values in columns 3 and 4, do not decrease, on account of errors of observations, I suppose. If calculated for table XIII, column 3 is decreasing, column 4 increasing. If calculated for table XIV, both columns 3 and 4 are decreasing, from the mean of the first three values to the mean of the last three.

It seems to me that the facts here illustrated, give a new reason for the great difference of the specific resistances of conductors, as derived by different observers from experiments, under conditions much varying and either partly unknown, or at least underrated in their influence. From observations of Davy, Becquerel, Ohm, Christie, Lenz, Pouillet, Buff, Frick, Müller, Lamy, Arndtsen, Matthiessen and Wiedemann, as recorded in G. Wiedemann's Galvanism, 1863, I extract the following table of the extreme values of the conducting power of different metals, for which the conducting power of silver is taken as 100. The values vary

For copper	between the limits			65·8	and	280·9,	ratio	1	to	4·27
" gold	"	"	"	55·2	"	161·8,	"	1	"	2·93
" zinc	"	"	"	24·06	"	93·6,	"	1	"	3·88
" tin	"	"	"	11·45	"	47·2,	"	1	"	4·12
" iron	"	"	"	12·35	"	48·9,	"	1	"	3·96
" platinum	"	"	"	7·93	"	48·0,	"	1	"	6·05
" lead	"	"	"	7·77	"	63·3,	"	1	"	8·15
" antimony	"	"	"	4·29	"	6·5,	"	1	"	1·51
" mercury	"	"	"	1·63	"	4·62,	"	1	"	2·83
" bismuth	"	"	"	1·19	"	1·9,	"	1	"	1·6

While the method of calculation of columns (Cu), (R) and (*a*), of tables X to XIV, gave the appearance of the ratio of increase being equal for the whole amount, and every part, of the so-called internal resistance, the copper wire included, the above computations show that, for low intensities, the copper wire follows its own rate of increase, or rather decrease, leaving indeed, as was to be expected, the full amount of increase with the true internal resistance, viz., within the liquids of the battery. In table XII, the mean of the first three values of the true internal resistance, in column (R), is 3·66. The same true internal resistance at low intensities, may be calculated either by the formula

$$(R)=\frac{(P_2-P_1)I_1I_2-P_3I_3(I_1-I_2)}{I_3(I_1-I_2)},$$

with the same observations, (Cu) has been calculated, as per page 51; or, the values for (Cu) computed there, and specified in columns 3 and 4, on page 51, may simply be deducted from the corresponding mean values of the whole internal resistance of table

XII. Thus we get (R) at low intensities, equal 20·90−4·66=16·24; and equal 21·99−4·27=17·72; with a mean of 16·98. From 3·66 to 16·98, the increase is as 1 to 4·64; while the increase of the full internal resistance, the copper wire included, is only from 5·02 to 21·445, or from 1 to 4·27, for the corresponding values of table XII. Here again the influence of the introduction of 100 cm. of copper wire appears as reducing the true amount of increase of resistance, and it seems safe to recognize this increase as residing mainly if not entirely, within the liquids. The contrary result exhibited in columns (Cu), (R) and (a), is therefore due exclusively to the method of calculation.

My series of experiments, most of them, show the values for the internal resistance, after the general great increase, to decrease for the lowest intensities. This becomes more visible from a graphical representation of the course of the internal resistance. This circumstance may partly depend on constant faults of the observations of small deflections of the compass needle. But it seems certainly to depend partly on the circuit being formed with copper conductors. The influence of the intensity upon the internal resistance, appears to become constant at low intensities. Any further variation of the internal resistance will then be due to the influence of temperature upon the liquids on one side, and upon the copper conductors on the other side. Now, as the resistance of the copper increases with the temperature, from 3 to 4 times more than the resistance of the liquids decreases, their combined result may produce a reduction of the internal resistance, to some extent, with further decrease of intensity.

On page 388 I ought to have mentioned the so-called "Uebergangswiderstand," or resistance to passage from solids into liquids, as one of those circumstances which may influence, or bring forth the results of my experiments. However, from what I could learn about this kind of resistance, I at first could not make much of it. Fechner represented it as in direct proportion with the intensity of the current (see G. Wiedermann's Galvanismus, vol. i, page 449, which, however, is contradicted by De la Rive's Treatise, vol. ii, page 402). Such relation would not harmonize at all with my experiments. Poggendorff found the reverse to be the case; but the idea of such resistance was generally discountenanced, and the polarization was considered as sufficient to explain the whole matter, in most cases. To be sure, the existence of such resistance in other cases was acknowledged, and Neumann and Wild gave methods to determine it. Experimenting with a Daniell's battery, Neumann found the increase of this peculiar resistance to be in direct proportion with the intensity of the current. But I could not form any idea about the amount of this resistance compared with the common resistance of the liquids, since I had at hand nothing but a meager report about those experiments. Besides this, the figures given by Neumann were then (1857) not free from doubt as to their being increased on account of a possible neglect of a part of the polarization.

Apart from all these doubts, I have to confess it, the indiscriminate use of the formula E=IR was the chief reason of my neglecting the resistance to passage, "Uebergangswiderstand," since the electro-motive force of the battery seemed to increase in the same ratio as the internal resistance, and did so indeed if calculated from column (*a*), after the common method. Later, guided by the fact of the resistance of the copper wire, if calculated from low intensities, following its own course, and by the evident inconsistency of combining intensities widely differing from each other, I proposed to calculate the electro-motive force not with the direct intensity, but with those intensities every higher resistance is derived from. Taking table XII, as a specimen, there result from the first and last resistances of 14 columns, the following values for the electro-motive force:

(*a*)													
4·37													
4·31	3·86												
4·60		5·66											
			7·37										
				7·05									
					6·96								
						9·66							
							7·82						
								8·30					
									9·03				
										9·21			
											9·38		
												9·92	
													9·69
8·77	8·95	9·16	9·29	9·34	9·41	9·48	9·48	9·53	9·56	9·58	9·63	9·67	9·62

The mean of the first three values of column (*a*) is 4·42; the mean of the last six values is 9·67, the ratio of increase therefore equal 1 to 2·133. I could not venture to determine, without knowing exactly the influence of temperature, whether or not, this increase of electro-motive force is due, partly, or exclusively, to this influence of temperature upon the resistance of the unit of the rheochord, or to a loss of electro-motive force, which I suppose to occur at high intensities. But I expect that a closer investigation of the matter will support my views about this point.

With the foregoing examination of the electro-motive force, I hope again to have thrown some new light upon the reason of differences between the values of the electro-motive force of a battery, as given by different experimenters, or derived from different methods. The variations are here not so great as in case of the specific resistances; the electro-motive force of the Grove battery for instance, varying from 167 (Poggendorff's lowest figure) to 192 Lenz and Saweljev), when the force of Daniell's battery is taken as 100. The reason for this small amount of variation however seems to be obvious. There are less observations recorded as in the other case, and perhaps mainly such results which were considered as "reliable," thus excluding extreme values which, under certain circumstances are liable to turn up.

If I take from the above table, 9·67 as an approximation to the true electro-motive force of the battery, the internal resistance of the battery, at common temperatures, would result as $\frac{9{\cdot}67}{0{\cdot}8865}=10{\cdot}9$, and the internal resistance would appear to increase from 10·9 to 21·30, or from 1 to 1·954, and this from some other reason than the influence of temperature upon the measuring rheochord wire. These figures however cannot convey a true idea of the relative importance of the temperature on one side, and of all the other reasons, if there exist more, for the increase of electro-motive force, and internal and external resistance, on the other side, since the simple formula of Ohm does not detail what is constant, and what undergoes variations in different degrees.

What this reason is I am still at a loss to know. I hold that it is not polarization. It seems very probable that the resistance to passage, "Uebergangswiderstand," will furnish the key to the results of my experiments. But it will require other experiments quite differently arranged and detailed to settle this question. I think it will no longer do to use Ohm's simple formula, and to permit the intensity of the current, and the temperature produced by it, to influence the determinations of electro-motive forces and resistances, to an unknown extent, and varying widely according to uncontrolled circumstances.

Table VI.

Battery, zinc in diluted sulphuric acid; gas coke in properly acidulated solution of bichromate of potash. Both liquids had been used once before.

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.	Overall mean	Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.	Overall mean
0	23°	·4245	....			0	20·9	·3819	....		
2	20·6	·3759	15·47 / 41·76	28·61		2	19·4	·3521	23·63 / 27·29	25·46	
0	21·5	·3939	....			0	20·7	·3779	....		
2	19·6	·3561	14·9 / 22·39	18·65	25·69	2	19·1	·3462	21·84 / 29·21	25·52	25·00
0	21·2	·3879	....			0	20·3	·3699	....		
2	20·1	·3660	33·42 / 26·24	29·83		2	18·9	·3424	24·90 / 23·14	24·02	
0	21·5	·3939	....			0	20·4	·3720	....		
2	19·4	·3521	16·85 / 23·63	20·24							

Table VI (continued).

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.	
0	20·4°	·3720	....		
4	18·6	·3365	37·91 / 42·73	40·32	
0	20·2	·3680	....		36·5
4	18·2	·3287	33·45 / 31·91	32·68	
0	20·3	·3699	....		
4	18·2	·3287	31·91 / 35·25	33·58	
0	19·8°	·3600	....		
6	17	·3057	33·78 / 35·00	34·39	
0	19·7	·3581	....		33·34
6	16·8	·3020	32·30 / 32·30	32·30	
0	19·7	·3581	....		
6	16·3	·2925	26·75 / 28·49	27·62	
0	19°	·3443	....		
8	15·8	·2830	36·93 / 36·93	36·93	
0	19	·3443	....		
8	15·7	·2811	32·42 / 28·86	30·64	33·44
0	19·4	·3521	....		
8	15·8	·2830	32·76 / 32·76	32·76	
0	19·4	·3521	....		
0	18·6°	·3365	....		
10	14·4	·2567	32·17 / 29·30	30·73	
0	19	·3443	....		31·36
10	14·7	·2623	32·0 / 32·0	32·0	
0	19	·3443	....		
10	14·7	·2623	32·0 / 33·54	32·77	
0	18·6°	·3365	....		
20	12·1	·2145	35·16 / 36·7	35·97	
0	18·3	·3308	....		35·27
20	11·8	·2089	34·27 / 34·87	34·57	
0	18·2	·3287	....		
20	11·6	·2054	33·32 / 35·50	34·41	

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.	
0	20·1	·3660	....		
4	17·7	·3191	27·21 / 26·10	26·65	
0	20·2	·3680	....		28·42
4	17·8	·3211	27·38 / 33·02	30·20	
0	19·8	·3600	....		
0	19·5°	·3541	....		
6	16·5	·2962	30·69 / 29·67	30·18	
0	19·6	·3561	....		31·08
6	16·6	·2981	30·84 / 33·12	31·98	
0	19·4	·3521	....		
8	15·6°	·2792	30·64 / 26·43	33·54	
0	18·8	·3405	....		
8	15	·2679	29·25 / 28·05	28·65	31·69
0	19	·3443	...		
8	15·3	·2736	30·96 / 34·79	32·87	
0	18·6	·3365	....		
0	18·8°	·3405	....		
10	14·6	·2605	32·56 / 31·09	31·82	
0	19	·3443	....		31·75
10	14·5	·2586	30·17 / 33·19	31·68	
0	18·6	·3365	....		
0	17·8°	·3211	....		
20	11·6	·2054	35·50 / 34·38	34·94	
0	18	·3249	....		34·66
20	11·6	·2054	34·38 / 34·38	34·38	
0	18	·3249	....		

TABLE VI (continued).

Rheo-chord.	Com-pass.	Tan-gent.	Int. resist.	Mean values of int. resistance.	
0	18°	·3249	....		
30	10	·1763	35·59 / 34·23	34·91	37·33
0	18·3	·3308	....		
30	10·3	·1817	39·24 / 40·25	39·75	
0	18·1	·3268	....		
30	10·1	·1781	35·93 / 35·48	35·71	

Rheo-chord.	Com-pass.	Tan-gent.	Int. resist.	Mean values of int. resistance.	
0	18·2°	·3287	....		
30	9·85	·1736	33·58 / 35·79	34·68	34·37
0	17·7	·3191	....		
30	9·6	·1727	35·32 / 33·21	34·26	
0	18·2	·3287	....		

Rheo-chord.	Com-pass.	Tan-gent.	Int. resist.	Mean values of int. resistance.	
0	18·2°	·3287	....		
40	8·7	·1520	34·41 / 35·96	35·18	34·72
0	17·8	·3211	....		
40	8·4	·1477	34·07 / 34·47	34·27	
0	17·7	·3191	....		
40	8·6	·1513	36·96 / 37·33	37·15	36·09
0	17·4	·3134	....		
40	8·3	·1459	34·84 / 35·24	35·04	
0	17·3	·3115	....		

Rheo-chord.	Com-pass.	Tan-gent.	Int. resist.	Mean values of int. resistance.	
60	7·4°	·1329	44·64 / 44·64	44·64	41·37
0	17·3	·3115	....		
60	6·9	·1210	38·11 / —	38·11	
0*	16·4	·2943	....		
60	7·0	·1228	42·96 / 43·42	43·19	
0	16·3	·2925	....		
60	6·8	·1192	41·27 / 41·27	41·27	39·76
0	16·3	·2925	....		
60	6·5	·1139	38·26 / 38·26	38·26	
0	16·3	·2925	....		

Rheo-chord.	Com-pass.	Tan-gent.	Int. resist.	Mean values of int. resistance.	
0	16·3°	·2925	....		
120	4·3	·0752	41·53 / 41·19	41·36	41·85
0	16·4	·2943	....		
120	4·4	·0770	42·52 / 42·15	42·34	
0	16·5	·2962	....		
120	4·3	·0752	40·83 / 42·29	41·56	

Rheo-chord.	Com-pass.	Tan-gent.	Int. resist.	Mean values of int. resistance.	
0	16·1°	·2886	....		
120	4·1	·0716	39·59 / 39·95	39·77	39·57
0	16	·2867	....		
120	4	·0699	38·69 / 40·08	39·38	
0	15·6	·2792	....		

Rheo-chord.	Com-pass.	Tan-gent.	Int. resist.	Mean values of int. resistance.	
0	15·6°	·2792	....		
200	2·8	·0489	42·47 / 39·47	40·97	41·54
0	15·8	·2830	....		
200	2·8	·0489	41·78 / 42·47	42·12	
0	15·6	·2792	....		
200	2·7	·0472	40·69 / 41·48	41·08	

Rheo-chord.	Com-pass.	Tan-gent.	Int. resist.	Mean values of int. resistance.	
0	15·8°	·2830	....		
200	2·7	·0472	40·03 / 41·69	40·86	40·09
0	15·3	·2736	....		
200	2·6	·0454	39·79 / 38·84	39·32	
0	15·6	·2792	....		

* This observation was made after the battery having been open for some time.

Table VII. *Internal resistance.*

Rheochord.	Tangent.	(a)															(b)				
0	1·9820	....																			
10	1·8008	99·38	....																		
20	1·6689	106·60	116·52	....																	
30	1·5225	93·41	99·41	84·	....																
40	1·4455	107·77	112·05	109·41	157·73	....															
50	1·3484	106·41	109·22	106·21	124·9	98·87	....														
60	1·2955	113·23	118·19	118·8	141·2	132·6	194·9	....													
70	1·2442	118·04	124·1	126·5	148·8	145·4	188·8	182·5	....												
80	1·1659	114·29	118·5	119·0	133·5	126·9	141·6	120·0	78·9	....											
90	1·1185	116·58	121·3	122·2	136·0	131·0	144·6	129·6	107·9	156·0	....										
100	1·0767	118·93	123·8	125·4	139·0	135·2	148·1	136·9	122·8	161·4	167·6	....									
110	1·0303	119·08	123·7	125·2	137·4	133·7	144·3	134·2	122·7	147·9	143·6	122·0	....								
120	·9939	120·70	125·5	127·2	139·2	136·1	146·2	137·7	128·5	151·1	149·3	140·1	163·0	....							
130	·9593	121·94	126·8	128·7	140·3	137·5	147·2	139·7	132·0	152·1	151·0	145·1	160·2	157·2	....						
140	·9320	124·27	129·4	131·7	143·6	141·5	151·4	145·1	138·9	159·0	159·9	157·6	174·4	181·1	211·3	....					
150	·8989	124·49	129·5	131.8	143·0	140·9	149·9	144·0	138·2	155·6	155·6	152·8	163·6	163·8	167·6	131·5	....				
160	·8773	127·06	132·5	135·1	146·7	145·2	154·8	149·8	145·2	163·2	164·6	164·0	176·6	181·0	190·7	180·7	256·1	....			
170	·8472	126·91	132·1	134·6	145·5	144·1	153·5	147·8	143·4	159·2	159·8	158·4	167·6	168·8	172·5	159·7	177·7	121·4	....		
180	·8260	128·61	134·0	136·8	147·8	145·0	155·5	151·1	147·2	163·0	164·1	163·5	173·0	175·1	179·8	171·7	189·9	162·0	219·6	....	
190	·8014	128·97	134·3	137·0	147·8	146·6	155·1	150·8	147·1	161·8	162·7	161·9	170·0	171·4	174·5	166·8	178·7	156·7	179·8	145·6	....
200	·7844	131·0	136·6	139·6	150·6	149·8	158·5	154·8	151·8	166·7	168·2	168·3	177·1	179·5	183·9	178·8	192·5	177·7	204·7	197·1	271·6
Mean values,		128·51	133·9	136·6	147·7	146·1	155·5	150·5	146·9	162·8	163·9	163·2	172·9	175·2	180·3	171·6	198·9	Mean value of all these figures, 183·6			

Table VIII. (R.+Cu.) *Internal resistance, 200 centimeters of copper wire included.*

Rheochord.	Copper wire.	Tangent.	(Cu.) Resist. of the copper.	(R.) True inter. resistance.	(a)													(b)		
0	0	1·9820																		
0	200	·7844			....															
2	"	·6063	4·13	2·68	6·81	....														
4	"	·4751	3·92	2·43	6·35	5·24	....													
6	"	·4031	3·83	2·51	6·34	5·93	7·20	....												
8*	"	·3585	4·07	2·66	6·73	6·68	8·30	10·08	....											
10*	"	·3310	4·41	2·89	7·30	7·62	9·78	12·36	16·08	....										
12	"	·3042	4·59	3·01	7·60	8·07	10·24	12·45	14·41	12·25	....									
14	"	·2851	4·82	3·17	7·99	8·65	11·00	13·32	15·30	14·84	17·85	....								
16	"	·2614	4·82	3·17	7·99	8·61	10·67	12·44	13·54	12·53	12·43	8·06	....							
18	"	·2493	4·70	3·69	8·39	9·17	11·45	13·45	14·83	14·41	15·24	13·85	25·20	....						
20	"	·2401	5·33	3·49	8·82	9·80	12·35	14·02	16·38	16·41	17·96	18·00	28·62	34·2	....					
30	"	·1911	5·84	3·82	9·66	10·89	13·49	15·63	17·11	17·36	18·41	18·52	22·05	22·77	19·0	....				
40	"	·1575	6·07	3·98	10·05	11·33	13·85	15·80	17·09	17·23	18·06	18·25	20·38	20·61	18·13	16·88	....			
50	"	·1326	6·16	4·03	10·19	11·44	13·81	15·57	16·65	16·73	17·48	17·43	19·00	19·04	17·00	15·33	13·25	....		
60	"	·1158	6·42	4·12	10·54	11·69	14·41	15·76	16·81	16·90	17·50	17·46	19·01	19·03	17·34	16·13	15·54	18·93	....	
70	"	·1033	6·42	4·20	10·62	11·96	14·34	16·05	17·09	17·22	17·82	17·82	19·29	19·34	17·75	17·06	17·17	20·51	22·64	....
80	"	·0910	6·34	4·16	10·50	11·77	14·00	15·57	16·49	16·54	17·02	16·94	19·35	18·14	16·62	15·46	14·73	15·62	13·88	40·0
		Mean values,			10·55	11·81	14·25	15·79	16·80	16·89	17·45	17·41	19·22	18·84	17·24	16·22	15·81	18·35		

* These lengths of the wire were hotter than shorter lengths, on account of conduction. 7·5 cm. length was the hottest, being very dark red.

TABLE IX. *Internal resistance.*

Rheo-chord.	Tan-gent.																					
0	1·4322	(*a*)																(*b*)				
6	·4672	2·91																				
8	·4083	3·19	7·86																			
10	·3730	3·52	9·84	13·13																		
12	·3413	3·76	10·27	12·37	11·53																	
14	·3165	3·97	10·80	12·69	12·41	13·52																
16	·2931	4·12	10·83	12·35	12·01	12·32	11·05															
18	·2772	4·32	11·50	13·14	13·15	13·95	14·21	18·87														
20	·2595	4·43	11·49	12·93	12·86	13·38	13·32	14·89	11·32													
30	·2050	5·01	12·76	14·18	14·40	15·07	15·42	16·58	16·07	17·61												
40	·1687	5·34	13·22	14·53	14·77	15·37	15·68	16·54	16·20	17·16	16·47											
50	·1439	5·59	13·58	14·85	15·12	15·70	16·01	16·48	16·12	16·85	16·18	15·76										
60	·1263	5·80	14 01	15·29	15·60	16·19	16·50	17·31	17·15	17·93	18·14	19·57	24·73									
70	·1124	5·96	14·37	15·55	15·87	16·48	16·84	17·58	17·46	18·20	18·55	19·89	22·98	20·86								
80	·1008	6·06	14·36	15·60	15·92	16·50	16·85	17·55	17·43	18·11	18·37	19·38	21·32	19·06	16·90							
90	·0908	6·09	14·26	15·45	15·74	16·27	16·58	17·21	17·07	17·67	17·70	18·28	19·31	16·73	14·08	10·80						
100	·0827	6·13	14·22	15·36	15·64	16·14	16·42	17·01	16·86	17·42	17·33	17·70	18·34	15·87	13·53	11·38	12·1					
110	·0761	6·17	14·24	15·36	15·63	16·12	16·39	16·96	16·82	17·34	17·23	17·52	18·05	15·80	13·87	12·43	13·54	15·30				
120	·0715	6·31	14·60	15·77	16·09	16·62	16·93	17·55	17·54	18·00	18·20	18·85	19·80	18·28	17·40	17·61	21·14	27·68	45·43			
130	·0664	6·32	14·54	15·69	16·00	16·50	16·79	17·39	17·28	17·82	17·91	18·41	19·16	17·59	16·61	16·51	22·95	22·21	26·91	10·20		
140	·0621	6·35	14·54	15·68	15·97	16·47	16·76	17·33	17·22	17·75	17·80	18·25	18·91	17·38	16·42	16·28	18·19	17·23	23·07	12·13	14·42	
150	·0581	6·34	14·45	15·56	15·83	16·31	16·58	17·12	17·00	17·50	17·46	17·78	18·27	16·67	15·60	15·22	16·60	18·01	19·11	10·09	10·00	5·25
Mean values,		6.34	14·51	15·64	15·93	16·43	16·71	17·28	17·17	17·69	17·72	18·15	18·78	17·31	16·31	16 00	19·25	19·15	23·03	10·81		
														18·51								

TABLE X. (R+Cu.) *Internal resistance, 25 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the cop. per wire.	(R.) True inter. resistance.	(*a*)											(*b*)					
0	0	1·3223																			
25	0	1·1512																			
25	4*	·5375	·45	3·18	3·53	—															
25	6	·4519	·50	3·38	3·88	6·56	—														
25	8	·3992	·55	3·69	4·24	7·54	9·15	—													
25	10	·3615	·59	3·98	4·57	8·32	10·0	11·18	—												
25	12	·3315	·63	4·22	4·85	8·78	10·52	11·58	12·1	—											
25	14	·3063	·66	4·41	5·07	9·24	10·83	11·78	12·19	12·31	—										
25	16	·2863	·69	4·60	5·29	9·67	11·28	12·29	12·84	13·33	14·63	—									
25	18	·2690	·71	4·78	5·49	10·02	11·64	12·66	13·26	13·82	14·84	15·1	—								
25	20	·2534	·73	4·91	5·64	10·30	11·87	12·85	13·44	13·95	14·74	14·81	14·48	—							
25	30	·2017	·82	5·55	6·37	11·61	13·34	14·46	15·24	15·98	16·85	17·38	17·96	19·01	—						
25	40	·1674	·88	5·98	6·86	12·28	14·00	15·11	15·87	16·56	17·33	17·78	18·24	18·93	18·8	—					
25	50	·1434	·92	6·19	7·11	12·73	14·45	15·54	16·3	16·96	17·7	18·12	18·53	19·11	19·48	19·75	—				
25	60	·1244	·94	6·35	7·27	12·86	14·51	15·54	16·23	16·83	17·45	17·81	18·13	18·57	18·28	17·86	15·74	—			
25	70	·1109	·97	6·49	7·46	13·15	14·81	15·85	16·55	17·16	17·78	18·14	18·47	18·91	18·85	18·88	18·25	22·14	—		
25	80	·0996	·98	6·60	7·58	13·29	14·92	15·93	16·62	17·22	17·8	18·14	18·45	18·85	18·77	18·49	18·22	20·32	18·14	—	
25	90	·0919	1·00	6·81	7·81	13·73	15·44	16·52	17·27	17·92	18·57	18·98	19·36	19·83	20·22	20·86	21·38	24·83	26·74	39·35	—
25	100	·0845	1·00	6·92	7·92	13·91	15·62	16·70	17·45	18·10	18·76	19·17	19·55	20·02	20·47	21·15	21·73	24·71	26·02	31·92	24·2
Mean values for 50, 60 and 70,					7·28	12·91	14·59	15·64	16·36	16·98	17·64	18·02	18·38	18·86	18·87	18·83	Mean value of all other figures except the three of the two last columns, 21·52				
" " " 80, 90 & 100,					7·77	13·64	15·33	16·38	17·11	17·75	18·38	18·76	19·12	19·57	19·82	20·17					
" " " 50 to 100,					7·52	13·28	14·96	16·01	16·74	17·36	18·01	18·39	18·75	19·21	19·34	19·50					

* This length of platinum wire was heated dark red.

Table XI. (R+Cu.) *Internal resistance, 50 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the copper wire.	(R.) True inter. resistance.	(a)											(b)					
0	0	1·3062																			
50	0	1·0493																			
50	4*	·5212	·78	3·17	8·95	—															
50	6	·4399	·85	3·48	4·33	6·82	—														
50	8	·3886	·92	3·78	4·70	7·72	9·15	—													
50	10	·3535	1·00	4·08	5·08	8·64	10·36	12·14	—												
50	12	·3247	1·05	4·32	5·37	9·22	10·91	12·32	12·55	—											
50	14	·3008	1·10	4·52	5·62	9·65	11·3	12·56	12·83	13·17	—										
50	16	·2831	1·16	4·77	5·93	10·35	12·2	13·69	14·47	15·83	19·6	—									
50	18	·2670	1·21	4·93	6·14	10·7	12·53	13·95	14·69	15·76	17·6	15·6	—								
50	20	·2496	1·23	5·01	6·24	10·7	12·36	13·54	14·02	14·59	15·25	13·1	10·7	—							
50	30	·1974	1·37	5·58	6·95	11·85	13·53	14·71	15·29	15·91	16·52	15·95	16·03	17·81	—						
50	40	·1664	1·49	6·05	7·54	12·88	14·68	15·96	16·68	17·43	18·17	17·99	18·39	20·0	23·68	—					
50	50	·1419	1·54	6·28	7·82	13·21	14·95	16·11	16·82	17·5	18·15	17·97	18·29	19·52	21·11	17·92	—				
50	60	·1242	1·58	6·47	8·05	13·52	15·24	16·42	17·08	17·73	18·35	18·22	18·53	19·61	20·9	18·86	20·17	—			
50	70	·1110	1·63	6·65	8·28	13·86	15·6	16·79	17·46	18·12	18·75	18·66	19·0	20·04	21·39	20·11	21·84	24·09	—		
50	80	·0996	1·65	6·74	8·39	13·95	15·66	16·81	17·46	18·09	18·67	18·59	18·88	19·84	20·92	19·64	24·09	20·97	17·36	—	
50	90	·0908	1·67	6·85	8·52	14·14	15·84	17·0	17·65	18·28	18·86	18·79	19·1	20·02	21·1	20·05	21·07	21·56	19·9	23·18	—
50	100	·0827	1·68	6·87	8·55	14·1	15·76	16·87	17·48	18·07	18·61	18·52	18·79	19·64	20·47	19·28	19·84	19·71	17·7	17·87	12·1
Mean values for 50, 60 and 70,					8·05	13·53	15·26	16·44	17·12	17·78	18·42	18·28	18·61	19·72	21·13	18·96	Mean value of all other figures, except the last, 20·67.				
" " " 80, 90 & 100,					8·49	14·06	15·75	16·89	17·53	18·15	18·71	18·63	18·92	19·83	20·83	19·66					
" " " 50 to 100,					8·27	13·79	15·51	16·66	17·32	17·97	18·56	18·46	18·76	19·78	20·98	19·31					

* This length of platinum wire was heated but very dark red.

TABLE XII. (R+Cu.) *Internal resistance, 100 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the copper wire.	(R.) True internal resistance.	(a)	(b)																
0	0	1·3240																				
100	0	·8865																				
100	2*	·6307	1·63	3·30	4·93	—																
100	4	·4863	1·61	3·25	4·86	4·12	—															
100	6	·4150	1·75	3·53	5·28	5·69	7·64	—														
100	8	·3730	1·92	3·89	5·81	6·68	9·17	11·76	—													
100	10	·3373	2·03	4·11	6·14	7·19	9·58	11·36	10·9	—												
100	12	·3075	2·10	4·27	6·37	7·51	9·76	11·16	10·77	10·64	—											
100	14	·2891	2·24	4·53	6·77	8·15	10·66	12·37	12·67	13·99	19·42	—										
100	16	·2692	2·30	4·67	6·97	8·42	10·88	12·46	12·74	13·71	16·11	13·05	—									
100	18	·2528	2·37	4·81	7·18	8·70	11·15	12·70	13·03	13·93	15·73	13·86	14·83	—								
100	20	·2394	2·44	4·95	7·39	9·01	11·51	13·09	13·5	14·45	16·12	14·9	16·13	17·73	—							
100	30	·1900	2·70	5·51	8·21	10·07	12·67	14·26	14·84	15·79	17·1	16·67	17·58	18·3	18·46	—						
100	40	·1580	2·86	5·81	8·67	10·7	13·32	14·9	15·51	16·43	17·58	17·33	18·1	18·66	18·82	19·4	—					
100	50	·1363	3·00	6·08	9·08	11·23	13·91	15·51	16·18	17·12	18·25	18·11	18·87	19·44	19·66	20·76	22·81	—				
100	60	·1195	3·08	6·26	9·34	11·55	14·24	15·83	16·51	17·43	18·51	18·41	19·12	19·65	19·86	20·85	22·08	21·13	—			
100	70	·1071	3·18	6·44	9·62	11·91	14·64	16·26	16·97	17·91	18·99	18·95	19·68	20·22	20·47	21·68	23·12	23·35	26·37	—		
100	80	·0954	3·19	6·45	9·64	11·9	14·55	16·09	16·74	17·6	18·58	18·50	19·13	19·57	19·75	20·42	20·95	19·97	19·17	11·54	—	
100	90	·0873	3·25	6·58	9·83	12·14	14·81	16·38	17·05	17·93	18·92	18·87	19·51	19·98	20·17	21·0	21·74	21·26	21·33	18·18	27·77	—
100	100	·0798	3·27	6·62	9·89	12·19	14·83	16·38	17·03	17·89	18·84	18·78	19·39	19·82	20·0	20·69	21·22	20·62	20·40	17·69	22·31	16·4
0	100	·0832																				
Mean values for 50, 60 and 70,					9·35	11·56	14·26	15·87	16·55	17·49	18·58	18·49	19·22	19·77	20·00	21·10	22·67					
" " " 80, 90 & 100,					9·79	12·08	14·73	16·28	16·94	17·81	18·78	18·72	19·34	19·79	19·97	20·70	21·30					
" " " 50 to 100,					9·57	11·82	14·49	16·07	16·74	17·65	18·68	18·60	19·28	19·78	19·98	20·90	21·99					

Mean value of all other figures, except the last one, 20·79.

* This length of platinum wire did not show any sign of dark red heat.

TABLE XIII. (R+Cu.) *Internal resistance, 150 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the copper wire.	(R.) True inter resistance	(a)											(b)						
0	0	1·2877																				
150	0	·7492																				
150	2	·5714	2·68	3·74	6·42	—																
150	4	·4676	2·78	3·86	6·64	7·0	—															
150	6	·3972	2·83	3·94	6·77	7·12	7·28	—														
150	8	·3536	2·99	4·16	7·15	7·74	8·4	10·22	—													
150	10	·3247	3·19	4·45	7·64	8·53	9·63	11·91	14·47	—												
150	12	·2974	3·30	4·59	7·89	8·85	9·98	11·88	13·16	11·78	—											
150	14	·2792	3·58	4·84	8·32	9·46	10·82	12·93	14·51	14·54	18·68	—										
150	16	·2606	3·57	4·96	8·53	9·74	11·11	13·07	14·41	14 4	16·32	14·02	—									
150	18	·2462	3·68	5·13	8·81	10·11	11·57	13·56	14·92	15·09	16·85	15·84	18·19	—								
150	20	·2343	3·81	5·29	9·10	10·51	12·07	13·89	15·56	15·91	17·70	17·31	19·63	21·38	—							
150	30	·1860	4·14	5·76	9·90	11·51	13·17	15·13	16·41	16·82	18·05	17·93	18·90	19·07	18·51	—						
150	40	·1551	4·37	6·07	10·44	12·16	13·77	15·78	17·0	17·43	18·51	18·49	19·28	19·45	19·16	20·19	—					
150	50	·1339	4·55	6·33	10·88	12·69	14·46	16·37	17·6	18·07	19·12	19·17	19·93	20·15	20·01	21·4	23·16	—				
150	60	·1174	4·66	6·49	11·15	13·0	14·77	16·66	17·84	18·31	19·30	19·37	20·07	20·28	20·17	21·34	22·28	21·15	—			
150	70	·1051	4·78	6·64	11·42	13·32	15·13	17·03	18·22	18·71	19·69	19·81	20·49	20·73	20·67	21·96	23·06	22·98	25·44	—		
150	80	·0941	4·80	6·69	11·49	13·37	15·14	16·97	18·11	18·56	19·47	19·55	20·17	20·35	20·27	21·41	21·7	20·93	20·77	15·54	—	
150	90	·0866	4·92	6·84	11·76	13·72	15·54	17·42	18·6	19·09	20·04	20·17	20·83	21·07	21·04	22·27	23·21	23·23	24·35	23·62	35·46	—
150	100	·0787	4·91	6·83	11·74	13·65	15·42	17·22	18·34	18·80	19·66	19·75	20·34	20·53	20·46	21·34	21·81	21·29	21·34	19·43	22·21	9·62
0	100	·0824																				
Mean values for 50, 60 and 70,					11·15	13·0	14·79	16·35	17·89	18·36	19·37	19·45	20·16	20·39	20·28	21·57	22·83					
" " " 80, 90 & 100,					11·66	13·58	15·03	17·14	18·35	18·82	19·72	19·83	20·45	20·65	20·39	21·67	22·24					
" " " 50 to 100,					11·40	13·29	14·91	16·75	18·12	18·59	19·55	19·64	20·30	20·52	20·43	21·62	22·53					

Mean value of all other figures except the last one, 22·69.

TABLE XIV. (R+Cu.) *Internal resistance, 200 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu) Resistance of the copper wire.	(R) True inter. resistance.	(a)	(b)																
0	0	1·2544																				
200	0	·6611																				
200	2	·5233	3·59	4·0	7·59	—																
200	4	·4305	3·53	3·94	7·47	7·28	—															
200	6	·3758	3·74	4·16	7·90	8·19	9·74	—														
200	8	·3397	4·00	4·45	8·45	9·10	10·85	12·82	—													
200	10	·3098	4·17	4·65	8·82	9·56	11·40	12·77	12·72	—												
200	12	·2868	4·35	4·84	9·19	10·13	11·97	13·34	13·68	14·94	—											
200	14	·2681	4·52	5·03	9·55	10·61	12·51	13·91	14·47	15·72	16·67	—										
200	16	·2504	4·61	5·14	9·75	10·85	12·68	13·97	14·43	15·29	15·52	14·29	—									
200	18	·2358	4·72	5·26	9·98	11·12	12·97	14·21	14·69	15·49	15·74	15·20	16·30	—								
200	20	·2262	4·92	5·48	10·40	11·70	13·71	15·17	15·91	17·06	17·86	18·39	21·30	29·12	—							
200	30	·1806	5·34	5·94	11·28	12·76	14·79	16·21	16·97	17·05	18·61	19·02	20·22	21·26	19·6	—						
200	40	·1514	5·62	6·26	11·88	13·47	15·58	16·94	17·73	18·67	19·31	19·73	20·70	21·46	20·48	21·85	—					
200	50	·1282	5·69	6·34	12·03	13·57	15·51	16·78	17·46	18·24	18·72	18·99	19·67	20·13	19·24	18·93	15·26	—				
200	60	·1149	5·97	6·65	12·62	14·32	16·39	17·78	18·58	19·47	20·08	20·50	21·31	21·91	21·29	22·47	22·96	36·39	—			
200	70	·1016	6·01	6·70	12·71	14·38	16·39	17·72	18·46	19·28	19·82	20·17	20·87	21·37	20·77	21·44	21·2	26·39	16·39	—		
200	80	·0901	5·97	6·65	12·62	14·22	16·11	17·34	17·99	18·71	19·15	19·41	19·97	20·34	19·72	19·78	18·79	20·94	12·66	17·04	—	
200	90	·0828	6·09	6·79	12·88	14·31	16·48	17·74	18·43	19·18	20·12	19·96	20·56	20·96	20·42	20·8	20·35	22·95	17·38	18·08	33·42	—
200	100	·0777	6·30	7·02	13·32	15·09	17·14	18·50	19·28	20·13	20·70	21·09	21·79	22·30	21·9	22·85	23·26	26·93	23·55	27·53	45·32	62·35
0	100	·0794																				
Mean values for 50, 60 and 70,					12·45	14·09	16·1	17·43	18·17	19·0	19·54	19·89	20·62	21·14	20·43	20·95	19·81					
" " " 80, 90 & 100,					12·94	14·54	16·58	17·86	18·57	19·34	19·99	20·15	20·77	21·20	20·68	21·14	30·80					
" " " 50 to 100,					12·69	14·31	16·34	17·64	18·37	19·17	19·76	20·03	20·69	21·17	20·56	21·04	20·30					

Mean value of all other figures except the last one, 23·44.

ART. VIII.—*On Colorado Meteorites—Russel Gulch Meteoric Iron, and Bear Creek Meteoric Iron;* by Prof. J. LAWRENCE SMITH, Louisville, Ky.

THE first of these irons I described in the September number of this Journal, calling it the "Colorado meteorite." Owing to the discovery of another in the same territory (specimens of which have been in my possession for some little time), it will be proper to designate the first mass as the "Russel Gulch" iron and the other as the "Bear Creek" iron. Of this last there are two short notices in the November number of this Journal, pages 260 and 286, the specimen of it in my possession has enabled me to make a thorough examination of the constituents. The piece I have has a portion of the exterior attached.

As has already been stated by Prof. Shepard, it is coarsely crystalline, and laminated from the effects of decomposition between the crystals; the surface contains considerable pyrites, although Prof. Shepard did not discover any in his specimen. I was enabled to separate and analyze magnetic pyrites, schreibersite and nickeliferous iron. Of the magnetic pyrites sufficient was separated to make a quantitative determination which was as follows:

Sulphur,	35·08
Iron,	61·82
Nickel,	·41
Insoluble residue,	1·81
	99·12

The schreibersite was not obtained in sufficient quantity for a complete analysis; about 50 milligrams of the pure mineral gave all the constituents usually found in this interesting mineral.

The nickeliferous iron, constituting of course the great bulk of of the mass, was composed as follows:

Iron,	83·89
Nickel,	14·06
Cobalt,	·83
Copper,	minute quantity
Phosphorus,	·21
	98·99

The laminæ of iron are often very brilliant, having the luster of silver and caused me to suspect more nickel than was found. It was supposed that in the decomposition of the crystals the iron would disappear more rapidly than the nickel, and that by a process of cementation, the nickel would accumulate in the laminæ; but from careful examination of the process of decomposition, there is no doubt that the interior of the mass will not differ materially in its composition from the analysis already given of the nickeliferous iron. Besides the minerals already mentioned, and which properly belong to the original mass, there is much oxyd of iron, containing some nickel arising from the decomposition of the surface.

ART. IX.—*On a new locality of Tetrahedrite, Tennantite, and Nacrite, with some account of the Kellogg Mines of Arkansas;* by Prof. J. LAWRENCE SMITH.

A SHORT time since Prof. E. T. Cox of Indiana sent to me an antimonial copper ore containing silver, one fragment being the termination of a crystal having a number of small but beautiful faces, another was a minute crystal of a different form; in the hands of Prof. Cox a blowpipe analysis had given about five per cent of silver in some of the mineral.

The crystalline fragments were first examined and they enabled me clearly to trace out tetrahedrite in one and tennantite in the other. The faces on the tetrahedrite were small but beautiful and very numerous; from the number on the fragment examined there would not have been less than from 60 to 70 had the crystal been perfect: it corresponds very nearly to the cyrstal figured in Dufrenoy's Mineralogy, plate 124, fig. 441, which he speaks of as coming from Moschellandsberg, a locality that I am not able to discover. Good measurements were made on a few of the faces.

P on P 70°; P on b^3 159° 30′; P on a^2 144° 30′

Specific gravity of different specimens varied from 4·78 to 5·08; the latter was the sp. grav. of the above crystal. The analysis of two specimens, No. 2 being a part of the crystal, gave

	1.	2.
Antimony,	26·50	27·01
Sulphur,	26·71	25·32
Copper,	36·40	33·20
Iron,	1·89	·82
Zinc,	4·20	6.10
Silver,	2·30	4·97
Arsenic,	1·02	·61
	99·02	98·03

The quantity of No. 2 analyzed did not exceed 300 milligrams.

There are two minerals consisting of minute micaceous scales on the quartz containing this gray copper. One of them I could not obtain in sufficient quantity for examination; from an imperfect examination I conclude that it is muscovite; the other mineral, a soft unctuous talc-like mineral, is nacrite, composed as follows:

Silica,	65·02
Alumina,	26·11
Oxyd of iron,	2·20
Manganese,	*trace*
Potash and soda,	1·18
Water,	4·98
	99·49

These minerals came from an exceedingly interesting mine in Arkansas that is as yet almost unexplored; I have obtained a full description of it from Prof. Cox and I think it would be well to give it here, for besides being likely to prove of considerable commercial value when properly explored, there will doubtless be found many interesting mineral species there.

The Kellogg mines are situated 10 miles north of the city of Little Rock in Pulaski Co, Ark. The country in the vicinity is rolling, the highest hills are about 270 feet above the water level of the neighboring streams. The surface rocks are thick and thin beds of sandstone alternating with shales occupying the base of the coal measures. The rocks are but little disturbed and are for the most part horizontal. There are no metamorphic rocks showing themselves at the surface nearer than Little Rock on the south side of the Arkansas river. Innumerable veins of milky quartz are seen traversing the sandstones and shales.

About seventeen years ago lead ore was discovered at these mines by Mr. Kellogg, companies were organized and mining operations carried on extensively for about one year, when the flattering accounts of the gold discoveries in California caused the miners to leave, and the work which had been badly conducted was abandoned. Many tons of the ore which is an argentiferous galena (containing 60 to 200 ounces of silver to the ton) were extracted from the mine and finally the greater part was shipped to England and sold at a good price. A smelting furnace has been erected on the grounds, but for lack of skill, the proprietor never succeeded in working the ore profitably, consequently the impression was produced that the ore could not be smelted, but there is no good reason for such an opinion.

Since the mines have been abandoned, the old shafts, ranging in depth from fifteen to seventy feet, are all filled in, and the country has become covered with a dense undergrowth of brush and briars. About one year ago Prof. Cox revisited these mines for a company who had in view to lease or purchase them; it was during this visit that the gray copper above referred to was discovered. This ore has previously escaped the observation of others who had explored these mines. It is impossible at present to see the ore in place, and those who previously worked the mine give conflicting statements as to the manner in which the ore is found.

The vein-rock and associated minerals with the galena are white quartz, spathic iron, zinc blende, copper pyrites, gray copper, tennantite and nacrite.

The mines are now in the hands of a new company, and the latest information from their operations are, that matters look well; the vein now being worked is nearly three feet wide, principally lead ore, the balance being zinc blende; twenty hands are at work, and the shaft is down forty-five feet. My opinion is, that in time this mine will become of considerable importance, and lead to further developments of argentiferous galena in that region.

ART. X.—*On recent Soundings in the Gulf Stream.* — Abstract of a paper read before the National Academy of Sciences; by HENRY MITCHELL, Assistant U. S. Coast Survey.

EARLY in the spring of the present year an application was made to the Coast Survey by the International Ocean Telegraph Company for information relative to the form and character of the bottom of the Straits of Florida between Key West and Havana along the proposed track of the submarine telegraph cable which is to connect the United States with the West India Islands. It was clearly the province of the Coast Survey to supply information of this sort, and a special survey was therefore ordered under instructions from Mr. J. E. Hilgard who, during the illness of Prof. Bache, conducts the work of this bureau. These instructions were carried out carefully and under favoring circumstances, so that the results are entitled to confidence.

The distance from Sand Key, on the extreme southern point of the Florida reef to El Moro rock at the entrance to Havana, is but a trifle over 82 miles. To lay a cable over this short distance would seem to be an easy task and one that should long since have been executed. In fact, however, the locality offers a new problem to the engineer, viz: *to lay a cable nearly at right angles to a strong stream, or system of streams, flowing through a rocky pass of great depth.* The new survey, if it does not, as is hoped, supply the elements for the solution of this problem, at least develops and gauges the difficulties of the task, and incidentally adds a few items of interest to physical inquiry.

The line of maximum depression was struck at a point 24 miles north of the Moro, and followed some distance to the northeast with depths of 853, 845 and 794 fathoms. The direction of this line does not correspond to that of the Gulf Stream in this neighborhood; but a glance at the map will show that a S.W. course would be a natural one for the *Polar Current*, as it is called, which runs near the bottom.

The numerous soundings of this survey make it possible to develop a profile of section from Sand Key to the Moro, and the subjoined table gives the numerical data for such a profile.

Section of Soundings across the Straits of Florida, from Sand Key to El Moro.

	Points on profile.	Distances from Sand Key.	Distances from El Moro.	Depths. By Indicator.	Depths. By outrun of line.	No. of sta'ns used.	Kind of bottom.	Remarks.
Northern approach to channel.	A	2¾	79½		65		rock.	Coral strewn over with shells.
	B	7½ to 8½	74½	111	125	5	"	Specimen of coral debris obtained.
	C	11	714	129	132	1	"	
	D	14½	67¾	2~9	309	2	"	Specimen of coral debris.
	E	18¼	64	369	397	1	mud.	Specimen of gray mud.
	F	24¼	58	432	466	1	"	Specimen of mud nearly white.
	G	29⅓	53⅓	504	553	2	"	Specimen nearly white with dashes of red.
	H	34	48¼	687	No indication of depth by the outrun of line.	1	"	Specimen of stiff mud, nearly white.
	I	38	44¼	794		1	"	Specimen gray and granular mud.
Southern approach to channel.	i	45½	36¾	845		1	"	Specimen nearly white with red tinge.
	h	51¼	31	842		3	"	Specimen same as above.
	g	55¾	26½	813		2	"	Specimen same as above.
	f	60	22¼	455		2	"	Specimen of mud with drab color.
	e	61½	20¾	380		1	"	No specimen—some doubt of cast.
	d	67¼	15	710		1	hard.	
	c	73¼	9	748		1	mud.	
	b	7~½	3¾	583	620	1	sand.	Sand or mud of reddish brown hue.
	a	80½	1¾	243	244	1	rock.	A small shell obtained.

In this profile, which is, strictly speaking, that of a diagonal section, the point of maximum depression is found 37 miles from the Moro, and is 843 fathoms. The approaches to the great valley from the two coasts are dissimilar in general features. From the northward the bottom falls away in *terraces* whose intervening slopes are nowhere abrupt; while from the southward an irregular and hilly approach is found with indications of abrupt if not precipitous changes of elevation. Above the terraces of the north shore the sea lies almost motionless, while among the cañons of the southern half of the Straits flow the Gulf Stream and its counter currents.

These natural distinctions authorize us in taking up separately the descriptions of these approaches, and we shall proceed to do so briefly, commencing at Sand Key and following the profile southward from A to I: then commencing at the Moro and following northward from *a* to *i* (see table).

Northern Approach.—Leaving Sand Key, the water deepens rapidly to 13 fathoms, then shoals again to 7 fathoms upon a coast bar or ridge parallel to the reef, and scarcely ⅘ths of a mile distant from it. Seen from the deck of a ship upon a fine day this bar is marked by a narrow belt of pale blue-green water in beautiful contrast with the dark blue-black of the ocean. The bottom can be seen on crossing it and appears to be a pure white rock *in situ*, strewn sparsely over with fragments of the weathered and brown reef rock. Two miles farther out carries us to the point A, where our table for the profile commences with sixty five fathoms of water on a slope of one foot in thirty seven. The next points B and C lie upon a nearly level plain which terminates about twelve miles from the reef in a slope of one foot to twenty-two. Upon this terrace numerous soundings were made covering about eight miles of longitude, which show that the formation belongs to the reef system and lies parallel to it. Chips of white coral rock were brought up in one of the casts—in all of them the hard bottom was felt by the hand. At what appears to be the foot of the fore slope of this terrace (point E) the bottom is found to be soft mud, and a specimen procured proved to be of a grey color quite in contrast both as regards color and consistency, with that obtained above or beyond. It differed from the white muds beyond, of which we shall hereafter speak, in possessing a granular character and retaining the same when dry. It is conceived that this terrace was once a dry reef covered over like Sand Key with dark fragments of agglomerated reef rock, and that a subsequent submergence has caused all this loose and weathered material to be swept down to the foot of the fore slope.

Between D and E, in about 300 fathoms, the *swept* portion of the Florida Reef, if not also the *base* of the formation, is passed. At F, G and H the bottom is of nearly white mud, with dashes of red at the last named point. These muds were found to *set* on drying. The mud with dashes of red is supposed to be the debris of a kind of coral, quite common upon the reef, which is spotted as if with drops of blood. These three stations seem to comprise another grand terrace, because at the 500 fathoms curve there seems to be a considerable belt where a difference of a mile in latitude or longitude scarcely altered the soundings. If this is so, we must suppose that we are not yet beyond the reef and that the rock still underlies the material which the specimen cup procures. *At the foot of the fore slope of this second terrace* (I) *in* 794 *fathoms, the mud is again grey* and *granular* while the next station beyond is of the ordinary white tinged with red.

Do these features belong to the history of the Gulf Stream or to the geology of the coral reef? As these slopes and terraces are now scarcely traversed by the streams, we are inclined to regard them as exhibiting the order in which, through successive ages, the reef has alternately subsided and stood still. As far as the swept portion of the reef apron extends, we see no indications of any caving down of the structure; and in the neighborhood of the second terrace the presence of mud forbids the supposition of long continued abrasion.

Southern Approach.—The Moro Rock is nearly perpendicular at the water line but retreats at points higher up. Its northwest profile is convex with a mean dip of 45° from the castle wall to the sea. Leaving this rock and advancing 1¾ miles northward, the bottom declines 1 foot in 7 to point *a*, where the depth is 243 fathoms and the bottom, *rock.* From *a* to *b* the depth increases very rapidly, 1 foot in 6, and the foot of the Moro Rock is passed. The bottom at *b* is a reddish brown mud which becomes in part granular on drying—*in many respects it resembles the specimens from the foot of the fore slope of the coral terrace on the north bank of the straits.* It is no doubt weathered debris swept down from the Moro.

The dip of the rocky part of this space between *a* and *b* is unquestionably much more precipitious than the mean we have stated, because 1 foot in 6 is altogether too great an inclination for the material found at *b*.

Beyond *b* the slope is gradual, 1 foot in 32, and terminates at *c* in the nearly horizontal bed of a depression which we shall call the Moro Channel. Here at *c* the depth is 748 fathoms. Six miles farther carries us across the Moro Channel and we find the depth a trifle more shallow, 710 fathoms, at *d*.

At *e* and *f* we find ourselves near the summit of a submarine mountain whose height above the bed of the Straits is about twenty four hundred feet. This mountain, lying but a few miles to the northward of the axis of the Gulf Stream, may be claimed as a point of decided interest in this survey. It is scarcely twenty one miles from the shore of Cuba whose hills are in full view if the weather is fine. Six casts were made upon its summit under the greatest difficulties, owing to the current. Only three of these proved successful and but one yielded a specimen of bottom. The depth on the summit was found to be about 400 fathoms. On looking over the work of former years we find that Capt. B. F. Sands in 1858 made deep sea soundings in this locality, and that he struck one sounding of 320 fathoms on the same parallel, but some twelve miles to the westward. He procured a specimen and observed the temperature to be 60°

which is the usual amount for this depth in the Straits of Florida. The Polar current which underlies the stream, following the line of maximum depression, has a temperature of less than 45°. At first thought, it might be supposed that an obstacle in the track of the stream would cause an ascension of the Polar current, but when we consider that this Stream Bank has not the nature of a bar, and that the deep channel way beyond is ample, there would seem to be no reason for an ascension of the cold waters in this neighborhood.

Several other casts, not referred to in our table, because too far to the eastwasd of the section line, furnish some clue as to the form of the Stream Bank. It appears to be triangular in its general figure, presenting at its west angle a bold prow to the stream. As the current is here flowing with an accelerating velocity, a *deposit* is impossible. This bank, it appears to us, must have, like the adjacent reef, a firm constitution. It is an interesting question whether it belongs to the mountain system of Cuba (as its line of least water running E. and S. E. might seem to indicate), or whether it is an ancient reef now wearing and crumbling away. The least depth is about that of the foot of the *swept* portion of the reef apron on the north side of the Straits —it may indicate the true depth of the Gulf Stream itself, and if so, its summit is not now abraded, while its base must be wearing away under the action of the Polar current. A bank so situated must have precipitious slopes.

Observations upon the trend of the lead line, on hauling in, furnish indications that the thickness of the upper moving stratum, i. e., the depth of the Gulf Stream, is scarcely more than one third of the maximum depth of the channel. This stream seems to be an *overflowing* of water, not a profound movement. In the exchange between the Gulf of Mexico and the Atlantic, the office of the Gulf Stream appears to be the *restoration of surface level*, while the office of the counter stream, ("Polar current") below, is the *restoration of equilibrium thus disturbed*, between waters of different specific weights or densities. To illustrate this view of compensating currents, we may be suffered to recall an instance from our experience in observations at the mouth of Hudson River. In the dry season (July) the surface *outflow* (brackish) through the Narrows of New York harbor, occupies nine out of the twelve tidal hours, while in the lowest water stratum the case is more than reversed, the *inflow* (salt) predominates to that extent, that as a general thing it is *continual* along the bottom, although not *constant* in velocity. The same conditions, with variable proportions, were followed some distance up the river. On running a line of levels from New York city to Albany it was found that the bed of the Hudson lies below the *mean level* of the sea for over a hundred miles; but that the surface of the fresh water, even in the dry season, is above this level—not so much above, however, as to *equalize the difference of specific weight between it and the sea water*, so that the latter, during the summer months, flows in along the bed of the stream, while the former *overflows* into the ocean.

In the recent survey, observations upon surface densities were carried over several hundred miles. These show decided contrasts between the ocean and the stream, but no greater than the differences of temperature might lead us to expect.

The Gulf Stream is essentially confined to the southern half of the Strait in the portion crossed by this survey, but no westwardly drift along the north shore was observed except at one time a feeble flood tidal current setting close along the reef. It is not impossible that the widths of the Gulf Stream vary, as its velocities are known to do, and both of these may in many cases depend upon long continued gales of wind. During the period of the recent survey, however, the weather was exceedingly calm in the Gulf, and as far as learned, generally quiet at sea, yet the velocities of the stream altered in a marked manner, and so much so that the changes became a matter of comment among pilots and ship masters arriving at Havana. It would be exceedingly interesting and practically useful to ascertain from systematic inquiry the order of these variations. We would suggest as a reasonable hypothesis that these variations follow those changes of *mean-sea-level* which depend upon the declinations of the sun and moon—more especially the latter. There are no two seas upon the earth whose tidal phenomena differ more essentially than those of the Gulf of Mexico and the Atlantic Ocean; and it is a matter of certainty that the elevations of these two bodies of water are not affected in the same manner and degree by the half-monthly changes of the moon's declination. Professor Bache's paper on the "Tides of Key West," published in the Coast Survey Report of 1853 shows that the *mean level* of this station is one foot higher when the moon is in the equator than when she is at her greatest declination. In the North Atlantic the order is the reverse of this; the mean level is there about three inches higher at the maximum than at the zero declination.* Small as these relative changes of elevation may seem they must bear a large proportion to the total head of the Gulf Stream which suffers exceedingly little resistance in its course.

* From computations of the Coast Survey, and from Phil. Trans. R. S., 1839.

ART. XI.—*Observations upon the Glacial Drift beneath the bed of Lake Michigan, as seen in the Chicago Tunnel;* by E. ANDREWS, A.M., M.D., Prof. of Surgery in Chicago Medical College.

IN the November number of this Journal there is an article from E. W. Hilgard, State Geologist of Mississippi, which contains serious errors respecting the Drift formation in Illinois. The mistakes occurred, doubtless, because the distinguished author had not an opportunity for personal observation here, and was obliged to rely on the information of others less competent than himself.

He remarks that the erratic blocks are nearly all well water-worn, and that the drift "is more or less irregularly, but distinctly, *stratified*," and that "*no glacier scorings* are mentioned either on the pebbles or on the adjacent rocks."

The truth is this. The drift of Illinois, Indiana, Michigan and Wisconsin consists of two distinct formations, one above the other. The lower is the well known "glacial drift" of authors. It is a heterogeneous mass, full of boulders and pebbles, which are only imperfectly rounded and sometimes quite sharp at the edges. Vast multitudes of the larger blocks are scratched and polished on one side by unmistakable glacier action. In a large part of the formation it is extremely difficult to discover any traces of stratification, though it can be noticed by great care.

The second formation always overlies the former, and consists of sand and gravel distinctly stratified, and filled with well rounded and water-worn pebbles. The two deposits are so unlike each other that there is no possibility of confounding them. Their relation to each other is best shown in the numerous railroad cuts which traverse them. It is there seen that at a distance from the valleys of streams, the old glacial drift usually comes to the surface, and often rises into considerable eminences. In Illinois, at least, the closest scrutiny generally fails to discover in it any stratification. As we approach the streams, however, the glacial drift sinks out of sight, and is overlaid by perfectly well stratified sand and gravel. The latter exists in enormous quantities, sometimes bordering the valley miles in width, and by its thick masses fully maintains the general height of the country. At the border of the valleys of the streams the sand and gravel suddenly cease, terminating in an abrupt descent; or perhaps the lower strata may continue beneath the alluvium of the bottom lands.

The Chicago tunnel is excavated for two miles in the glacial drift beneath the bed of Lake Michigan. It has been closely watched by a committee of the Chicago Academy of Sciences, as well as by Mr. Chesborough the city engineer, Mr. Krœshell the inspector, and Mr. Gowan the contractor. From my own personal observation, and from those of the above-mentioned gentlemen, I derive the following facts. The tunnel is to supply the city with fresh water drawn from the lake at a distance of two miles from the shore. For this purpose a coffer dam was erected in the lake, two miles from the land, and within it a shaft was excavated in the clay to the depth of about seventy-five feet below the surface of the water. A similar shaft was sunk at the shore end, and from the bottoms the workmen drifted horizontally until they met beneath the lake.

The shaft at the shore end descended first through beach sand and then through tough clay, mostly free from boulders, and apparently a deposit from the lake. At the depth of about sixty-two feet the workmen came suddenly upon the hard glacial drift, containing glacier-scratched boulders, and in every way very different from the clay above it. The material appeared to be a soft comminuted shale reduced to a clay by the same means which transported it from its original strata. Every cubic yard of it contained millions of broken and scarcely rounded little fragments of the shale. These were accompanied with larger blocks of it, mixed with glacier-scratched boulders of limestone, sandstone, granite, syenite, and every other kind of rock which exists in the regions north of us. In this and similar material the whole of the rest of the shaft and the entire two miles of the horizontal part of the tunnel was excavated. Some extremely interesting facts were observed. For instance, this hard clay showed no trace of stratification when any particular part of it was inspected, yet it was so intercalated with other beds as to clearly prove its right to be called a stratum. After sinking eleven feet through it the workmen came to a thin bed of clay free from boulders, and beneath that to a stratum of sand, six inches in thickness, with another layer of hard clay beneath that. This stratum of sand was traced horizontally for over a thousand feet, when it ascended and disappeared through the roof of the excavation. Several hundred feet farther on another thin stratum of sand was struck whose upper surface clearly showed *ripple marks.* It was singular to observe that the clay resting upon it preserved a perfect cast of the ripple marks after the sand was removed from beneath it. This stratum extended only about fifty feet, when it thinned out and disappeared. About six thousand feet from the shore a stratum of softer clay entered the roof of the excavation, resting upon the hardpan beneath. Both formations contained boulders. These two strata followed so exactly the level of the tunnel that their junction was traced for four thousand feet farther, and was only lost at the outer extremity of the work, two miles from shore. It would seem therefore that in spite of the absence of minute layers in the clay, the stratified character of the whole mass is clearly made out.

The most surprising phenomenon discovered, was the existence all through the glacial drift, of numerous isolated "pockets" or cavities filled with stratified gravel. These "pockets," as the workmen called them, lay in all imaginable positions, sometimes with their strata set up at high angles. They were generally from a few inches to a few feet in diameter, and terminated abruptly on all sides in the solid impermeable clay. The gravel was water-worn, and often so clean that it would scarcely soil a handkerchief. Its interstices commonly contained a few gallons of water at the lower part, and some air or gas at the upper. The gas in many instances was inflammable, and was doubtless derived from the numerous boulders of highly bituminous limestone found in the clay. That the pockets were perfectly isolated is shown by the fact that though nearly eighty feet beneath the surface of the lake, they scarcely leaked a drop of water after they were once emptied. The existence of these masses of gravel is very surprising. The cavities, when emptied, looked exactly in many instances like the casts of rounded boulders. I can only account for them by the theory that they were deposited as frozen masses of gravel, and thawed after they were well imbedded in the clay, leaving their strata in whatever position they happened to be put while frozen.

After getting beneath the deposits made by the lake itself, the excavations furnished not the slightest traces of any organic remains.

Along the west shore of Lake Michigan, for a distance of over a hundred miles north of this place, the glacial drift rises some eighty feet above the water in precipitous bluffs. In many places the bluffs are eroded by the waves, and show fine sections. To one standing close by it is often extremely difficult to notice any stratification, but to an observer stationed in a boat a hundred yards distant, dim but evident traces of a horizontal arrangement appear. The strata are best seen by noting the level bands where the springs ooze out.

The more recent formation may frequently be noticed as a well stratified deposit filling the hollows or valleys of the older drift, and rising to nearly the same height above the lake. It perhaps belongs to the Champlain epoch. It is greatly to be desired that some geologist should thoroughly examine the recent geology around Lake Michigan, as there are problems of great interest to be solved in connection with it; but as yet it is an unexplored field.

Chicago, Nov. 26, 1866.

ART. XII.—*Shooting Stars in November*, 1866; by H. A. NEWTON.

THE brilliant exhibition of the November meteors witnessed in Europe on the 14th of that month is a confirmation (if such confirmation was needed) of the astronomical character of these bodies, and of the thirty-three-year cycle. The European observations are evidently those which will throw most light upon their cosmical relations. Yet those made in this country on the nights of Nov. 12th–13th and 13th–14th must have decided value. The radiant point in Leo rises above our horizon about 11 o'clock P. M., which corresponds with 4^h A. M. Greenwich time. Our observations then from midnight onward on the morning of the 14th may be regarded as a continuation of those which in England were interrupted by the approach of daylight. They serve to give the law of decrease in density of the meteoroids as we leave the group. On the other hand, during the former night the earth was approaching the group, being at dawn only fifteen hours distant from its center.

1. *At New Haven.*—On the two nights 10th–12th of November the sky was entirely overcast; so also on the nights 14th–16th. On the night of Nov. 12th–13th we commenced counting the shooting stars ten minutes after 11 o'clock. There were fifteen or more in the party, principally students in the College. It was intended that at least twelve persons should be continually looking for the meteors. This number was maintained throughout the watch on this and the following nights, except for a very short period when only eight or ten were present. During part of the time, on the first night particularly, there were, besides the twelve, from two to five others assisting in counting. Two of us gave our attention to the location of the paths of particular meteors, remarkable for size, color, trains, &c., and to other objects aside from the counting.

We watched from the top of the tower of Graduates' Hall, from which there is an unobstructed view of the heavens. To nine persons were assigned particular portions of the sky around the horizon, and three looked toward the zenith. The meteors were counted aloud to prevent duplication. The total number seen by the party in each quarter-hour was thus obtained. It was also important to learn how many meteors each observer saw. To prevent the confusion that would result from counting in a double series, I gave to each person a card with directions to keep a tally upon it of those seen by himself. A few of these tallies were afterwards found to be imperfect, but the residue enable us to compare our numbers with those seen elsewhere by fewer observers.

The first party continued the watch until 1^h 40^m A. M., counting in these two and a half hours 236 meteors, as follows:

Time.	Duration.	No. seen.	No. per hour.
11^h 10^m to 11^h 30^m	20^m	37	
30 " 45	15	27	
45 " 12 0	15	26	108
12 0 " 15	15	22	
15 " 30	15	17	
30 " 45	15	21	
45 " 1 0	15	21	81
1 0 " 15	15	25	
15 " 30	15	20	
30 " 40	10	20	97
	Total in 2^h 30^m	236	94 hour. av.

The meteors were generally small and very few of them were from Leo. Few left trains. During these 2½ hours nine of the party saw severally 34, 10, 41, 26, 40, 62, 22, 62 and 68. This gives an average of 40½ to each observer, or 16 per hour. The proportion of the mean for single observers to the whole number seen is 17 per cent.

The large variation in the numbers seen (from 10 to 68) is due to a variety of causes. The three who looked to the zenith saw much the larger numbers. Some of the others may have looked too low down in the horizon, or there may have been a slight haze in the direction toward which they were looking. Besides all this, there is undoubtedly a personal difference depending on closeness of attention and sharpness of eyes.

At 2^h 40^m, after an interval of one hour, a new party began to count, and the following was the result:

Time.	Duration.	No. seen.	Hourly No.
• From 2^h 40^m to 2^h 45^m	in 5^m	15	
45 " 3 0	15	44	177
3 0 " 15	15	38	
15 " 30	15	37	
30 " 45	15	38	
45 " 4 0	15	27	140
4 0 " 15	15	38	
15 " 30	15	44	
30 " 45	15	43	
45 " 5 0	15	44	169
5 0 " 15	15	54	
15 " 30	15	36	180
	Total in 2^h 50^m	458	162 hourly av.

The following are the reports of the numbers seen by individual observers. Those looking the whole time saw 56, 41, 100, and 55; one from 3^h onwards saw 26, one from 3^h 15^m saw 49, one ending at 4^h 10^m saw 32, and one ending at 4^h 30^m saw 23. This gives an average hourly number of about 19½ for each observer, which is 12 per cent of all seen.

By 3^h A. M. the proportion of conformable meteors had considerably increased, so that they were then estimated to be at least one-fourth of the whole number visible. At 5 o'clock the proportion, though greater, was still less than one-half. During the quarter-hour 5^h 15^m–5^h 30^m the increasing light of the dawn in the east was interfering very considerably with the numbers visible.

The sky was beautifully clear throughout the night. The center of the radiant of the conformable flights seemed to be about R. A. 147° 30′, Dec. +23° 15′. It was not very easy to determine its shape and dimensions owing to the small number of flights near the radiant. The zodiacal light was remarkably fine in the east.

On the night of Nov. 13th–14th a new relay of observers began to count at 11 o'clock. They were relieved by a fourth party about 2 o'clock A. M. The arrangements were similar to those of the previous night. The following are the results for the successive quarter hours.

11^h–12^h.	12^h–1^h.	1^h–2^h.	2^h–3^h.	3^h–4^h.
22	37	47	33	65
29	43	37	36	36
35	56	50	55	56
36	61	37	55	55
122	197	171	179	212

At 4 o'clock it was decided to break up. A desultory counting gave 20 during the next ten minutes, or 901 in all. Between 1^h 15^m and 2^h 30^m the number of observers was not quite as large as usual, and the attention was somewhat broken by the changing of the party. Throughout this time and the hour following the clouds interfered to an appreciable extent.

A considerable portion of the meteors were much more brilliant than those of the previous night; also a much larger proportion proceeded from the Leo radiant. These were brighter than the others. At a quarter past twelve o'clock it was estimated that about three-fifths of all were conformable. During the next hour there was an evident increase in this ratio.

During the first three hours four persons saw severally 116, 98, 82, and 96; one saw in 3½ hours 99. This gives a mean of 32 per hour for each observer, which is 20 per cent of the number seen by the whole party. From half past two o'clock onward the mean hourly number for one person, as deduced from the reports of ten of the party, was about 38, that is, about 18 per cent of the whole.

If we compare the observations of the two nights, we see that the greater brilliancy of the meteors on the second night made the proportion seen by single observers to be greater. At the same time there was a much greater uniformity in the tallies reported. This is reasonable, for when the meteors are faint we may rightly expect a large *personal equation.* The average number of observers for the two nights was probably about fourteen. The mean of the proportions seen by single observers for the two portions of the two nights was about 17 per cent. Hence we may say that with such observers, such meteors, and such modes of observing, as we had on these two nights, fourteen persons will see about six times as many as one person. I think it probable that even so large a party loses a third, or more than a third, of the meteors that could be seen by an indefinite number of observers, especially when the flights are in general faint.

While the general position of the radiant on the second night would seem to be the same as that given on the first night, some stars moved from points nearer γ Leonis. Several paths produced backward would cut the line joining γ and ϵ Leonis within two or three degrees of the former star. I saw, however, no path that could not be referred to a radiant area of narrow breadth in latitude. In longitude its length would have to be three or four degrees, unless we admit, as Prof. Twining supposes, that there is a motion of the radiant. Prof. Hewitt of Olivet, Mich., gives a number of paths for the first night that seem to proceed from a point nearer γ than ϵ.

2. *At New Haven.*—Upon the roof of Sheffield Hall a party of about ten students, under the direction of Prof. Lyman, counted 603 meteors in five hours, from 12 o'clock onward, on the morning of the 13th of November. The following is the result of their observations for the successive quarter hours.

12^h–1^h.	1^h–2^h.	2^h–3^h.	3^h–4^h.	4^h–5^h.
24	25	38	43	27
21	31	22	39	38
17	..	30	35	34
21	47 for $\frac{1}{2}^h$	39	38	34
83	103	129	155	133

On the next night a similar party in the same place counted 492 meteors between eleven and two o'clock, omitting the quarter hour between 11^h 15^m and 11^h 30^m. This is a mean of 179 per hour. The following table gives the results.

	11^h–12^h.	12^h–1^h.	1^h–2^h.
	19	48	42
	..	48	53
	31	56	52
	38	50	55
Hourly mean	117	202	202

These results agree as well perhaps as could be expected with those of the party on Graduates' Hall. A considerable number of paths were drawn upon the charts upon both evenings which will serve to determine the altitude, lengths, &c., of the trajectories, if the same have been observed elsewhere.

3. *At New Haven.*—Prof. Twining watched alone on the morning of Nov. 14th, giving special attention to the lengths of the paths, the duration of the flights, and the position and size of the radiant area. He says: "from midnight to 1^h A.M., looking toward Leo, I observed 35 shooting stars, in one hour, and in an area of about 110° of arc laterally, and 70° vertically. Of these there were 24 conformable from an area of radiation about 8° in diameter, whose center was in N.P.D. 65½° and A.R. 147½°. Two-thirds of all were directed nearly from this center. The sky was very clear. The conformable meteors were rather massive, with tracks about 1′ broad. Three were much broader, and left trains for 2^s to 6^s of time. The two longest flights that I observed were 20° and 22° of arc and about 1^s in time.

"Again I watched from $3^h\ 8^m$ A.M. to $4^h\ 8^m$ A.M., or one hour. In a space equal to the former and looking toward the radiant I saw 43 meteors, of which 38 were conformable to an area covering nearly the bend of the Sickle,—but far the greater number radiating closely from the small star in its middle, being the old radiant of Nov. 13th, 1833. The flights were generally from 5° to 15° long, and the longest 22° in $\cdot 7^s$ of time. The average of the 62 conformable flights, for the two hours, was about 10° of arc, in $\cdot 5^s$ of time. But the flights of the earlier hour were shorter than those of the later, while the times were longer. It is of course true that the velocity of meteors *must be retarded by the gaseous medium* in which their visible paths are developed. The force of this medium, condensed before their masses, is so great that, not unfrequently, a curve, or even an angle is described in a meteor's path. These sudden deviations—as well as the frequent explosions—may often be due to the meteor's passage from the *secondary atmosphere of the earth* (allowing this really to exist, as I have formerly suggested, and being composed, perhaps, of aqueous vapor) into its atmosphere proper.*

"Better means of determining the radiant—or rather the lines of flight—than the unaided eye affords are now necessary. The best I have thought of would be a conical shell mounted upon a pillar and rotated by clock work, like a telescope. The cone should have its axis directed to the presumed radiant,—its opposite elements spreading, say 90°,—its apex truncated to an opening but little greater in circle than the pupil of the eye, and its larger circle, or base, traversed by wires divergent from its center, at equal intervals, and these last supporting and normally

* This Journal, [2], xxvii, 20.

cut by a system of circular wires showing equal intervals of arc when viewed from the apex,—the whole combination appearing to the observer like the meridian lines and circles of polar distance in a stereographic polar projection. The open base may be slightly illuminated if the wires are not sufficiently visible against the sky.

"With this apparatus adjusted to a proper position of the axis, it is obvious that conformable meteors will traverse lines, along or between the divergent wires; and that the inclinations to the wires can be closely estimated, as well as the distances from the center at which the prolonged paths would pass. At the same time the parallel circles would, if properly disposed and designated, afford a scale to mark the beginning and the end of flights with the best attainable accuracy. The intersection of selected standard stars by the wires might be agreed upon, in common, to fix a position for the axes of the shells, in all places where they should be employed for comparative observations, although, if the axial position were ascertained in each case, that uniformity would not be indispensable."

4. *At Philadelphia.*—On the morning of the 13th Mr. B. V. Marsh saw in a half hour ending at $1^h\ 40^m$, 2 conformable meteors and 6 others; in a half hour ending at $4^h\ 36^m$, 5 conf. and 3 others. The weather was clear and bright. The number for the hour (16) corresponds with the number (18) for single observers on that night at New Haven. On the next morning Mr. Marsh saw in 36 minutes, between 12^h and 1^h, 23 conf. and 5 unconf. meteors. Later in the morning the sky was mostly overcast.

5. *At Newark, N. J.*—Mr. C. G. Rockwood, on the night of Nov. 12th–13th, watched from $10^h\ 45^m$ to $2^h\ 30^m$ A. M., omitting the quarter hour from $12^h\ 45^m$ to 1^h. The sky was clear except a haze near the horizon. The following table gives the results.

	Conf.	Nonconf.	Total.
From $10^h\ 45^m$ to $11^h\ 0^m$,	0	5	5
" 11 3 " 12 0,	2	23	25
" 12 0 " 12 45,	6	5	11
" 1 0 " 2 0,	16	15	31
" 2 0 " 2 30,	5	8	13
Total in $3^h\ 27^m$,	29	56	85

On the next night, with four assistants, he watched from $11^h\ 20^m$ to $2^h\ 40^m$, counting 261 meteors, as follows:

Time.	Conf.	Nonconf.	Total.	Duration.
$11^h\ 20^m$–$12^h\ 0^m$	13	43	56	in 40^m
12 0 –12 30	27	29	56	30
12 30 – 1 0	33	24	57	30
1 30 – 2 0	40	15	55	30
2 0 – 2 30	20	14	34	30
2 30 – 2 40	2	1	3	10
Total,	135	126	261	in $2^h\ 50^m$

For a good part of the time it was cloudy in the south and southwest and also low down in the northeast. After 2^h A. M. the clouds increased rapidly and soon covered the sky.

6. *At Poughkeepsie, N. Y.*—Seven of the pupils of Miss Maria Mitchell saw, at the Vassar College Observatory, 354 meteors in seven hours on the night of Nov. 12th–13th, and on the next night 419 were seen by six of them in five hours.

7. *At Canonsburg, Pa.*—Prof. Kirkwood reports 64 seen by six persons in 45 minutes, ending at 4^h 39^m A. M. of the 13th, of which about 50 were from Leo. The next night was cloudy.

8. *At Franklin, N. Y.*—Mr. William A. Anthony, with two assistants, counted on the morning of the 14th, between 2^h and 4^h, 180. On account of the cold it was impossible to stand still and watch the heavens, and one hour, or an hour and a quarter at most, would, he thinks, include the time they were watching.

9. *At Cambridge, Mass.*—Mr. F. W. Russell watched during several evenings in the first half of November. He has plotted 60 or 70 flights, which were remarkable for size or beauty, and reports 875 in all. The details have not yet been received.

10. *At Chicago, Ill.*—Mr. Francis Bradley reports 27 meteors seen by three persons in one hour ending at 2^h 30^m on the morning of Nov. 12th. On the next night five observers saw in the hour and a half ending at 1^h A. M., 65 meteors, of which 24 were from Leo. Clouds or haze prevented further observation.

11. *At Olivet, Mich.*—Prof. J. H. Hewitt, to whom on account of his previous experience in observing I had written requesting particular attention to the shape of the radiant area, watched on the night of Nov. 12th–13th, together with Mr. M. R. Gaines, from 11 to 5 o'clock. The night was mostly clear. He says: "of those which went from the Sickle, the tracks of the larger number, I think, were in the general direction of a line joining γ and ϵ, and these tracks were much nearer together than the tracks of those which proceeded in a direction perpendicular to that line. That is, supposing an ellipse to represent the radiant area, the larger diameter would be in the direction of $\gamma\epsilon$. We frequently remarked that our observations coincided with your suspicions that the radiant area would be such an ellipse."

12. *At Detroit, Mich.*—Mr. O. B. Wheeler reports 56 for three observers for one hour from 2^h 20^m A. M. Nov. 13th. Forty-two were conformable. Clouds prevented observation on other nights.

13. Mr. Charles G. Boerner of Vevay, Ind., sends a chart upon which he has recorded the paths of meteors observed on the mornings of the 12th and the 13th. The next night was cloudy.

14. *At Iowa City, Iowa.*—A party of students of the Iowa State University, under the direction of Prof. Hinrichs, watched through the nights of Nov. 12th and Nov. 13th. During the first of these two nights the sky was mostly clouded except from

about one to three o'clock A.M., where it was pretty clear overhead. Thirty-five meteors were seen, of which twenty-two were in the hours named. Three persons were observing.

On the next night, Nov. 13th–14th, it was partially overcast until near 10 o'clock. The number seen was 440. The hourly number, the number of observers, and the state of the sky, are given in the following table.

Time.	No. obs.	No. seen.	Sky.	Time.	No. obs.	No. seen.	Sky.
$8\frac{1}{2}^h$– $9\frac{1}{2}^h$	3	4	Cloudy.	$12\frac{1}{2}^h$–$1\frac{1}{2}^h$	4	90	Clear.
$9\frac{1}{2}$ –$10\frac{1}{2}$	3	8	Partly clear.	$1\frac{1}{2}$ –$2\frac{1}{2}$	5	112	Clear.
$10\frac{1}{2}$ –$11\frac{1}{2}$	3	7	Some clouds.	$2\frac{1}{2}$ –$3\frac{1}{2}$	5	138	Clear.
$11\frac{1}{2}$ –$12\frac{1}{2}$	4	61	Clear.	$3\frac{1}{2}$ –$4\frac{1}{2}$	5	20	Clouding.

Soon after $3\frac{1}{2}^h$ A.M. the sky became wholly overcast. The next night the sky was also entirely covered.

15. *At Washington, D. C.*—Observations were made at the U. S. Naval Observatory which will soon be published in full.

16. *In Bay of Panama.*—Mr. Frank H. Bradley writes to Prof. Twining, that with about a quarter of the sky clear he counted eleven meteors between 1^h 45^m and 2^h 30^m A.M. on the morning of Nov. 13th. The sky then became overcast.

On the next morning he was on deck from 2^h to 3^h A.M., and in that time counted 30 meteors, 17 of which seemed to be radiant from a point near the horizon in the N.N.E. The sky was clear from N.E. to N.W. and a little past the zenith, but about 3^h A.M. the clouds closed entirely.

On the night of the 14th–15th he was on deck for some time, with much clear sky, but saw no meteors.

17. I am indebted to Prof. Henry, who has kindly placed in my hands for examination the reports received by the Smithsonian Institution from various observers.

Prof. Hopkins of Williams College gives the times of 205 meteors on the night of the 12th–13th, of 453 on the next night, and 4 on the third night. The apparent paths of a large proportion of them is also given. The following are the numbers for the successive hours.

Time.	12th–13th.	13th–14th.	Time.	12th–13th.	13th–14th.
Before 7^h	1	6	12^h–1^h	2	51
7^h– 8	2	9	1 –2	10	71
8 – 9	0	19	2 –3	45	53
9 –10	7	16	3 –4	40	61
10 –11	10	21	4 –5	41	69
11 –12	23	33	5 –6	24	44

Between 11^h 30^m P.M. and 2^h 15^m A.M. of the first night the clouds interfered seriously, and sometimes even covered the sky. This series of observations will no doubt prove to be of special value for the computation of altitudes.

The reports received by the Smithsonian Institution from a large number of other observers will be of value for the same purpose.

18. Two meteors deserve special notice. One at $11^h\ 7^m$, Nov. 13th, appeared at New Haven low in the Lynx, and passing a little north of the zenith, crossed Andromeda between α and β, and disappeared low in the S.W. having described a path of 135°. I was at first a bright point, but after a time burst out into a flame and left a train for several seconds. The duration of flight was called four seconds. At Newark and Philadelphia the same star described a similar long arc. At Williamstown it appeared 5° from Mars towards Canis Minor, and ended ½° S. of Diphda; duration 7 seconds. These data give the first altitude 88 miles (142 kilometers), the least altitude 66 miles (106 km.), and the length of the path, according to the Williamstown observation, 325 miles. It must have passed beyond Diphda, however, as seen from that place, since it disappeared in the S.W. at Philadelphia. Seven seconds for 325 miles gives 46 miles per second for the velocity, a result probably too great.

19. At 11 minutes past 2 o'clock A.M., Nov. 14th, a very bright green (or blue) meteor appeared, at New Haven, in R.A. 148°, Dec. +16½°, and went to R.A. 143½°, Dec. +9°, leaving a train about 4° long. This train floated away 8° to the north in a path parallel to the horizon, being visible for 9 minutes. Before disappearance it had become shorter and broader so as to be 2° or 3° long and 1½° broad.

The same meteor was seen in Newark by Mr. C. G. Rockwood to descend vertically, ending at R.A. 163°, Dec. +15½°. The cloud or train floated also northward, parallel to the horizon, crossing δ Leonis. A corresponding path is given by Mr. Henry M. Parkhurst of Brooklyn.

At Williamstown the record was "origin 20° south of Regulus: course W.S.W.; length 40°; blue trail."

The first altitude was then about 120 miles (193 km.), the altitude at disappearance about 60 miles (97 km.), and the length of path 115 miles.

The cloud as seen from Newark bent up as is usual with such trains, while at New Haven it only grew shorter and broader, a result doubtless of perspective. The meteor's distance from New Haven at disappearance was 120 miles, and the cloud was doubtless still farther from us. Hence its length must have been more than 5 miles and its breadth over 3 miles. The true motion of the cloud was northward, at right angles to the motion of the meteor, being in nine minutes at least 17 miles, and probably about 20. It was evidently due to a current in the atmosphere, whose velocity was about 125 miles per hour.

The material of the meteor must have been considerable in order to have filled several cubic miles with its debris. And yet this debris must have been very attenuated to float in an atmosphere so light as that which is 60 or 90 miles from the earth's surface.

20. The great display which was looked for with such general interest both in this country and in England was witnessed in Europe early on the morning of the 14th.

At Valentia, Ireland.—The following is an extract from a letter from Dr. B. A. Gould, who was at Valentia, Ireland, engaged in determining the longitude of American stations by means of the Atlantic cable.

"At 12^h 30^m (Greenwich time) meteors were so abundant that I caused the telegraphic staff to be aroused, in confident expectation of a 'meteoric shower.' From this time to about 2^h 25^m A.M. the sky was quite clear (except for six or seven minutes), not more than one-fourth part being at any one time obscured. At 1^h A.M. the sky was brilliant with meteors of every degree of brightness, from the 4th magnitude to 15′ diameter, and the brilliancy of Jupiter. The largest ones, and certainly there were fifteen or twenty such, were as brilliant and large as a ship's rocket at half a mile distance.

"The comparatively slow and uniform movement of most of them, their long bright trains, and pure white light, presented a strong resemblance to a flight of rockets.

"The center of divergence was in Leo, then not high in the east. The radiant was not well defined, but a locus of probably a degree and a half in diameter. I think that I observed ten or twelve of which the paths produced would form tangents to such a circle.* During the whole display I saw but two unconformable meteors, both of them faint. * *

"Between 12^h 39^m 0^s and 1^h 5^m 0^s I counted 310. * * * With the aid of a friend, who faced south while I faced north, I counted 203 during the 90 seconds between 1^h 9^m 0^s and 1^h 10^m 30^s. Ten minutes later the frequency seemed to have much diminished.

"At 1^h 38^m there were not more than 65 or 70 to the minute, and frequently five or six seconds would pass without any being seen.

"Between	1^h	45^m	15^s	and	1^h	46^m	15^s	(1^m)	only	23	were seen.
"	1	49	0	"	1	51	0	(2^m)	"	22	"
"	1	58	0	"	2	1	0	(3^m)	"	17	"

"At 2^h 15^m they seemed scarcely more numerous than on an ordinary August night."

21. *In Exeter, England.*—Mr. J. T. Tucker, of Exeter, in a letter to the writer states that he counted 954 meteors between 12^h 30^m and 1^h 30^m A.M. of Nov. 14th.

22. *At Manchester, England.*—Mr. Joseph Baxendell, F.R.A.S., devoted special attention to the place of the radiant, and the time of the maximum. He gives for the former, R.A. 149° 33′, Dec. +22° 57′·5, which is the mean of a number of observations. For the time of maximum frequency he gives 1^h 12^m A.M. (Gr. time), and thinks that the probable error cannot exceed one minute. He saw the shower of 1833, being then at sea off the west coast of Central America, and says that the present display

* A diagram gives the center of this circle as about R.A. 148°, Dec. +23½°.

was far inferior to the former, both in the number of meteors seen and in the brilliancy of the larger ones.*

23. *At Greenwich.*—According to an extract from the *London Herald*, the hourly numbers seen at the Greenwich observatory were as follows:

9^h–10^h	10 meteors,	12^h–1^h	2032 meteors,	3^h–4^h	528 meteors.
10 –11	15 "	1 –2	4860 "	4 –5	40 "
11 –12	168 "	2 –3	832 "	Total,	8485 "

24. *Thickness of the group.*—The inclination of the plane of the group to the ecliptic is probably about twice the latitude of the radiant, or 19°. The denser part of the shower was included in a period of about 1^h 30^m; and during this time the earth moved about 100,000 miles. The corresponding thickness of the group would be 100,000 sin 19°, or 33,000 miles. The density gradually diminishes as we leave the center of the group, and the thickness, including these rarer portions would be much greater.

25. *Geographical limits of the shower.*—The sun was vertical at 12^h 30^m A.M. (Gr. time) in E. lon. 168½°, S. lat. 18¼°. If this time be taken for the beginning of the shower as a great display, and if 10° be allowed for twilight, a line crossing the equator in E. lon. 68½° and running N. 18¼° E. separated daylight from darkness and forms the eastern limit beyond which the shower was not probably visible.

The radiant was vertical at 2^h A.M. (which may be taken for the end of the shower) in N. lat. 23½°, E. lon. 65°. The western limit would be a great circle of which that point is a pole, to wit, a line crossing the equator in W. lon. 25°, and running N. 23½° W. This line passes from Newfoundland through the center of the two Atlantic oceans. Regions west of this line were behind the earth throughout the shower. Along this line a few meteors with long paths were probably visible.

26. If there shall be a shower in Nov. 1867 (and it is quite probable that there will be one), and if the group lies sensibly in a plane, these limiting lines would be removed 90° or 100° westward. But what curves in the line of the group have been produced by the perturbing action of the earth, of Jupiter, and of the other planets we cannot say. Such curves apparently exist, and may change the time of maximum, and therefore the region in which the shower may be expected next November.

When full and authentic reports from English astronomers shall be received I hope to resume the subject.

* Proc. Man. Lit. and Phil. Soc., vi, 31.

ART. XIII.—*Correspondence of Prof.* JEROME NICKLÈS, *dated Nancy, October 2d,* 1866.

Obituary: Hermann Goldschmidt, the Astronomer.—The subject of this notice attained to a considerable reputation as an artist, but he is better known to the scientific world, in which he held a high position, by his numerous discoveries among the heavenly bodies.

He was born June 17th, 1802, but during his whole life his health was delicate. Destined at first to commerce, he quitted it to devote himself to painting, and early became distinguished in that career. He was, however, ignorant of his true vocation until he had attained the age of forty-five years. One of his friends, Dr. Hoefer, to whom we are indebted for these details, tells us the circumstances under which he became an astronomer. The recital is copied from Goldschmidt himself. "I had just returned," says he, "full of disgust from a very long sojourn in England. I tried in innumerable ways to dissipate my melancholy humor, but without success, when one day I chanced to attend LeVerrier's lecture on astronomy. The professor explained an eclipse of the moon which was to take place the same evening (March 31st, 1847). I understood the explanation, and in my enthusiasm I exclaimed *anch' io son.* From that moment I commenced with ardor to study a science of which I had as yet only the feeblest notions."

Three years after, Nov. 15th, 1852, Goldschmidt discovered, with a small glass which he had just bought, a planet which received from Arago the name of *Lutetia*, having the brightness of a star of the 10th magnitude. The 26th of October he discovered *Pomone*, which resembled a star of the 11th magnitude. He afterward successively discovered the following: *Atalante*, Oct. 5th, 1855; *Harmonia*, March 31st, 1856; *Daphne*, May 22d, 1856; *Nysa*, May 27th, 1857; *Eugénia*, July 11th, 1857; *Melete*, Sept. 9th, 1857; *Palés*, Sept. 19th, 1857; *Doris*, id.; *Europa*, Feb. 6th, 1858; *Alexandra*, Sept. 10th, 1858; *Danae*, Sept. 19th, 1860; *Canope*, May 9th, 1861. By reason of these discoveries he several times received the astronomical prize from the Academy of Sciences. He also determined the position of more than ten thousand stars which before had no place upon any known map of the heavens—and it was among these stars that he found the planets previously enumerated.

He made these discoveries with a small glass—and his observatory was situated in one of the most frequented streets of Paris. Not favored by fortune, Goldschmidt lived on a pension paid him by the French government. For a long time he had been troubled with his eyes, but this affliction affected him much less than diabetes, the symptoms of which he first felt in 1854. He then retired to the country, and for three years lived at Fontainbleau, dividing his time between painting and astronomy. Toward the latter part of last August his disease became complicated with other difficulties. He hastily finished his papers upon the physical constitution of the sun, and died on the 20th of August. He leaves a widow and two daughters without fortune. They will doubtless be adopted by the "Société de Secours Amis des Sciences."

Spectrum of aqueous vapor.—We now know the nature of the rays which Brewster discovered in 1833, and which have since been termed telluric or atmospheric. M. Janssen has made several investigations under the patronage of the Minister of Public Instruction, and has found that these rays are occasioned by the vapor of water. By means of new optical dispositions he has proved that the bands of Brewster were formed of fine lines, like the lines of Fraunhofer, and that they were constant in the spectrum, though of variable intensity according to the height of the sun. Relying upon this character of the telluric rays he has made a chart of the spectrum in which the distinction between the solar and telluric rays is clearly shown.

Janssen has also made numerous other experiments. In September, 1864, from the summit of the Faulhorn, he observed the rays of terrestrial origin and found they became weak in proportion as they were elevated and as the light had less thickness of atmosphere to traverse. In the same year he made an experiment upon Lake Geneva, and by reason of the humid air of the lake he was able to reproduce the same rays artificially. The flame from a large pile of pine wood at the distance of 21 kilometers presented these lines, but when viewed at a less distance no ray was visible except the brilliant one of sodium. Janssen stationed himself on the side of the lake opposite the fire, so that the light from the blazing pile, which was on a level with the surface of the water, might penetrate strata of air saturated with moisture.

It was necessary to ascertain if these effects were caused by the water in solution in the atmosphere, or whether, as Mr. Secchi thought, they were to be attributed to the vesicles of which mist and fogs are composed. A direct experiment confirmed him in the opinion that they were produced by the vapor. Janssen operated with a tube thirty-seven meters in length, which was filled with vapor by a steam engine of six horsepower. Care was taken to prevent the tube from cooling, and the light was furnished by a flame of gas placed in the axis of the tube. When the light passes through the tube filled with vapor subjected to the pressure of seven atmospheres it shows the principal telluric rays, among which Janssen places the groups A and C and a large part of B, contrary to Kirchhoff, who attributes A and B to potassium. The red and yellow of the spectrum of water-vapor are more brilliant than the blue and violet. Therefore the color of the vapor of water should be orange; hence, also, the red of the setting sun, that is, of the sun seen near the horizon. Janssen does not agree upon this point with the conclusions of Prof. Cooke, which were published in this Journal for March, 1866. According to the latter the vapor of water absorbs most completely the yellow and the red rays, hence the blue rays predominate in the spectrum that is transmitted. Prof. Cooke has, however, discovered and demonstrated by his own researches (this Journal, [2], xli, 184, also Journal de Pharmacie et de Chemie, June, 1866, p. 480), the influence of the vapor of water upon the phenomenon in question.

A new property of magnesium.—One evening while preparing some perchlorid of manganese, $MnCl^2$ (this Journal, [2], xli, 107), with the peroxyd of manganese, the chlorhydric acid of commerce and ether, I observed that the color was not green, as it appeared to be in the daytime, but *black*. I was using gas for a light, and substituted in place of it first an oil lamp and afterward a wax candle, but the effect was the same, the color still appeared only black.

The *green* color reappeared by the flame of magnesium, which comports itself in this respect like the light of the sun. It is well known that bright-tinted flowers, colored stuffs, or pictures, exhibit much less brilliancy of coloring by wax or even gas light than when seen by the light of day, and should an artist, at the close of the day, wishing to supply the waning light, continue his work by the aid of wax lights or gas, he would be surprised the next morning at the assemblage of colors he had made the evening previous. They would in no way represent his thought, so different would they appear when viewed in the two lights.

By burning a thread of magnesium a light may be obtained which will make these colors appear the same as when seen by sunlight itself. Colors do not mingle or interchange by this light as they do by ordinary lights. Green does not appear to be blue in it, neither does blue have the slightest appearance of green. In short, all shades preserve the same appearance as when viewed in the full light of day. The flame of magnesium is whiter than solar light, and the blue predominates in it. Chemistry aids the painter not merely by furnishing colors more or less bright, but it now gives him a new mode of illumination by means of which he can labor at night without fear of optical deception, as well as if it were daylight.

The influence of sodium upon flame.—On inquiring the reason for the extinction of color by the usual flame, which we have just been discussing, it will be found that numerous causes produce this effect, one of which is *sodium*, which burns with a *yellow* (monochromatic) flame, that may be obtained either by bringing common salt supported on platinum wire into the flame of the Bunsen lamp, or by burning alcohol saturated with salt. All the colors are altered by this flame, with the exception of blue-violet, which is complementary to the yellow. Red appears black or white, sometimes bluish when it contains blue (see below, *physiological effects*). Mixed green appears *yellowish* or bluish (chlorophyl Schweinfurth green). The pure greens appear black (ex. $MnCl^2$, $MnBr^2$, MnI^2 combined with ether, $BaOMnO^3$, Cr^2O^3, gold leaf seen by transmitted light, Cr^2Cl^3, &c.). Vide Annales de Chem. et de Phys., [4], viii, 298, for the enumeration of the various colors which have been experimented with.

The following table gives the result of some trials which I have made with a spectrum prepared by applying pigments to white paper. We give the composition of the spectrum and the colors with which it was obtained.

Colors seen by daylight.	Coloring material.	Colors seen by a monochromatic flame.
Red.	Ochre (Fe^2O^3), - - -	Black.
Orange.	Iodid of mercury (HgI),	White.
Yellow.	Chromate of lead ($PbOCrO^3$).	White.
Green.	Manganate of baryta, - -	Black.
Blue.	Aniline blue,	Black.

In this spectrum so wonderfully changed by the flame of alcohol saturated with salt, sunlight and the flame from magnesium instantly restored the normal colors, even while the sodium flame was burning in the neighborhood. They also reappeared by gaslight, but with much less intensity, and when the colors are not very brilliant they are modified as if they were illuminated by the soda flame.

Thus etherial solution of perchlorid of manganese when impure appears by gas light *black* instead of *green*. A mixed green composed of chromate of lead ($PbOCrO^3$) and ultramarine behaves in the same manner.

If the illuminating flame were saturated with sodium its extinctive effects would be still more energetic, ordinary flames containing but very little of this metal. Spectral analysis shows us that instead of completely extinguishing colors it merely alters them a degree more or less, darkening some and enlivening others, and creating confusion between blue and green.

The small quantities of sodium which all ordinary flames contain, are derived from several sources, viz., the mineral matters of wicks of lamps and candles, ashes of fuel and atmospheric air, which last, according to Bunsen, always contains traces of it.

Vogel has determined the proportion of soda which illuminating gas contains (Journ. de Pharm. et de Chem., October, 1866), and Mulder has shown (in the same Journal, May, 1866), with what facility marine salt volatilizes when heated with coal.

Small as the quantity of sodium is which illuminating gas contains, it is sufficient to affect certain colors, and to produce on a small scale all the effects of absorption or extinction which are readily seen in a flame saturated with it. Examples of this may be seen in certain green colors mentioned above.

Physiological effects of the monochromatic flame.—The foregoing results explain a well known phenomenon, which has hitherto never been accounted for. In the flame of alcohol and salt, the hands and face appear of a *livid green* hue, while the lips change to a *blue-violet.* This livid tint is known to all who have seen punch or a pudding burn, and is due to the alcohol more or less saline which is employed in these mixtures. Workmen at furnaces and forges are familiar with these peculiar tints, which appear upon the features illuminated by their fires.

In the first case the effect is produced by the NaCl which the alcohol contains of itself or which it derives from the alimentary substances; in the latter case the soda is obtained from the dross, and ashes of the combustible matters. The question arises, why under these conditions, the natural flesh color is changed to a *bluish* or livid green. The reply is evident. It has been shown above, that the colors which best resist the extinctive effects of the soda flame are those which come from blue.

That there is blue in human blood may easily be seen by the color in daylight of the large veins on the skin of the hand. All the other tints which enter into the composition of flesh color being extinguished except the blue, that shade alone remains upon the face of the experimenter, but being also illumined by a yellow flame, it is plain that the effects of the two colors will be to produce a *green*, varying in shade from yellowish to bluish according to the intensity of the blue, and producing a most sinister aspect on the human countenance. The eye speedily accommodates itself to these effects, but I have good reason for thinking that one cannot with safety, continue to work for any great length of time by this monotonous light. The retina after a time becomes so much affected as not to be able to bear without irritation either daylight or the ordinary illumination used at night, a result possibly caused by the absence of chemical rays in the flame, or because it injures the optic nerve which is poorly adapted to such a medium.

After sitting for a considerable time in the soda light, there comes a time when it is difficult to distinguish between the different shades of the same color. I have many times seen a tuft of leaves appear of the identical shade of the hand which held it, so that the whole had the effect of a bronze, while at the beginning of the experiment before the eye had become fatigued, it was easy to distinguish between the violet of the chlorophyl and the livid green of the flesh color.

Employment of the Sodium flame by artists.—We have previously shown that the different colors of the spectrum may be reduced to white or black, unless they contain blue which is the only color unaffected by the soda flame.

In observing such a spectral image it will be noticed, that if all the colors are reduced to either white or black, the borders are more or less darkened or dulled as in a photograph of the spectrum. Looking at a painting, especially a pastel containing very little if any blue, under these conditions, one is struck with the fact, that although the colors vanish, the grayish tone which represents them gives the appearance of a pencil drawing. The model or plan exists by reason of the half tints so that by the monochromatic light, one is sometimes able to go back to the design without touching the picture and can thus give in some sort the autopsis of a work of art.

The flame of sodium may yet aid the painter in comparing shades, in grouping colors and weighing their tones.

In the same manner, two colors, for example two *greens* which appear identical upon the palette, in the daytime, may be different when seen by common evening light, and are more likely to differ when viewed by the sodium flame, one being decolorized and the other transformed into black. In the same manner, of two *reds* seen under the same conditions, one may appear white, while the other containing *blue*, will assume a *violet*-tint complementary to the yellow of the monochromatic flame.

Common salt ignited on a platinum wire in the flame of a Bunsen burner, strikingly exhibits the chemical differences which sometimes exist between two similar shades of color. This means may be useful in distinguishing original pictures from copies, for it is not likely that Raphael or Van Dyck, for instance, exployed exactly the same pigments as their copyists have used.

If one desire to render the flame of a gas burner or of an oil lamp monochromatic, it cannot be done with NaCl, for the flame is not hot enough to volatilize that compound. Metallic sodium should be used for this purpose, which may be introduced into the gas burner or held in the flame upon platinum wire.

Perchlorid of Lead, $PbCl^2$.—In connection with what we said last year (this Journal, [2], xli, 107 and 55) upon the halogen compounds corresponding to the peroxyds, we have since obtained the compound $PbCl^2$ corresponding to the peroxyd of lead PbO^2. Unstable in a free state, it may be preserved for a long time in presence of a solution of chlorid of calcium.

It is prepared by passing a current of chlorine into chlorid of lead held in suspension in a solution of CaCl of 40° Beaumé. The liquid becomes yellow and acquires very curious properties. Thrown into a small quantity of water, it gives a precipitate of PbCl—with excess of water a brown precipitate is formed of PbO^2. $PbCl^2+2HO+Aq=PbO^2+2ClH+Aq$.

In this case the hydrochloric acid does not react, because of the excess of water present, if there were less the result would be $PbO^2+2ClH=2HO+PbCl+Cl$.

The perchlorid of lead does not act upon the nitrate of bismuth, behaving in this respect differently from $TlCl^3$ (this Journal, [2], xli, 107). When heated it blackens cane sugar but not glucose, and hence may serve to distinguish between these two kinds of sugar.

Treated with anhydrous ether and syrupy phosphoric acid, the solution of perchlorid of lead thickens, and yellow oily drops appear, which are perchloro-plumbic ether. This ether readily dissolves gold, and as the metal is taken up chlorid of lead separates assuming the form of the gold employed. The perchloro-plombic ether readily decomposes; the products are protochlorid of lead and chlorinated ethers. The ease with which chlorine separates from it, is the cause of its solvent power on gold, in which respect it is like the bodies presently to be noticed.

New solvents for Gold.—The perchlorids dissolve gold readily when that metal is in the form of leaf, on account of the facility of their decomposition with liberation of chlorine. If ethereal solution of perchlorid of manganese be employed, the green color of the manganese compound grows lighter in proportion as the gold dissolves, for $MnCl^2$ is reduced to MnCl, and the reaction is complete, when the liquid has exchanged its green color for the yellow of the solution of gold, (it is the same with $MnBr^2$ and MnI^2).* On evaporating the liquid, a film of gold adheres to the vessel. The same solution added to $FeOSO^3$ yields the precipitate of gold so characteristic for its dichroism.

The sesquichlorids, and the sesquibromids which are easily reduced—for example, the compounds corresponding to Mn^2O^3, Ni^2O^3, Co^2O^3; also Fe^2Br^3 even in presence of a certain proportion of FeBr—dissolve gold; Fe^2I^3 is also a good solvent for gold especially in presence of ether. It is only necessary to add a small quantity of Fe^2O^3 to the ethereal solution of iodhydric acid, in order to dissolve the metal. This proves that iodine in the nascent state acts upon gold. For this reason gold is acted upon even by iodhydric acid *in presence of ether.* No action takes place when only water is present. It can no longer be said with truth, that free iodine does not act upon gold. I have found that gold may be dissolved by it in presence of water,

* This Journal, [2], xli, 107.

when put into a close vessel and raised to a temperature of 50°. The action is more slow if ether is used in place of water. Exposure to strong sunlight will hasten the solution.

Some new facts concerning amalgamation.—In vol. xli, p. 225 of this Journal, Prof. Silliman has described some properties of the *magnetic amalgam*, composed of mercury and sodium. The following experiment readily shows the great difference between the action of mercury and that of sodium amalgam.

Take a square of glass, to which apply side by side two leaves of beaten gold. If a drop of ordinary mercury be placed on one of these leaves, it adheres without sensibly increasing in area. On the contrary a small drop of the amalgam spreads out with great rapidity, so that in a few seconds the mercury has covered a space many hundred times larger than that which the original drop occupied.

I showed in 1853 (in this Journal)* that the metals moistened by mercury are permeable to it; that proposition has been verified upon the metals since discovered or prepared, viz., *thallium*, *aluminium* and *magnesium*. Thallium is easily amalgamated, and becomes brittle by the penetration of mercury; on the contrary, magnesium and aluminium resist its action or are not wetted by it until recourse is had to electric action, such as is realized by the intervention of sodium or zinc.

It would be interesting to observe the deportment of *indium* toward mercury. If it were capable of being moistened it would form with it a brittle amalgam; on the other hand, if it were not moistened it would retain all its elasticity. I leave the question to those who are fortunate enough to possess this metal so rare, and so difficult to obtain in a metallic mass.†

Chemical synthesis.—M. Berthelot continues his beautiful researches in synthesis, and is at present occupied with the generation of hydrocarbons. Our readers know that he formerly obtained acetylene, C^4H^2, by the direct union of hydrogen and carbon (this Journal, 1862). Berthelot has lately shown that a whole series of hydrocarbons, polymeric with C^4H^2, may be derived from it as follows:

Acetylene,	C^4H^2	
Di-acetylene, - - - -	C^8H^4	$=2C^4H^2$
Tri-acetylene or benzine, -	$C^{12}H^6$	$=3C^4H^2$
Tetracetylene or styrolene, -	$C^{16}H^8$	$=4C^4H^2$
.... - -	....	
Retene, - - - - -	$C^{36}H^{18}$	$=9C^4H^2$

This table is the result of actual experiment and not of theoretical speculation.

* J. Nicklès, On the Permeability of Metals to Mercury, [2], xv, 107.

† A sheet of platinum that has been for four months in contact with amalgam of sodium still preserves all its elasticity.

Berthelot has observed still another series of hydrocarbons, between styrolene and retene, the boiling point of which is between 250° and 340°, and which possess to a great extent the characteristic fluorescence of pyrogenic oils of resin. Berthelot regards these hydrocarbons as C^4H^2 six, seven, and eight times condensed. Between 210° and 250° there passes over a liquid which, when placed in a freezing mixture, yields crystals of naphthaline. The origin of this interesting hydrocarbon is easily explained, naphthaline being in fact only pentacetylene less H^2.

$$\underbrace{C^{20}H^{10}-H^2}_{\text{Pentacetylene.}} = \underbrace{C^{20}H^8}_{\text{Naphthaline.}}$$

Naphthaline is produced equally well when acetylene is passed into a tube heated to redness. There is, however, in this case but a small quantity formed, for the acetylene is chiefly decomposed into carbon and hydrogen.

Acclimation of the Camel in Australia.—The introduction of the camel into Australia has been previously announced, and it was effected by the "Société d'Acclimatation." We now learn that these animals have adapted themselves to that country, as has been shown by a recent expedition consisting of seventy horses, fourteen camels, and fifteen men. The springs of living water upon which they depended having been dried up, sickness broke out in the camp. The men fell back upon their stores of spirituous liquors, the horses took to flight, while the camels alone remained at their post. It is owing to this circumstance solely that the expedition was reorganized. At last accounts the caravan had arrived at Thompson river.

Acclimation of the Salmon.—The eggs of the salmon which have been introduced into the waters of Australia have hatched and the young fish are prospering. Ice has been used in the transportation of the eggs, which, according to Mr. Youle, retards the phenomena of embryonic evolution. This gentleman has found that the vitality of the eggs may thus be preserved for three or four months. It is in this manner that eggs taken from the Rhine at Huningen in Alsace have been successfully transported to Australia. Sweden and Norway are both occupied in stocking their rivers with salmon, so that the fine example of the Zoological Society of Acclimation will not be lost.

Spontaneous generation.—This interesting question is from time to time discussed by the Academy of Sciences, but without much progress being made toward a decision. Mr. Donné, a naturalist who formerly opposed the doctrine of spontaneous generation, has made some late researches which have caused him to change his mind on the question, and he has just ranged himself on the side of Messrs. Joly, Musset, and others, giving it as his opinion that spontaneous generation is a possible fact.

His later experiments, like those which he published an account of in 1863, were made with eggs. At that time he wrote: "The matter of which the egg is composed ought to be eminently suited to a primitive organization. I will leave the entire eggs to themselves, and when the alteration of their contents has well progressed, I will examine with the microscope the interior substance. If spontaneous generation is possible I ought to find organized beings there." The result was negative. Mr. Donné found neither mold nor infusoriæ, and he decided against spontaneous generation. Since then objections have been raised which decided Donné to resume his experiments. He reasoned thus: "The small quantity of air contained in the eggs was perhaps not sufficient to determine the phenomenon of a spontaneous generation, that is, to give life to a certain molecular arrangement of organic matter." Consequently he conducted his experiment in such a way that a larger quantity of air could have access to the eggs, the air having been previously deprived of any bodies it might hold in suspension, by passing through carded cotton. This time he obtained a generation of different kinds of mold, but found no traces of animalcules. He concludes 1st, "Microscopic vegetation may be produced at will in organic matter, left to itself, and protected from the intervention of foreign germs. 2d. Air is necessary to the development of infusorial animalcules. 3d. Air is indispensable to spontaneous generation in both kingdoms. The temperature of 30° is the most favorable to these productions."

To these conclusions the adversaries of the doctrine oppose their usual objections, viz., there were sources of error in the experiment, atmospheric germs in some way penetrated the eggs of which the shells were broken. The question thus remains still at the same point, and up to the present time it cannot be said to be experimentally resolved.

Mexican Scientific Commission.—This commission, instituted by M. V. Duruy, Minister of Public Instruction, continues its labors, which will perhaps be the only work to survive the unfortunate intervention of the French in Mexico. The commission is engaged solely with science, and may be judged of by what has formerly been said of it in this Journal, (Jan. 1866, p. 110). The third part of the second volume of its publications has appeared, containing geological papers by J. Marcou upon the frontiers between Mexico and the United States; by MM. Dolfus, Pavie, &c., upon Mexican volcanoes; and the geological sections from Vera Cruz to Mexico. Other papers are reports upon the Mexican fauna and flora, also upon the ruins of Uxmal and Mayapan, Ti-hoo and Izamal, &c.

Bibliography.

Traité des propriétés des figures, par le General PONCELET. 2d edition, 2 vols. in 4°, avec planches.—This work, which is a complete *exposé* of this important subject, contains also the principal discoveries which the illustrious general has made in this department of inquiry. He has been engaged on the work since 1812, and was occupied with it when taken prisoner of war in Russia on the retreat from Moscow. The second edition, besides many improvements, contains *the general theory of the centers of harmonic means; polar reciprocity; analysis of transversals*, and their principal application to the projective properties of curves and geometric surfaces.

Cours d'algébre superieure, par SERRET. Membre de l'Institut, Prof. au College de France, et à la Faculté des Sciences des Paris. 3d edit., 2 vols. in 8vo.—The first two editions of this work were disposed of with great rapidity. The third contains many improvements by the author. While this learned man does not pretend that the work is a *complete* treatise upon higher algebra, it contains notwithstanding a body of doctrine which will be of great use to those geometricians who are engaged in this important branch of mathematical analysis.

Traité d'Astronomie pour les genes du monde. 2 vols. in 12mo, avec 2 planches and 162 figs. dans le texte.—This work contains a resumé of the lectures which Mr. PETIT has given during the last 27 years at the Observatory of Toulouse, of which he was director. The treatise is elementary, but calculations are not excluded. There are besides, in the form of notes, details and anecdotes in respect to important discoveries as well as distinguished astronomers.

Eléments de Mécanique, par Mr. VIEILLE. In 8vo, de 256 pages avec figures.—Vieille is Inspector General of the University of France. This work of his is designed for the use of the various colleges, and is fully adapted to that purpose.

Le Chimiste: a Journal of Chemistry applied to Arts and to Agriculture; published by HENRY BERGÉ, Professor of Chemistry at the *Museé de l'Industrie* at Brussels.—This journal appears semi-monthly, costs but 8 francs per year, and, according to its title, contains the novelties in the department of chemistry applied to the arts. Each part consists of 16 pages 8vo.

ART. XIV.—*On the supposed Tadpole nests, or imprints made by the Batrachoides nidificans* (Hitchcock), *in the red shale of the New Red Sandstone of South Hadley, Mass.;* by CHARLES UPHAM SHEPARD.*

No impressions belonging to this or any other geological formation surpass if they equal these in their extreme delicacy of surface and sharpness of outline, rivaling as they do in these respects the most perfect metallic castings. Dr. Hitchcock, by whom they were first described, has well observed concerning them, that even viewed by the side of the splendid specimens of foot-prints, rain-drops and other rock-markings displayed in the Ichnological cabinet of this college (Amherst), "they are the most attractive of all."

Dr. Hitchcock was led to conceive of and adopt the theory of their origin first suggested and made public by Prof. Silliman, Jr., and the late Capt. N. S. Manross, viz., that they proceeded from the gyratory movements of tadpoles; though he very cau-

* Several excellent photographic representations accompanied this paper, which are omitted, as it was impossible to do them justice on wood.

tiously observes, "in concluding that the impressions were made by batrachians similar to those now living, I am by no means free from doubts as to the identity of the phenomena."* The single figure he has given † (Pl. L, fig. 1) of these markings, if taken by itself does certainly favor the hypothesis adopted; though it fails in its uninterruptedly smooth and continuous surfaces as compared with the rough and broken sides of the recent tadpole cavities,—not to mention the rounded borders to the edges of the latter, when contrasted with the hexagonal outline of the corresponding part in these specimens. The cavities made by tadpoles morever are without any order in respect to each other, and vary somewhat among themselves in size and depth. Occasionally also, unoccupied spaces are seen between the holes, whereas in the shale nothing is more striking than the general uniformity among the impressions, and the very complete manner in which the entire surface is covered by them,—raised lines (sometimes resembling swollen veins), being the only boundaries between contiguous cavities.

The slabs of shale present three rather distinct varieties of these impressions, one of which is very accurately represented in the plate above referred to. In this the depressions are imperfectly arranged in rows, with a marked tendency to a concentric arrangement. The borders of the cavities are distinctly hexagonal, and the edges often equilateral. The cavities have a depth equal to about one-eighth their diameter. They are perfectly symmetrical, smooth and glossy. In a few of the specimens, the sides and bottoms are slightly pitted with ovoidal bodies of the size and shape of coarse gunpowder. The slab removed from such a surface of course exhibits upon its convexities corresponding granules in relief. As they are distributed without any order, and not generally present, they would appear to be due to seeds, as these of a larger size and spherical form are frequent in the formation.

In the second variety we have little more than the strongly nerved outlines of the hexagons. The cavity is shallow, or nearly obsolete; but on its bottom, and proceeding from one and the same side relatively in each impression, is often seen a tripartite, flame-like marking, or brush, which spreads over nearly half the area. The direction of this fan-shaped brush is constant throughout the series, thus evincing an origin from a common cause, and one that acted simultaneously. The impressions moreover are occasionally traversed by raised lines proceeding from a subjacent layer, and thereby subdivided into smaller compartments; but in these instances it is always easy to trace the hexagonal boundaries of the superior layer. The depressions are obviously arranged in rows, somewhat approximating to fur-

* Ichnology of New England, 4to, 1858, p. 122. Boston. † Idem.

rows, the parallel sides of which are more conspicuous than the transverse edges which subdivide the furrows into cells.

It may here be observed that the fan-shaped brush is scarcely at all visible in the first described variety. The diameters of the cavities in both are the same, being from one to one and a half inches. The differences in the depth of the cavities in the two varieties probably grew out of the hardness of the bottom where they originated.

The second kind, or shallow impressions, are constantly associated with the third variety presently to be described, being situated from one-quarter to one-third of an inch only above them. A series of singularly interrupted and overlapping wave lines, obviously the remains of the parallel or zigzag, furrow-edges of the second variety above described, plainly enough show that they were produced by ripple action, through a gentle current of water setting transversely across the furrow-ridges.

The third kind of impressions is considerably different from either of the foregoing, and requires a more particular description. The hexagons are disposed in long, nearly straight, parallel series, though now and then a row suddenly runs out where it abuts directly against a furrow-ridge; or in other words a ridge is seen to bifurcate, or to be replaced by a furrow. The cavities in this variety have nearly double the breadth or area of the two first varieties. In hexagons of the third variety the two opposite sides that are at right angles to the furrows have treble the length of the other two pairs, which seemingly have been shortened at their expense. The angles of the hexagon also are not equal. The four situated at the extremities of the longer sides, are less than 110°, while the two remaining (transversely opposite) ones are over 130°. The four shorter edges moreover are often flattened down into a broad band, while the long transverse ridges remain thin and sharp, though not straight at top, but gently arcuated. Indeed they are sometimes so low and faint as to become almost obsolete, thus changing the row of cells almost into a trough, whose borders are composed of the shorter zigzag sides of contiguous hexagons (under angles of 130°);—the whole seeming to have originated in a contraction of these sides, and a corresponding elongation of those at right angles to the furrow. The flattened band is not perfectly horizontal, but inclines a little toward the bottom of the trough, and constantly in one direction throughout the series,—its lower side being situated upon the upper or most shallow side of the hexagonal cell or cavity, or in other words the greatest depression in the furrow adjoins the superior edge of the band—it being kept in mind that the greatest concavity in the cells is never central but always somewhat marginal. In some of the slabs the furrow-edges are much less deeply truncated, rarely they are flatly bevelled; and in one case for a little distance, I have seen them replaced by four narrow planes. But the most singular feature of those specimens with a single broad band, consists in the presence upon it of a circular scar, which is uniformly located between the large angle of 130° and the adjoining smaller one of 110°, just in one corner of the impression, and always in the same corner relatively, throughout the series. Its diameter is about one-fifth of an inch, and it would appear to have arisen from the presence of some adhesive matter at these points which has operated to interfere with the usually easy cleavage of the shale, whereby several layers of it have remained adhering together, producing either a depression or an elevation upon it, according as the scar is found on one side or the other of the separated shale. In addition to the foregoing, the tripartite brush is seen radiating directly from the scar, obliquely into and nearly across the bottom of the contiguous depression, pointing as it were to the scar on the contiguous band.

It should further be mentioned that the repetitions of these impressions of each separate sort are very numerous, and each equally smooth, sharp and perfect, through a thickness of from one-third to half an inch, and in every instance where overlapped by a different variety, the parallelism of the rows is very obvious.

The difficulties in the way of the tadpole theory early induced me to question it as explaining the above appearances; and I was led to seek other modes of accounting for the phenomena more in harmony with the facts. For a time, at the suggestion of a very eminent authority in comparative anatomy, I endeavored to find an explanation in the supposition that they proceeded from the spawn of gigantic batrachians, whose footprints at neighboring localities are so common in shale of the same formation. But such an origin, besides other incompatibilities, required an organized association of the ova into a flat tier or mat, made up of parallel rows (one egg in depth), for rods in length and many feet in width. No reptilian germs are known to be extruded in such a shape. My next conception was, that the imprints may have owed their origin to a gigantic species of alga, allied to the *Hydrodictyon utriculatum*, though constituting a different genus, and possibly pertaining to a different family altogether, of these fresh-water plants.

A recent mineralogical visit to the granite quarries of Rockport at Cape Ann, by bringing under my inspection a very remarkable exhibition of ripple-marks upon the sea-shore, leads me to refer the South Hadley imprint to a similar cause. The recent ripple-marks occur in a very striking manner almost directly in rear of the Sandy Beach Hotel, in a somewhat sheltered place at the head of a little bay or cove, where the sand is fine and the bottom hard. A gently swelling, elongated bar, six or eight rods in length, running parallel with the shore is here found. Its breadth is about half its length, and its elevation where the highest, twelve or fifteen inches above the narrow flat creek-bottom between it and the shore. The breadth of this interval does not exceed ten or fifteen feet, the middle half of which is nearly flat, while the sides therefrom slope upward very gradually each way. The bar is left bare at about half tide. The water flows in and out of the creeklet at both ends of the bar, and when the tide is sufficiently high, flows back and forth cross-wise, to the bed of the creek. During the rising of the tide, the bed of this elongated depression is more or less covered with water for nearly an hour before the bar is wholly submerged. Throughout this period, as well as at all other times while accessible, and best of all, at low water, when the surface is left wholly bare, an almost perfect repetition of the second and third varieties of the South Hadley impressions is every where visible, though the size of the cavities is constantly from two to threefold that of the fossil specimens. With singular precision may be seen the parallelism of the furrows (corresponding with the sea-margin), the cross partitions (though generally more faint than in the shale), the zigzag margins formed by those sides of the cells which give rise to the furrow-ridges, the frequent splitting of a ridge so as to form an additional (an interpolated) furrow, the smoothing down of a ridge so far as to produce the flat band, and the almost constant occurrence of the deepest part of the trough on the down-hill side of the furrow. Other coincidences might be pointed out with the aid of drawings; but the foregoing are perhaps sufficient for our purpose. The appearances remained in full view during several days of calm weather, the pattern being only slightly interfered with, during the ebbing and flowing of the tide. At low water the configuration of the surface was invariable.

The examination of these sea-shore markings led me to recur to a large sandstone slab (with a surface two feet square) procured two years ago from the Forrest-marble Oolite of Wiltshire, England, on account of its crustacean foot-prints. Here also we are presented with ripple-marks of the same regularity as on the Rockport beach. In area, the cavities are just half way between those from the sea-shore and those from the New Red Sandstone. The zigzag lines of the furrow-ridges, the position and distinctness of the transverse partitions, the greater depth of the cavities constantly toward one side rather than in the middle of the furrows, and the occasional bifurcation of the ridges, so as to embrace an additional trough are all plainly conspicuous. This specimen taken along with the Rockport sea-shore ripples leave no remaining doubt in my mind that the origin of the appearances in all three of the cases is ascribable to the same cause: viz., to a wave-like, vertical motion produced by the air on the surface of nearly still water, combined with feeble horizontal currents (acting in directions nearly at right angles to each other) upon the bottom.

Amherst College, Oct. 15, 1866.

Art. XV.—*On a Theory proposed by Fresnel, and on a mode of measuring the average size of very fine particles;* by Ogden N. Rood, Prof. of Physics in Columbia College.

If the light from a candle-flame be received on a ground glass surface, so obliquely that the incident ray makes only a very small angle with the glass surface, the light will be copiously reflected, and a bright uncolored image of the flame will be seen by reflexion. As the angle made by the incident ray is increased, the reflected image becomes first yellow, then red, and finally disappears altogether.

Fresnel has attempted to account* for this fact, on the ground that the more refrangible rays, having shorter wave-lengths, are caused to interfere by a difference of path, which is still too small to effect complete interference in the case of the longer waves of red light; the difference in path, depending on the depth of the minute scratches on the surface of the glass, and on the angle which the ray makes with this surface.

As it is not difficult to measure approximately the angle at which the red ray ceases to be reflected, it would be easy to put this theory to the test of experiment, if the average depth of the scratches on the ground surface were known.

The impossibility of obtaining such measurements, has hitherto prevented this theory of the action of finely roughened surfaces on light, from being either confirmed or overthrown.

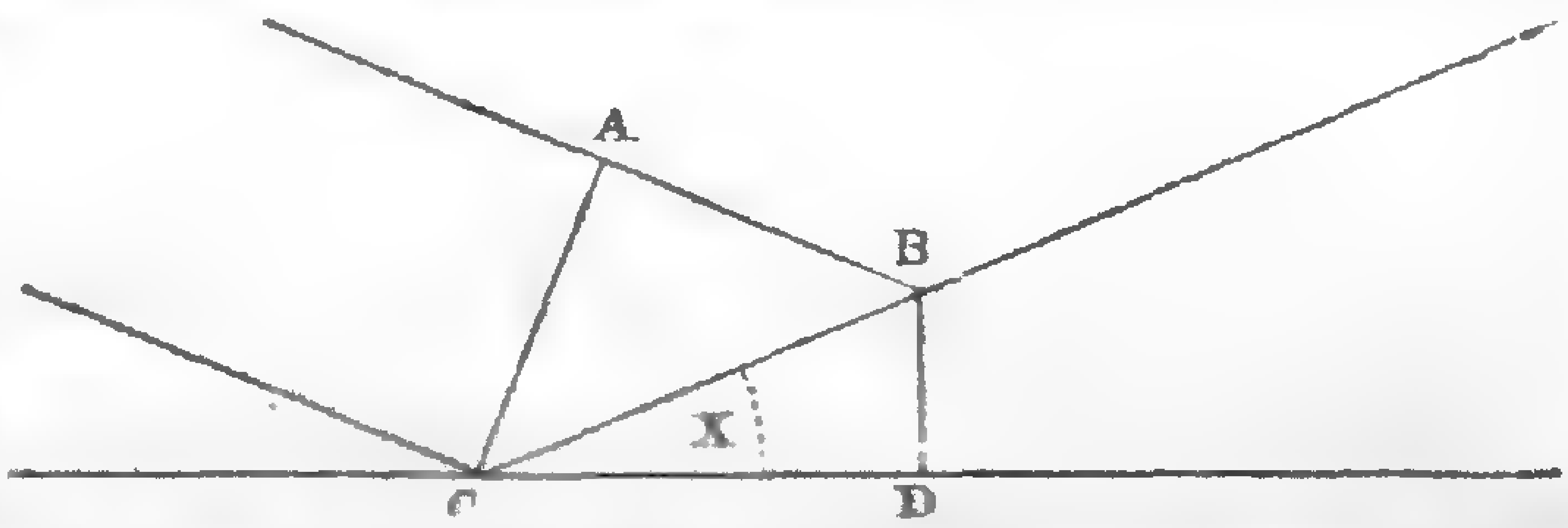
Some time ago, while experimenting on a plane polished surface of glass which had been smoked with lamp-black to complete opacity, I was surprised to find that the lamp-black surface, at a great obliquity, reflected all the rays of light with much brilliancy, so that it resembled in appearance a polished surface of metal or glass. With less degrees of obliquity the reflected light was yellow, red, and finally disappeared altogether.

The lamp-black surface in this experiment was obtained from burning paraffine, and it was found that the red ray ceased to be reflected at an angle of 18°, reckoning from the glass surface. The source of light was a small gas-flame and the experiments

* Pogg. Annalen, Bd. xii, p. 210.

were made in a darkened room at night, the glass plate with its lamp-black surface, being attached to the axis of a graduated circle, the lamp-black having been removed from the upper half of the plate, so as to allow the proper adjustments to be made with the aid of the naked glass surface. I then attempted to measure with the microscope the average size of the smaller and more numerous particles of lamp-black; the result obtained was that they varied in size from ·000018 to ·000012 of an inch. Several months *afterwards*, I made a calculation to ascertain what the difference in the path of the interfering rays would be, using these data, and what relation this difference bore to the length of a wave of red light.

Assuming the dimensions of the particles of lamp-black to be the same in all directions, we have the annexed construction. BD will represent the diameter of a particle of lamp-black, the ray AB is reflected from its surface, the ray CB from the layer next



below; X is the angle made by the light with the plate, and the difference in path of the two rays will evidently be equal to CB − AB, a quantity readily found by calculation.

Taking the size of the lamp-black particles to be equal to ·000018 of an inch, the difference in path of the two rays for an angle of incidence of 18° is ·000011, while the wave-length of the line C in the red space is nearly ·000026 of an inch. This shows that the difference in the path is not far from half a wave-length of red light, if the larger of the two estimates of the size of the particles of lamp-black is employed.

I then made a new set of experiments relative to the angle at which the red ray disappears, using as before lamp-black from paraffine. This was found to vary somewhat in different portions of the same plate, as is seen in the table below.

21°, 20°·75, 18°·75, 20°, 20° = 20°·1

New microscopic measurements on the size of the lamp-black particles were made with a different microscope, the value of the micrometer not being known; it was estimated that the size of the smaller and more numerous particles varied from $\frac{1}{45000}$ to $\frac{1}{90000}$ of an inch, but that there were more particles approaching the first number than the second, a circumstance of which I have not taken any advantage in the following calculation.

Taking the mean of these determinations, and combining it with the mean of the first determination, we obtain for the mean size of the particles $\frac{1}{68343}$ = ·0000146 of an inch.

The average angle of disappearance of the red ray being 20°, there results a difference of path =·0000998; that is, the difference of path is to the wave-length of red light nearly as 10 to 26.

When the difficulty of obtaining an approximate measurement of the size of the particles of lamp-black is considered, it is surprising to see how nearly the calculated difference in path approximates to half a wave-length of the light in question.

I found that a surface of magnesia produced by smoking a glass plate to opacity with burning magnesium wire, also reflected light in the same way at very oblique incidences. It was ascertained that the final tint was red, and that the red rays themselves disappeared at 11°. The size of the particles of magnesia was estimated at ·000036. Long after the measurements had been obtained I calculated the difference of path for the interfering rays; this was found to be,

	·000014
wave-length of C	·000026

giving a still nearer approximation to a difference of ½ a wave-length.

These experiments then seem to point out the correctness of Fresnel's theory, and we should I think be justified in reversing the process, and using the angle of disappearance of the red ray, in connexion with the known wave-length of this ray, for the purpose of calculating the average size of small particles or the average depth of fine scratches or furrows.

I give below the calculated values of the average size of the particles of lamp-black and magnesia.

Lamp-black from paraffine,	·0000188	calculated.
" " "	·0000146	measured.
Size of particles of magnesia,	·0000338	calculated.
" " "	·0000361	measured.

Some experiments were made on the angle of disappearance of the red ray with lamp-black produced by the burning of different substances; where the figures are connected by a bracket it is intended to indicate that the two angles were obtained from the same portion of the plate.

Lamp-black from stearine.	Lamp-black from camphor.	Lamp-black from a solution of spirits of turpentine in alcohol.
18°·25 }	16° }	22° }
18 ·75 }	15 ·9 }	21 }
16 }	15 ·1 }	20
16 }	15 ·4 }	
17°·25	15°·6	21°

It would appear from these last experiments that the average size of the particles of lamp-black from burning camphor is somewhat greater than from paraffine, while in the case of "burning-fluid" the particles are smaller.

New York, Dec. 4th, 1866.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On a new form of magneto-electric machine.*—When the armatures of an ordinary magneto-electric machine with permanent steel magnets are wound with coarse wire, currents of electricity are obtained which are capable of developing magnetism in an electro-magnet. It is easy to see that the magnetism thus developed may in its turn be made to generate a current of electricity, and that this again may induce magnetism in a second and larger electro-magnet, and so on alternately. Mr. H. Wilde has availed himself of this principle to construct magneto-electric machines of extraordinary power. As the author's descriptions are not very clear, even with the aid of figures, we shall content ourselves with giving the general construction of the apparatus and the results obtained with a particular machine. In this machine the generator or primary source of the electric current was a magneto-electric machine consisting of six small permanent magnets weighing only one pound each and capable of lifting collectively a weight of, at most, 60 lbs. The current from this excites an electro-magnet weighing three tons, the total weight being about four and a half tons. The armatures are driven at a uniform velocity of 1500 revolutions per minute by means of a steam-engine and a very strong leather belt. With this machine pieces of iron rod fifteen inches in length and one-fourth of an inch in diameter were melted. With an intensity armature a light was obtained between points of gas carbon sufficiently intense to cast shadows from the flames of street lamps at a distance of a quarter of a mile. It is easy to see that by passing the current derived from the electro-magnet through another and larger electro-magnet a vast increase of electric force could be obtained, of course at the expense of a greatly increased motive power. With an unlimited increase of motive power an unlimited increase of electric force could be obtained, as in fact the whole machine is to be regarded as a means for transforming heat into mechanical power, and this last into electricity. It is to be regretted that the author has given no precise data from which the amount of electricity set free can be determined with precision. The quantity of water decomposed per minute, with the expenditure of a measured amount of mechanical work, is what we require in order to form a correct estimate of the value of the apparatus, as compared with that of other electro-motors. In any case, however, it is safe to predict a brilliant and useful future for the new apparatus.—*Proc. of Royal Society*, xv, 107. W. G.

2. *On the synthesis of chlorid of thioxyl.*—Wurtz has made the very interesting observation that chlorid of thioxyl, $S_2O_2Cl_2$ or $SOCl_2$, may be produced by the direct union of anhydrous hypochlorous acid with sulphur,

$$Cl_2O + S = SOCl_2.$$

The vapor of hypochlorous acid is passed into chlorid of sulphur holding sulphur in suspension, and the operation is discontinued as soon as the sulphur has entirely disappeared. The chlorid of thioxyl may then be separated from the chlorid of sulphur by distillation. Chlorid of thioxyl as thus prepared is a colorless liquid which has a penetrating odor reminding of sulphurous acid and chlorid of sulphur. Its density at 0° is 1·675, and its boiling point 78° at 746 mm. Water resolves it into chlorhydric and sulphurous acids, $SOCl_2+H_2O=2HCl+SO_2$.

Liquid hypochlorous acid explodes on contact with sulphur, and it is for this reason that the action must be moderated by suspending the sulphur in chlorid of sulphur and keeping this at a temperature of −12° C. From the above it is clear that Cl_2O may unite directly with a radical, a fact which stands related to the observation of Carius that HClO unites directly with certain hydrocarbons.—*Comptes Rendus*, lxii, 460.

W. G.

3. *On a new series of hydrocarbons.*—SCHORLEMMER has discovered among the products of the distillation of cannel coal, besides the homologues of marsh gas and benzol, other hydrocarbons attacked by concentrated sulphuric acid. When the oil, after treatment with the acid, is distilled, the oils of the benzol and marsh gas series pass over first and there remains a black tarry mass. If this mass be distilled, a thick brown liquid with an offensive smell passes over between 300° and 400°. By repeated distillations with caustic alkali and with sodium a series of carburets may be obtained with the general formula $(C_nH_{2n-2})_2$; of these the author describes $C_{12}H_{20}$, $C_{14}H_{24}$, $C_{16}H_{28}$. These are all colorless oily highly refractive liquids, having a faint peculiar smell resembling that of the carrot or parsnip root. These oils unite with bromine to form colorless heavy liquids easily decomposed by heating. A molecule of oil takes up two atoms of bromine. Strong nitric acid dissolves the oils, forming nitro-compounds which with tin and chlorhydric acid give organic bases. With sulphuric acid and bichromate of potash the oils yield carbonic, formic, acetic, and perhaps other acids. The author considers it certain that the oils of this series are polymers of the acetylene series.—*Annalen der Chemie und Pharm.*, cxxxix, 244. W. G.

4. *On the compounds of tantalum.*—MARIGNAC has published the conclusion of his researches on niobium and tantalum, the first part of which has already been noticed in this Journal. To determine the atomic weight of tantalum, pure crystallized fluotantalate of potassium, $KF.TaF_5$, was treated with concentrated sulphuric acid and carried finally to a temperature of 400° C. On boiling with water, bisulphate of potash is dissolved out and sulphate of tantalum left in small granular crystals, which by strong ignition yield tantalic acid. The bisulphate of potash is brought by evaporation and ignition to the state of sulphate and weighed as such. Four analyses closely agreeing with each other gave the number 182·3 as the atomic weight of tantalum; a molecule of tantalic acid has therefore the formula Ta_2O_5, and the molecular weight 444·6. The analysis of the fluotantalate of ammonium leads to the number 182 as the atomic weight of tantalum, and this number is adopted by Marignac as most probable. The author remarks that the difference between the atomic weights of niobium and tantalum, which belong to the same natural family, is the same as that between the atomic weights of the closely allied metals, tungsten and molybdenum, namely, 88. Tantalic acid forms two classes of salts, in one of which it is monobasic and in the other quadribasic. The first class have the formula

$Ta_2\Theta_5 . M\Theta$, and the second the formula $3Ta_2\Theta_5 . 4M\Theta$: the tantalates of soda and potash belong to this last type and crystallize well. The oxyd and sulphid of tantalum described by Berzelius and others have respectively the formulas $Ta\Theta_2$ and TaS_2. Chlorid of tantalum has the formula $TnCl_5$; the calculated density of its vapor is 12·84, while Deville and Troost find 12·42. Tantalic acid not ignited dissolves easily in fluohydric acid and forms soluble and crystallizable salts with other fluorids, but it does not appear that there is a class of oxyfluotantalates corresponding to the oxyfluoniobates. The fluotantalate of potassium, $TaF_5 . 2KF$, crystallizes in the right rhombic system and is isomorphous with the corresponding fluoniobate. When boiled for a long time with water the salt changes to an insoluble body having approximately the formula $Ta_2\Theta_5 + 2(2KF . TaF_5)$, which may, however, be only a mixture. The formation of this insoluble compound gives the means of detecting the smallest quantity of fluotantalate in the oxyfluoniobate of potassium. Two fluotantalates of sodium have respectively the formulas $TaF_5, 2NaF + H_2\Theta$ and $TaF_5 3NaF$. The other salts described are $TaF_5, 2NH_4F$, $TaF_5, 2ZnF + 7aq.$, and $TaF_5, 2CuF + 4aq.$ In our first notice of Marignac's researches we have stated that that chemist had detected in niobite a small quantity of an acid which might prove to be new. Further investigation has, however, shown that this is titanic acid.—*Bull. de la Soc. Chimique*, Aug. 1866, pp. 118 and 115. W. G.

5. *On the preparation of iodhydric and phosphoric acids.*—PETTENKOFER has given a very elegant modification of Liebig's process for the preparation of iodhydric acid and alkaline iodids, and has further extended the method so as to obtain pure phosphoric acid as a subsidiary product. To half an ounce of common phosphorus in twelve ounces of distilled water at 60° or 70° C. one ounce of iodine out of eight ounces is to be added. The whole is to be stirred and the liquid poured off from the phosphorus and iodid of phosphorus upon the remaining seven ounces of iodine contained in a separate vessel. The solution of iodine as thus obtained is to be poured back upon the phosphorus and the alternate process repeated until all the iodine is dissolved and has come in contact with the phosphorus. The red-brown liquid last obtained becomes almost colorless after a short time, and there remains only a little red phosphorus. The filtered liquid, consisting of water, iodhydric, phosphorous and a little phosphoric acid, is to be distilled over an open fire till the liquid becomes syrupy. The distillate consists of iodhydric acid containing a little free iodine, and has a specific gravity of 1·39 to 1·40. It appears to keep well and serves for the convenient preparation of the iodids of potassium, sodium, calcium, &c. Saturated with bicarbonate of potash the acid yields on evaporation and crystallization a pure iodid in perfectly colorless crystals. The contents of the retort are to be poured out, the retort washed, and a few drops of concentrated nitric acid containing nitrous acid added, when the whole remaining iodhydric acid is decomposed into water and free iodine. The free iodine may be separated by filtration, after which the filtrate is warmed till it becomes colorless. The filtrate is then to be evaporated with about one and a half ounces of nitric acid of 1·20, added in small portions at a time until, on addition of pure acid, nitrous acid fumes are no longer evolved. The so-

lution of phosphoric acid is then to be evaporated till the vapor arising no longer reddens litmus. In this manner a pure phosphoric acid, free from arsenic and sulphur, was obtained, although the phosphorus employed contained traces of both substances.—*Ann. der Chemie und Pharm.*, cxxxviii, 57. W. G.

6. *On crotonic acid.*—BULK has given another instance of the conversion of one organic acid into another by simple addition of one molecule or two atoms of hydrogen. When crotonic acid, $Є_8H_6Θ_2$, is heated with an amalgam of sodium or with metallic zinc and dilute sulphuric acid, it passes gradually into butyric acid, $Є_4H_8Θ_2$, this last being in the modification in which it is obtained by fermentation.—*Ann. der Chemie u. Pharm.*, cxxxix, 62. W. G.

7. *On syntheses of guanidin.*—A. W. HOFMANN has succeeded in the synthesis of guanidin, $N_3\left\{\begin{array}{l}\overset{iv}{Є}\\ H_3\\ H_2\end{array}\right.$, by two different processes. An alcoholic solution of chlorpicrin, $Є(NΘ_2)Cl_3$, and ammonia is heated for some time in a closed tube to a temperature of 100°. Under these circumstances the reaction occurs which is represented by the equation

$$Є(NΘ_2)Cl_3+3NH_3=ЄH_5N_3, HCl+2HCl+HNΘ_2.$$

When orthocarbonic ether is heated to 150° C. with aqueous ammonia, guanidin and alcohol are formed, according to the equation,

$$Є(C_2H_5)_4Θ_4+3NH_3+H_2Θ=ЄH_5N_3, H_2Θ+4(Є_2H_5, HΘ).$$

The author suggests that the corresponding orthosilicate of ethyl, $Si(C_2H_5)_4Θ_4$, may by a similar process yield a species of guanidin in which silicon takes the place of carbon, and also that the well known compounds formed by the action of ammonia upon the chlorids of silicon and titanium may be simply mixtures of sal-ammoniac with the chlorhydrates of guanidin containing silicon or titanium in place of carbon.—*Ann. der Chem. u. Pharm.*, cxxxix, 107. W. G.

8. *On flame reactions.*—BUNSEN has made a systematic study of the action of different parts of the flame of the well known burner which bears his name, on various substances, either alone or mixed with fluxes and other reagents. As no mere abstract can do justice to a paper of this character we must refer our readers to the original. It can hardly be doubted that, wherever gas can be had, the flame of the burner will soon supplant the ordinary mouth blowpipe in testing upon a small scale by heat.—*Ann. der Chem. u. Pharm.*, cxxxviii, 257. W. G.

II. MINERALOGY AND GEOLOGY.

1. *Geological Survey of Illinois;* A. H. WORTHEN, Director. Volume I, *Geology*. xvi, and 504 pp. royal 8vo, with map, sections, &c. 1866, Springfield. Published by authority of the Legislature of Illinois.—In the September number of this Journal, we gave a brief notice of the issue of this valuable Report, it having reached us so near our publication day, that we were unable to do more than merely acknowledge its reception, and promise a more extended notice in a future number. Circumstances beyond our control prevented the preparation of this notice in

time for the November number, but we now propose to fulfil the promise, so far as limited space will permit.

As stated above, this Report occupies about 520 pages of letter-press, and is printed in large clear type, upon excellent paper, with well executed illustrations; and the whole is neatly and substantially bound in cloth. Chapter I consists of remarks on the General Principles of geological science,—the physical features of the State, its Surface geology, &c. In Chapter II the Tertiary deposits and the Coal-measures are described and their relations to the other formations of the state explained, by a section showing the thickness, order of succession, &c., of the various rocks occurring in Illinois. The Tertiary, consisting of various colored clays, greenish sand, &c., occupies but a limited area in the southern part of the state, and has yet afforded only a few imperfect casts of fossils, apparently of Eocene age.

The Coal-measures being of great economical importance, are described at length, and numerous sections of their various beds are given, as ascertained from natural exposures, borings, shafts, &c. Contrary to an opinion somewhat current among geologists, the State Geologist maintains that the Illinois coal-field is not broken up into several isolated patches, separated by intervals of older rocks, but is a continuous field, occupying near three-fourths of the entire area of the State. The maximum thickness of the whole series, exclusive of the Millstone grit, is, in the southern part of the State, about 900 feet, including six workable beds of coal, with an aggregate thickness of 30 feet. Going northward, the Coal-measures diminish in thickness, chiefly by the thinning out of lower beds, so that on the northern borders of the field, where the Millstone grit and Subcarboniferous rocks are wanting, some of the higher members are found resting directly down upon Devonian and Silurian rocks: thus apparently showing that as far back at least as the commencement of the Subcarboniferous period, the northern part of the state was more elevated than the southern, and that as the subsidence of the whole area progressed, the successive newer beds extended farther and farther northward. The whole series being, with one or two local exceptons, almost entirely undisturbed by upheavals, flexures, faults, &c., the miner meets with few of the obstacles here, that so materially diminish the profits of coal mining in more disturbed districts. From the facts given, it is evident that we can scarcely overestimate the value and importance of this inexhaustible store of mineral wealth, as a source of power and progress, to a state like Illinois, which also has a vast extent of the most beautiful undulating prairie lands unsurpassed in productiveness and easily brought under cultivation.

In regard to petroleum in Illinois, the State Geologist remarks that it has been found in small quantities in two or three of the southern counties; and that from the greater thickness, on the eastern borders of the State, of the rocks generally regarded as the source of the oil deposits in western Pennsylvania and eastern Ohio and Kentucky, it will be most apt to be found in paying quantities in the region of the Wabash valley. The correctness of this suggestion has been confirmed since the printing of the Report, by a valuable flowing well sunk at Terre Haute, Indiana.

In Chapter III, the various Subcarboniferous rocks are fully described in the order of their succession from above, and various analyses by the late Henry Pratten, Esq., showing their chemical composition are given. The thickness, geographical range, general physical characters, characteristic fossils, &c., of each of these rocks are also stated in considerable detail. This chapter likewise includes an interesting Report by Prof. G. J. Brush of Yale College, on the geodes so abundant at the Rapids of the Mississippi in the Keokuk beds.

The Devonian and Silurian rocks are similarly treated of in chapter IV; while in chapter V, we have a valuable and highly interesting Report on the Galena Lead region, by Prof. J. D. Whitney, now the State Geologist of California. Prof. Whitney's Report is illustrated by a large, neatly engraved and colored map of the Lead region, on which the boundaries of the several formations, the position and bearings of lead crevices, and the general topography of the country are accurately laid down. It also contains another map on a larger scale, of the country around Galena, on which similar information is given in more detail: likewise a columnar section showing the various rocks that occur in the lead district, their thickness, composition, order of superposition, &c. As it would be impossible in a notice like this, to give an intelligible idea of the amount of statistical and scientific information contained in this Report, respecting the mode of occurrence of the ore, the methods pursued in extracting it, the processes of smelting, the yield of lead, &c., we must refer the reader to the Report itself for such details.

Chapter VI is composed of a Report by Prof. Leo Lesquereux, on the Coal fields of Illinois, giving a large amount of information respecting the structure of the Illinois Coal series, and the relations of its various beds and outcrops to each other, and to those of Kentucky, Arkansas, Indiana, Ohio and Pennsylvania, as determined by a careful study of the fossil plants found associated with each of these beds. From the long experience this gentleman has had in exploring the Coal-measures of the West, and his extensive knowledge of fossil Botany, it may be readily inferred that this chapter will be found full of interesting and practical information. In Chapter VII, he likewise discusses at length the mooted question respecting the origin and formation of prairies, which he thinks are due to the gradual disappearance of marshes.

The chemical Report of Dr. J. V. Z. Blany, chemist of the survey, constitutes Chapter VIII. This Report contains much valuable information, consisting of numerous analyses of coals, iron ores, &c., chiefly the former, with classifications and descriptions of the same.

The remaining portions of the volume consists of detailed county Reports as follows:—On Randolph county, St. Clair county, Madison county, Hancock county, and Hardin county, by the State Geologist. The Report on the latter county is illustrated by a neat colored map, and also includes an interesting Report on the Rosiclare Lead mines, illustrated by diagrams, plans of the different workings, &c., by Prof. J. G. Norwood of the University of Missouri. The following counties are reported upon by Mr. Henry Engelmann, viz:—Johnson, Pulaski, Massac and Pope. These county Reports are all in great detail, and contain a large amount of practical and scientific information.

At the end of the volume, there is a copious glossary of scientific terms, followed by the index, and a neatly engraved section of the rocks seen along the Mississippi from the northern boundary of the State to Cairo.

This volume shows throughout that the survey of the State, so rich in resources, has been in the hands of an able and successful geologist. We earnestly hope that the Legislature may make the necessary appropriation this winter for a third volume, which we are informed the State geologist has in a forward state of preparation, including detailed reports of many county surveys, and other valuable information; and that nothing may prevent the onward progress of the survey to its final completion, and the publication of all the results. The publication of such reports not only advances the material interests of a State, by spreading useful information among the people, but by inviting capital, enterprise and emigration from other parts of our own country and from abroad.

2. *Contributions to the Paleontology of Illinois and other Western States;* by F. B. Meek and A. H. Worthen, of the Illinois State Geological Survey. (Proceed. Acad. Nat. Sci. Philad., July, 1866, p. 251.)—This paper contains descriptions of the following new species and genera of fossils from the Carboniferous rocks of the West:—*Belemnocrinus Whitii, Synbathocrinus Wachsmuthi* (type of a new subgenus *Nematocrinus*), *Cyathocrinus Farleyi, Rhodocrinus nanus, Onychocrinus diversus, Granatocrinus Shumardi, Schœnaster Wachsmuthi, Pteria* (*Pterinea?*) *Morganensis, Macrodon micronema, Platyceras lævigatum, Platyceras haliotoides, P. uncum, P.* (*Orthonychia*) *Chesterensis, P.* (*O.*) *subplicatum, P.* (*O.*) *infundibulum* (=*P. subrectum* Hall, 1860; not *P. subrectum* of the same author, 1859), *Metoptoma* (*Platyceras?*) *umbella, Polyphemopsis Chesterensis, Anomphalus rotulus* (type of a new genus allied to *Rotella*), *Microdoma conica* (type of a new genus), *Orthonema conica, Trochita? carbonaria, Pleurotomaria conoides, P. Coxana, P. spironema, P. valvatiformis, Murisonia inornata,* and *Nautilus* (*Cryptoceras*) *Rockfordensis.*

It also contains notices of two new genera of Crinoids, which are more fully described and illustrated in the second volume of the Illinois report. The first of these genera, *Strotocrinus*, is proposed for those greatly expanded species, such as *Actinocrinus perumbrosus, A. regalis,* &c., of Hall. Prof. Hall had proposed for this type the name *Calathocrinus*, which could not stand because von Meyer had previously applied it to another group in 1848. The other genus, *Steganocrinus*, is proposed for a curious group, of which *Actinocrinus pentagonus* of Hall is the type. This type differs from *Actinocrinus*, in having the rays, when found entire, greatly extended out horizontally in the form of slender, free, rigid arm-like appendages, covered all the way out by small pieces like the vault, and bearing the true arms along their lateral margins.

The authors likewise make some remarks on *Onychocrinus* of Lyon & Casseday, which they think most probably a good genus, though it has generally been regarded as a synonym of *Forbesiocrinus;* also on the genus *Platyceras* Conrad, which they think more nearly allied to the recent genus *Capulus*, than has been supposed in this country, though still generically distinct.

Most of these fossils, and others previously described by the same authors, will be fully illustrated and more elaborately described in a future Report of the Illinois Survey.

3. *A Geological and Agricultural Survey of* 100 *miles west of Omaha ;* by the American Bureau of Mines.* New York, 1866, 44 pp., 8vo.—This Report embodies the results of a reconnoissance made during the past summer by Prof. Thos. Egleston, along the line of the first hundred miles of the Union Pacific Railroad, west of Omaha, Nebraska. The survey was made under a commission from the railroad company, the chief object being probably to throw some light upon the question of the probabilities of finding workable beds of coal in that region, within accessible distances beneath the surface.

When it is remembered that the publications of previous explorers had made the general features of the geology of that part of the country so well known as to prevent the possibility of new and startling discoveries, it must be conceded that Prof. Egleston has made up quite an interesting report upon the physical features of the district explored—its agricultural capacities, climatology,† &c. He has also accurately described the Upper Carboniferous, Cretaceous, Drift, and alluvial formations previously known to exist there. From the Carboniferous beds he collected some thirty-five species of fossils, one of which (*Nautilus Illinoiensis*) had not, we believe, been before discovered at the localities mentioned. These fossils were identified by Mr. Meek,‡ and a list of them is given on pages 12 and 13 of the Report.

In regard to coal, Prof. Egleston thinks, from what is known respecting the structure of the Coal formation in northern Missouri and western Iowa, that workable beds may possibly be struck at a depth of 550 feet below the surface of the Missouri at Omaha, and at near 600 feet below the same horizon at Bellevue.

4. *Notes on the Geology of Western S. America ;* by A. Rémond, (from a letter to Prof. W. H. Brewer, dated Santiago, Chili, Oct. 11, 1866).—The following are among the discoveries which I have made on the west coast of South America.

(1.) Jurassic fossils in the metamorphic rocks about Lima ; some of the species strongly resemble those found in the belt of the same age in California.

(2.) At the Morro of Arica, lat. 18° 28′ S. on the coast of southern Peru, Jurassic species, one of them identical with fossils found by Dr. Philippi near Chaco, east of the Desert of Atacama, lat. 25° 12′ S.

(3.) A collection of fossil plants, probably of Triassic age, from the coal-bearing formation of northern Chili, a region previously unexplored by geologists. Some of these species are similar to those I brought from

* It should be here noted that the American Bureau of Mines is a private association, and not a government institution.

† The Smithsonian Institution's publications are credited for the meteorological data upon which the remarks on the climate are based.

‡ Our attention has been called by Mr. Meek to quite a number of typographical errors in this list of fossils, for which he is not responsible, as the list was not printed from a manuscript written by him, and he saw no proof of it as the Report went through the press.

Sonora two years ago; and two of the species, a Pecopteris and a Pterophyllum, are probably identical.

(4.) At the silver mines of Tres Puntas and Chanarçillo, species of lower Cretaceous; and above the coal beds many species of Lias, but most of them have been found before by Prof. Domeyko at Las Juntas and Tres Cruces.

(5.) Eocene fossils at Caldera, lat 27° 4′. Near this port are also extensive beds of recent shells well preserved.

(6.) Near Coquimbo many species from the middle and upper Tertiary.

5. *Carta Geologica di Savoja, Piemonte e Liguria;* del commendatore ANGELO SISMONDA, Professore di Mineralogia nella Universita di Torino, etc. 26×31 inches, colored. Published by the Italian government.—This geological chart, by Prof. Sismonda of Turin, gives, in colors, the geology of perhaps the most interesting part of Europe. It covers northwestern Italy, west of Cremona and Milan, and extends north, across the Alps, to Lake Geneva and the Rhone. It hence exhibits the rock formations of Italy stretching north over the regions of the southern Alps. Thus we observe, among its many points of great interest, the region of crystalline rocks (protogine, gneiss, mica schist, etc.) in which stands Mt. Blanc, lying *within*, and trending with, the great Jurassic belt that divides Italy and France; this Jurassic formation to the westward of Mt. Blanc being mostly unaltered, while that on the east is metamorphic. The difficult geological problem of the Alps receives a large part of its solution from the facts observed in northern Italy.

6. *Comptoir Minéralogique of F. Pisani at Paris.*—Mr. Pisani has opened rooms for the sale of minerals in the same court recently occupied by the late Louis Sæmann, No. 6 Rue de Mézières. He is an excellent mineralogist as well as chemist, and many difficult points in mineralogy have been elucidated by his analyses. We take pleasure in commending his establishment to all who desire to procure minerals either by the specimen or cabinet.

7. *Discovery of additional Mastodon remains at Cohoes, N. Y.*—A few weeks after the discovery at Cohoes of the lower jaw of a mastodon, a notice of which appeared in the last number of the Journal (p. 426), some additional remains were found in the same locality; and subsequently the skull and many other parts of the same skeleton were brought to light. These also are in an excellent state of preservation, and the whole, when seen together, exhibit admirably the prominent characters of the species, as well as some structural peculiarities of much scientific interest.

The remains are evidently those of the common North American mastodon—*M. Ohioticus* (*M. giganteus* Cuvier). The imperfect ossification of some parts of the skeleton, especially the epiphyses, shows that the animal was comparatively young, while the absence of tusks from the lower jaw would indicate a full-grown female.

The missing portions of the skeleton are without doubt in the same pot-hole, which contained those already found, and, although their recovery may involve considerable expense, it is greatly to be hoped that all may be secured; as the skeleton would then be one of the most perfect ever discovered, and prove a most important addition to the New York

State collection, in which, through the generosity of the Harmony Mills Co. of Cohoes, it is to be permanently deposited.

The pit, in which the mastodon remains were found, had evidently been formed by several pot-holes wearing into each other. It was about forty feet in diameter at the top, and forty in depth; and was filled chiefly with decayed vegetable matter, resembling peat, in which were imbedded many fragments of trees, mostly conifers. The arrangement of the materials showed that they had been deposited rapidly, and a part of a beaver dam, found near the bottom, would indicate that the whole had been swept in by a freshet. No other animal remains were found except those already mentioned, although the "beaver-sticks" probably indicate one cotemporary of the mastodon.

Some of the specimens of wood found with the skeleton, and evidently introduced at the same time, were sufficiently well preserved to admit of determination. Among these were noticed species of the white pine (*Pinus strobus* L.), the common hemlock (*Abies Canadensis* Michx.), the black spruce (*Abies nigra* Poir.), the American larch (*Larix Americana* Michx.), the swamp maple (*Acer rubrum* L.), and the white birch (*Betula alba* Spach.) O. C. M.

8. *A Catalogue of Official Reports upon Geological Surveys of the United States and British Provinces.*—In arranging a set of American Geological Reports in the Library of Yale College, the following catalogue became necessary; and it is here published in order that its inaccuracies and deficiencies may be noticed and corrected, while, in its incompleteness, it may be of assistance to some.[1]

Part I.—States east of the Mississippi River.

Maine.

1837. *Chas. T. Jackson*, 1st Ann. Rep., Augusta, 12mo, 128 pp. Atlas, 24 pl.
1838. *C. T. Jackson*, 2d Ann. Rep., Augusta, 12mo, 168 pp.
1839. " 3d " " 276 and lxiv pp.
1837. " 1st " Geol. of Public Lands, Maine and Mass., Boston, 12mo, 47 pp.
1838. *C. T. Jackson*, 2d Ann. Rep., Geol. of Public Lands, Maine and Mass., Boston, 12mo, 93 pp.
1839. *Ezekiel Holmes*, Explor. and Survey of Aroostook River Territory, 1st Ann. Rep., Augusta, 12mo, 78 pp.
1862. *E. Holmes* and *Chas. H. Hitchcock*, Nat. Hist. and Geol., 2d Ann. Rep., Augusta, 8vo, 387 pp.
1863. *E. Holmes* and *C. H. Hitchcock*, Nat. Hist. and Geol., Augusta, 8vo, 447 pp.

New Hampshire.

1841. *C. T. Jackson*, 1st Ann. Rep., Concord, 12mo, 164 pp.
1842. " 2d " " " 8 pp.

[1] Of those Reports marked with an * one copy is needed at the Library of Yale College; and also one copy of any Report not included in the list: persons having them to dispose of are requested to notify the Librarian.

1844. *C. T. Jackson*, Final Rep., Concord, 4to, 379 pp., map, 2 sections.
1845. " Views and Map, illustrating Scenery and Geology, Boston, 4to, 20 pp., 8 pl.

VERMONT.

1845. *Chas. B. Adams*, 1st Ann. Rep., Burlington, 8vo, 92 pp.
1846. " 2d " " " 267 pp.
1847. " 3d " " " 32 pp.
1848.* " 4th " " " 8 pp.
1856. *Augustus Young*, Prelim. Rep. on Nat. Hist., Burlington, 12mo, 88 pp.
1857. *E. Hitchcock*, 1st Ann. Rep., Montpelier, 12mo, 12 pp.
1858. " 2d " Burlington, 12mo, 13 pp.
1861. *Edward Hitchcock, E. Hitchcock, Jr., A. D. Hager*, and *Chas. H. Hitchcock*, Final Rep., Proctorsville, 4to, 2 parts, 988 pp., 38 pl.

MASSACHUSETTS.

1832. *E. Hitchcock*, Final Report (1st Part), Economic Geology, Amherst, 8vo, 71 pp.
1833. *E. Hitchcock*, Final Report (complete), Amherst, 8vo, 700 pp., Atlas, 19 pl.
1835. *E. Hitchcock*, Final Report (2d edition), Amherst, 12mo, 702 pp. Atlas, 19 pl.
1838. *E. Hitchcock*, Rep. on Reëxamination Economic Geol., Boston, 12mo, 139 pp.
1841. *E. Hitchcock*, Final Rep., Amherst, 4to, 831 pp., map and 55 pl.
1853. " Rep. on Surface Geology, Boston, 8vo, 44 pp.
1858. " " Conn. River Sandstone (Ichnology of New England), Boston, 4to, xii and 220 pp., 60 pl.
1865. *E. Hitchcock*, Supplement to Ichnology of New England, Boston, 4to, x and 96 pp., 20 pl.

RHODE ISLAND.

1840. *Chas. T. Jackson*, Final Rep., Providence, 8vo, 312 pp., map, section.

CONNECTICUT.

1837. *Chas. U. Shepard* (Mineralogy and Economic Geol.), New Haven, 8vo, 188 pp.
1842. *Jas. G. Percival*, Final Report, New Haven, 8vo, 495 pp., map.

NEW YORK.

1836. *John A. Dix*, Rep. on proposed Survey, Albany, 8vo, 60 pp.
1837. *John Torrey, James E. DeKay, Lewis C. Beck, Wm. W. Mather, Ebenezer Emmons, Timothy A. Conrad*, and *Lardner Vanuxem*, Ann. Rep., Albany, 8vo, 212 pp.
1838. (*The same, with exception of J. Torrey*, and addition of *Jas. Hall*,) Ann. Rep., Albany, 8vo, 384 pp.
1839. (*The same, with exception of J. E. DeKay*,) Ann. Rep., Albany, 8vo, 351 pp.
1840. (*The same*,) Ann. Rep., Albany, 8vo, 484 pp.

1841. (*The same*,) Ann. Rep., Albany, 8vo, 184 pp.
1842. *L. C. Beck*, Final Rep. Mineralogy, Albany, 4to, 536 pp., 8 pl.
1843. *W. W. Mather*, Final Rep. 1st Dist., Albany, 4to, 653 pp., 46 pl.
1842. *E. Emmons*, Final Rep., 2d Dist., Albany, 4to, 427 pp., 17 pl.
" *L. Vanuxem*, Final Rep., 3d Dist., Albany, 4to, 306 pp.
1843. *J. Hall*, " " 4th " " 4to, 525 pp., 19 pl.
1847. " " " Paleontology, Vol. I, Albany, 4to, 338 pp., 100 pl.
1852. *J. Hall*, Final Rep., Paleontology, Vol. II, Albany, 4to, 362 pp. 104 pl.
1859. *J. Hall*, Final Rep., Paleontology, Vol. III, Albany, 4to, 532 pp., 140 pl.
1846. *E. Emmons*, Final Rep., Agriculture, Albany, 4to, 371 pp., 21 pl., map. (Contains Emmons's "Taconic System.")
1850. *J. Hall*, 3d Reg. Rep., Appendix L, Contrib. to Paleontology, Albany, 8vo, 13 pp., 3 pl.
1857. *J. Hall*, 10th Reg. Rep., Appendix C, Contrib. to Paleontology, Albany, 8vo, 148 pp.
1859. *J. Hall*, 12th Reg. Rep., Appendix — Contrib. to Paleontology, Albany, 8vo, 90 pp.
1860. *J. Hall*, 13th Reg. Rep., Appendix F, Contrib. to Paleontology, Albany, 8vo, 76 pp.
1861. *L. Lincklaen*, 14th Reg. Rep., Appendix B, Guide to Geology N. Y., Albany, 8vo, 68 pp., 19 pl.
1861. *J. Hall*, 14th Reg. Rep., Appendix C, Contrib. to Paleontology, Albany, 8vo, 22 pp.
1862. *J. Hall*, 15th Reg. Rep., Appendix —, Contrib. to Paleontology, Albany, 8vo, 170 pp.
1863. *J. Hall*, 16th Reg. Rep., Appendix D, Contrib. to Paleontology, Albany, 8vo, 210 pp. 11 pl.
1864. *J. Hall*, 17th Reg. Rep., Appendix H, Albany, 8vo, 11 pp.
1866. " 18th " " —, " "

New Jersey.

1836. *Henry D. Rogers*, 1st Rep., Philadelphia, 8vo, 188 pp., map.
1840.* *Henry D. Rogers*, Final Rep. (Descr. Geol. N. J.), Philadelphia, 8vo, 301 pp., map. (Reprinted without map, Trenton, 1865.)
1855. *Wm. Kitchell*, 1st Ann. Rep., New Brunswick, 8vo, 100 pp.
1856. " 2d, " Trenton, 8vo, 248 pp.
1857. " 3d, " " 79 pp.
1857. *Geo. H. Cook*, Rep. on Cape May Co., Trenton, 8vo, 211 pp., map.
1864. " 1st Ann. Rep., Trenton, 8vo, 13 pp.
1865. " 2d " " 24 pp., map, section.

Pennsylvania.

1836. *H. D. Rogers*, 1st Ann. Rep., Harrisburg, 8vo, 22 pp.
1838. " 2d " " " 91 pp.
1839. " 3d " " " 119 pp.
1840. " 4th " " " 252 pp.
1841. " 5th " " " 179 pp.
1842. " 6th " " " 28 pp.

1858. *H. D. Rogers*, Final Rep., Vol. I, Philadelphia, [printed at Edinburgh.] 4to, xxvii and 586 pp., 27 pl., 8 sect.
1858. *H. D. Rogers*, Final Rep., Vol. II, Philadelphia, [printed at Edinburgh.] 4to, xxiv and 1045 pp., 45 pl., 7 sect.
1858. *H. D. Rogers*, Final Rep., Atlas, 2 maps (5 sheets), 2 sections.

DELAWARE.

1839.* *Jas. C. Booth*, 1st and 2nd Ann. Rep., Dover, 8vo, 25 pp.
1841. " Final Rep., Dover, 8vo, 188 pp.

MARYLAND.

1834. *J. T. Ducatel* and *J. H. Alexander*, Rep. on Projected Survey, Annapolis, 8vo, 39 pp., map.
1834. *J. H. Alexander*, Rep. on New Map, Annapolis, 8vo, 12 pp., map.
1835.* " Rep. Annapolis, 8vo, 34 pp.
1837. " Rep. " 8vo, 44 pp.
1834. *J. T. Ducatel*, 1st Ann. Rep., Annapolis, 8vo, 44 pp.
1835.* " 2d Ann. Rep., " 8vo, 60 pp. Map and sections.
1836. *J. T. Ducatel*, 3d Ann. Rep., Annapolis, 8vo, 60 pp. Map and sections.
1837. *J. T. Ducatel*, 4th Ann. Rep., Annapolis, 8vo, 60 pp.
1838. " 5th " " 8vo, 33 pp., 4 pl.
1839.* " 6th " " 8vo, 49 pp.
1840. " 7th " " 8vo, 59 pp. 3 pl.
1860. *Philip T. Tyson*, 1st Bienn. Rep., Annapolis, 8vo, 145 and 20 pp., map.
1862. *P. T. Tyson*, 2d Bienn. Rep., Annapolis, 8vo, 92 pp.

VIRGINIA.

1836. *Wm. B. Rogers*, Rep. Geol. Reconn., Philadelphia, 8vo, 143 pp., section.
1838. *W. B. Rogers*, 1st and 2d Ann. Reps., Philad., 8vo, 87 pp.
1839. " 3d Ann. Rep., ——, 4to, 52 pp.
1840. " 4th " Richmond, 8vo, 161 pp.
1841. " 5th " " " 132 pp.

NORTH CAROLINA.

1824. *Denison Olmsted*, 1st Ann. Rep., "Part I," ——, 12mo, 84 pp.
1852. *E. Emmons*, " " Raleigh, 12mo, 181 pp.
1856. " Rep. on Midland Counties, New York and Raleigh, 8vo, 351 pp., 15 pl.
1858.* *E. Emmons*, Rep. Agric. Eastern Counties, New York and Raleigh, 8vo, 314 pp.

SOUTH CAROLINA.

1826.* *L. Vanuxem*, Rep. published in newspapers, and most of it in Mills' Statistics of S. C.
1843.* *Edmund Ruffin*, Agricultural Rep., with Appendix, Columbia, 8vo, 176 pp.
1844. *M. Tuomey*, 1st Ann. Rep., Columbia, 12mo, 63 pp. (including Suppl. to Ruffin's Rep.)

1848. *M. Tuomey*, Final Rep., Columbia, small 4to, 293 and lvi pp., map.
1857. *Oscar M. Lieber*, 1st Ann. Rep., Columbia, 8vo, 136 pp., 9 pl.
1858. " 2d " " 8vo, 143 " 5 "
1859. " 3d " " 8vo, 223 " 3 "
1860.* " 4th " " 8vo, 194 " 4 "

ALABAMA.

1850. *M. Tuomey*, 1st Biennial Rep., Tuscaloosa, 8vo, xxxii and 176 pp.
1853.* " map. ——.
1858. " 2d Biennial Rep., Montgomery, 8vo, xix and 292 pp., map (edited by J. W. Mallet).

MISSISSIPPI.

1854. *B. L. C. Wailes*, 1st Rep., Jackson, 8vo, 371 pp.
1857. *L. Harper*. Prelim. Rep., Jackson, 8vo, 350 pp., 7 pl., map.
1858.* *Eug. W. Hilgard*, Ann. Rep., Geol. and Agric., Jackson, 12mo, 22 pp.
1860. *E. W. Hilgard*, Rep. Geol. and Agric., Jackson, 8vo, 391 pp., map.

TENNESSEE.

1835. *G. Troost*, 3d Rep., Nashville, 12mo, 32 pp., map.
1837. " 4th " " " 37 pp. "
1840. " 5th " " 8vo, 75 pp. "
1841.* " 6th " " 12mo, 48 pp. "
1844.* " 7th " " 8vo, 45 pp. "
1845.* " 8th " " 12mo, 40 pp. "
1848. " 9th " " " 39 pp., 2 pl.
[Troost's 1st and 2d Reports were not published.]
1856. *Jas. M. Safford*, 1st Biennial Rep., Nashville, 8vo, 164 pp., map.
1857. " 2d " " " 11 pp.

KENTUCKY.

1839. *W. W. Mather*, Rep. of Geol. Reconn. (1838), Frankfort, 8vo, 40 pp.
1856. *David D. Owen*, 1st Rep., Frankfort, 8vo, 416 pp., 7 pl., 2 maps, 7 sections.
1857. *D. D. Owen*, 2d Rep., Frankfort, 8vo, 391 pp., Atlas of 10 pl., and 1 chart.
1857. *D. D. Owen*, 3d Rep., Frankfort, 8vo, 589 pp., Atlas of 10 pl., and 1 chart.
1861. *D. D. Owen*, 4th Rep., Frankfort, 8vo, 616 pp.

OHIO.

1836. *S. P. Hildreth*, Legislative Rep. on Survey, Columbus, 12mo, 18 pp. 2 sections.
1837. *John L. Riddell*, Legislat. Rep. on Survey, Columbus, 8vo, 34 pp.
1838. *W. W. Mather*, 1st Ann. Rep., Columbus, 8vo, 134 pp.
" " 2d " " 8vo, 286 "

INDIANA.

1838. *D. D. Owen*, 1st Rep., Indianapolis, 8vo ?, 34 pp.
1839. " 2d " " " 54 "

1855.* *R. T. Brown*, Letter to Agric. Board, Indianapolis, 8vo, 30 pp.
1862. *D. D. Owen* and *Richard Owen*, Rep. Geol. Reconn., Indianapolis, 8vo, xvi and 368 pp., 11 pl.

ILLINOIS.

1853. *J. G. Norwood*, Rep. Prog., Springfield, 8vo, 13 pp.
1857. " " on Coals, Chicago, " 98 "
1866. *A. H. Worthen*, Rep. Geology, Vol. I, Springfield, large 8vo, 504 pp., with map and sections.

MICHIGAN.

1838. *Douglass Houghton*, 1st Rep., Detroit, small 8vo, 37 pp.
1839. " 2d " " " 39 and 123 pp.
1840.* " on Salt Springs, (House Doc. Vol. I, p. 18.)
" " 3d Ann. Rep., Detroit, 8vo, 124 pp.
1841. " 4th " " 184 "
" * " Rep. Progress of Maps, ——
1842.* " 5th Ann. Rep., ——
1861. *A. Winchell*, 1st Biennial Rep., Lansing, 12mo, 339 pp.
1846. *A. B. Gray*, Rep. to War Dept. on Mineral Lands, Lake Superior, Washington, 8vo, 23 pp., map.
1849. *Chas. T. Jackson*, Rep. (U. S.) on Mineral Lands, Washington, 8vo, 237 pp., 6 maps.
1849. *J. W. Foster* and *J. D. Whitney*, Rep. (U. S.) on Mineral Lands, Washington, 8vo, 330 pp., 9 maps, 7 pl.
1849. *Wm. A. Burt*, Rep. (U. S.) Mineral lands L. Superior, Washington, 8vo, 63 pp.
" *Bela Hubbard*, Rep. (U. S.) Mineral lands L. Superior, Washington, 8vo, 76 pp.
1850. *J. W. Foster* and *J. D. Whitney*, Rep. (U. S.) Geol. L. Superior Land Dist., Part I, Washington, 8vo, 224 pp., 4 maps, 12 pl.
1851. *J. W. Foster* and *J. D. Whitney*, Rep. (U. S.) Geol. L. Superior Land Dist., Part II, Washington, 8vo, xvi and 406 pp., 35 pl.

WISCONSIN.

1854. *Edward Daniels*, 1st Ann. Rep., Madison, 12mo, 84 pp.
1855. *J. G. Percival*, " " " " 101 " map.
1856. " 2d " " " 111 "
1858. *Edward Daniels*, " " " " 62 "
" " and others, " " " " 12 "
1860.* *J. Hall*, Ann. Rep. (for 1859), Madison, ——
1861. " " Madison, 12mo, 52 pp.
1862. *J. Hall* and *J. D. Whitney*, Final Rep., Vol. I, Albany, 8vo, 455 pp., 10 pl., 2 maps.

[To be concluded.]

9. *Human remains in Belgium.*—Mr. EDWARD DUPONT has presented to the Royal Academy of Brussels (June 30, 1866) a paper on his later researches in the caverns on the borders of the Lesse, near where it empties into the Meuse. He has examined two localities near Walsen, one

of which was not known before, and he has had the good fortune to find there numerous bones which he has described in detail.

It is known that in a work upon the Quaternary deposits of the province of Namur the author of these researches has distinguished three stages, which he designates, respectively, (1) from the presence of the Mammoth (*Elephas primigenius*), (2) of the great Cave Bear (*Ursus spelæus*), and (3) of the Reindeer (*Cervus tarandus*). But up to the present time he had found but few traces of the fauna of the first two stages. The two caverns called the Hyena cave and the Naulette cave have given him numerous remains which have confirmed his first impressions. In the first of these caves, called the cave of the Hyena, because of the quantity of bones of the *Hyæna spelæa* which it contains, he found teeth of the cave bear (*Ursus spelæus*), of the *Elephas primigenius* (a milk tooth), also bones of the *Rhinoceros tichorinus*, horse, fox, reindeer, &c., nearly all bearing marked traces of the teeth of a strong Carnivore. All the extremities are gnawed and there are no traces of the epiphyses; a great number of splinters are also gnawed. The bones of the hyena, on the contrary, bear no such traces, and as this, moreover, is the only Carnivore he has found there, he is inclined to believe that this was a hyena cave, and that the bones of other animals found in the same bed are the remains of their repast. The results of the explorations of this cave Mr. Dupont considers very important in their bearing upon the Quaternary deposits. These excavations determine the exact place, in the series, of the great cave Mammifers. In fact, the debris of the principal animals which compose this fauna are found also in the sandy-argillaceous stratified beds of alluvium (or "lehm") of the country; they evidently existed immediately before the deposit of these beds. Moreover, these stratified beds of gritty clay are found in the caverns as well as in the Quaternary outside in the province of Namur, between the great deposit of rolled pebbles on one side, and the argillaceous pebble deposit on the other. But the deposit of the rolled pebbles in the valleys is eminently characterized by the remains of the *Elephas primigenius*, so that the beds have justly received their name from their presence. On the other hand the deposit of yellow clay containing pebbles, which accords exactly with the deposit called red alluvium in the Paris basin, includes in the caves the fauna of the reindeer properly so called, that remarkable fauna whose distinguishing feature is the absence of all extinct species, and the presence of a series of animals still in existence, but now banished to colder climates. The true cave fauna, characterized principally by the great Carnivores, which are at the present day wholly extinct, separates the two fauna. This accords with the ideas Mr. Dupont had before brought forward in his paper on the Quaternary division of the province of Namur.

In the second of these caverns, named La Naulette, Mr. Dupont has found, among other organic remains, a bone of the *Elephas primigenius*, and a human jaw with a human ulna. The antiquity of these last bones cannot be contested since they are covered by several beds of stalagmites between which Mr. Dupont has recognized his medium stage, and upon which rest the deposits of the reindeer age. On the other hand this jaw differs from those of all the races found in Europe at the present day, in its forward prolongation (prognathism), a characteristic which is apparent to a certain degree in a jaw bone found by Mr. de Vibraye in the grotto of Arcy, in Bourgogne, associated equally with the *Elephas primigenius* and the *Rhinoceros tichorinus;* this peculiarity has also been observed in nine other jaws collected together in a cavern called the Cave of Frontal, at Furfooz. Mr. Dupont's discovery of these human remains is confirmed by Mr. Dumon, chief engineer of bridges and causeways, Mr. Eugene Cœmans, Mr. John Jones, and Lord Talbot of Malahide, who visited the cavern at the precise moment that the jaw was found, and who were convinced of its association with the other remains. The human bones have also been submitted by him to Messrs. Van Beneden, Spring, Bruner-Bey, Lartet, de Quatrefages, Busk, and Carl Vogt.

Mr. Dupont has found associated with these human remains many bones which bear the trace of the hand of man. One is a fragment of bone which is probably from a Ruminant. This bone is pierced with a hole which is evidently artificial, for the edges show a surprising neatness of finish. Moreover, the edges of this fragment of bone bear marks which appear to have been made with a very sharp instrument. Some persons, among whom is Mr. Quatrefages, believe that it is evidence of some peculiar method of cracking. Many fragments of marrow bones present also indications of man analogous to what has been found in other caverns, the bones evidently having been broken by the hand of man.

Mr. Dupont closes his notice with some remarks upon the fauna concealed in the alluvium of the Hyena and Naulette caves. Although the presence of three animal species may be respectively the distinguishing feature of the three Quaternary stages indicated above, we must conclude from the facts gathered only that these stages correspond to the periods in which the species that they indicate had their principal development, and not that these species did not exist before, or after, the period. Although in this case the beds of rolled pebbles are characterized by the presence of the *Elephas primigenius*, it does not follow that this species occurs only in this deposit, for we find it with the *Elephas meridionalis* in the *Forest beds*, as has been established by Sir C. Lyell in his Antiquity of Man, p. 224, and it was still living in Belgium during the deposit of the stratified alluvial beds (lehm). The *Ursus spelæus* seems to present an analogous fact, since the deposit of rolled pebbles of the cave of Frontal has furnished a canine tooth that appears to belong to this species. The common stag, the brown bear, and chamois are also remarkable examples of the same fact. Finally the reindeer seems to have lived, after the age of the *Elephas meridionalis*, in more southern regions than those in which it is now found; it existed in our regions with the *Elephas primigenius*, *Rhinoceros tichorinus*, &c., but it never acquired there that great numerical development which permits us to regard it as characterizing by its remains a long geological epoch subsequent to the disappearance of these large Quaternary species.

The article continues with results of other observations of interest.—*L'Institut*, Nov. 21st, 1866.

10. *Hübnerite, a new mineral.*—E. Riotte has described, in the Reese River Reveille, a new tungstate of manganese, entirely free from iron,

found in the Erie and Enterprise veins in Monmouth district, Nevada. From a notice of Riotte's paper by H. Credner,* we take the following. Crystallization trimetric, $I:I=105°$; generally in columnar masses or foliated, imbedded in quartz. Cleavage brachydiagonal, very perfect. Fracture, uneven. H.=4·5. G.=7·9. Color brownish-red to brownish-black. Streak yellowish-brown. Luster adamantine on the cleavage plane, and otherwise greasy. Translucent to opaque. Analysis by Riotte and Hübner gave, WO_3 76·4, MnO 23·4. BB. gives reactions for both tungstic acid and manganese. Partially soluble in chlorhydric acid leaving a yellow residue almost completely soluble in ammonia. Hübnerite is, according to Dr. Adelberg, found in both of the localities in a vein three to four feet wide in a metamorphic clay-slate, and is associated with scheelite, fluor-spar and apatite. A later article† by Breithaupt questions the correctness of the crystallographic measurements, and gives the density as 7·14.

11. *Mineralogical Notices;* by Wm. P. Blake.‡—*Kerargyrite.* Chlorid of silver occurs in thin crusts on gold-bearing quartz in the Morgan gold mine, Carson Hill, Calaveras county. This vein is in the main gold belt, and is regarded as a part of the chief gold vein of the state. It is noted for the massive specimens of vein gold which it affords. The association of chlorid of silver with the gold is novel, and has not been before observed by myself or others to my knowledge. A little galena occurs in the same vein, and in another part of it, gray copper ore, probably argentiferous, occurs sparingly and may be the source of the chlorid of silver. The crusts are about the thickness of an ordinary visiting card, and when freshly cut or scraped have a delicate pearl-gray color, which speedily changes to purple in the sunlight.

This species is also found in remarkably fine specimens in the Poorman lode,§ Idaho, associated with proustite, native silver, and native gold. Sheets of the chlorid are taken out of the soft clay of the vein, and are from one-eighth to one-quarter of an inch in thickness. It is also found in irregular massive aggregations of crystals, in cubes, without any modification, and over an eighth of an inch square. The color of my specimens is brown, passing into violet-blue in some portions.

Proustite.—The "ruby silver" which occurs with the chlorid in the Poorman lode, as above, is often in masses of several ounces, or even pounds, in weight, and it is reported to be occasionally seen in beautiful crystals, but none have yet come under my observation.

Copper-glance, Red oxyd of Copper, Native Copper.—These species are found together in the Red Cap claim, Klamath county, Cal., in serpentine. The metallic copper is seen in points throughout the massive sulphuret, and is sometimes enveloped in red oxyd. Both the copper and the oxyd are most abundant near the surface of the masses of ore, and they are apparently formed by the gradual decomposition of the sulphurets.

* Berg. und Hüttenmännisches Zeitung, xxiv, 370. † Ibid., xxv, 157.

‡ A portion of this paper was read before the California Acad. Nat. Sci., Oct. 15th, 1866, and another portion bears the date of Nov. 17th.

§ Specimens from this well-known locality are contained in many of the collections in the east.—G. J. B.

Danaite.—A cobaltic variety of mispickel is found associated with iron and copper pyrites at Meadow Lake, Nevada Co., Cal. It is in distinct, well formed, brilliant crystals of a tin-white color, and about a quarter of an inch in diameter. They are modified nearly as in fig. 289, Dana's Mineralogy. This mineral gives cobalt reactions before the blowpipe, and appears to contain a large percentage of this metal. The ore is said to contain nickel also, and is being mined for shipment.

Cinnabar in calcite.—Cinnabar of a beautiful vermilion color is found in Idaho abundantly spread through a gangue of massive compact limestone or marble. No quartz or other minerals are visible in the specimens.

Wulfenite.—Molybdate of lead occurs in the argentiferous lead ores of the Empire mine, Inyo Co., Cal. It is in crusts and seams about one-eighth of an inch thick, and is associated with galena, cerusite, malachite, and chrysocolla. The contrast of the brilliant yellow color of this species with the masses of green silicate of copper renders these specimens very beautiful and desirable for cabinets.

Sulphuret of silver.—This mineral is found in ragged masses matted with quartz crystals, and associated with free gold, in the "Silver Sprout" vein, Kearsarge District, Sierra Nevada.

*Tungstate of manganese.**—I have received from Mr. Ewer, fragments of a mineral from Nevada, which appears to be tungstate of manganese. It is in radiating prismatic crystals; color dark olive-green; high specific gravity, and before the blowpipe gives the reactions of tungstic acid and of manganese.

Specular iron.—Mr. Bennett of Durango, Mexico, has sent me some interesting crystallizations of specular iron ore, associated with oxyd of tin, from the tin washings of that place.

Tetrahedrite, galena, cerusite, pyromorphite, blende, with a little *red copper ore* occur together in the Chicago claim, Shasta county, Cal. The ore is rich in silver.

III. BOTANY.

1. *The Miscellaneous Botanical works of* Robert Brown, Esq., D.C.L., F.R.S., Foreign Associate of the Academy of Sciences of the Institute of France. Vol. I, containing 1, *Geographico-Botanical*, and 2, *Structural and Physiological Memoirs.* London: Published for the Ray Society by Robert Hardwicke, 192, Piccadilly. 1866. 8vo.—It was well determined by the Ray Society to collect and reprint Mr. Brown's published papers, originally scattered through various volumes, many of them little accessible. And Mr. Bennett, his intimate associate, and his successor at the British Museum, was the only proper editor. He has added to this volume a full and elaborate index,—a great boon to botanists,—also the following brief Preface:—

"The present volume contains the first portion of the works of the distinguished author, now for the first time collected in England, and reprinted from the originals, without change, in accordance with his express desire. It had been his intention to reprint them himself with annotations; but, unfortunately for science, this intention was never carried out, and it remained for the editor simply to superintend a verbatim reprint.

* This mineral is apparently Hübnerite, noticed on a previous page.—G. J. B.

"The memoirs are arranged in three divisions,—1st, Geographico-Botanical; 2d, Structural and Physiological; 3d, Systematic. Of course this arrangement is in some degree arbitrary, inasmuch as observations relating to both of the other divisions are continually occurring in the memoirs referred to each of them; but on the whole it has appeared to be the most convenient for reference. The present volume contains the first two of these divisions; the second will be devoted to Systematic Memoirs and Miscellaneous Descriptions of Plants; and a separate volume in large 4to, will contain the illustrative figures to both."

The memoirs are arranged according to date. The first volume consequently begins with the "*General Remarks on the Botany of Terra Australis*," in Flinders' Voyage, 1814; and ends with "*Some Account of Triplosporite, an undescribed Fossil Fruit*, 1851. The fruit is now pretty well determined to be that of *Lepidostrobus*. The most important of Mr. Brown's writings are therefore comprised in this volume, and the study of and reference to their rich and varied contents is immensely facilitated by the admirable index prepared, upon which the editor has evidently bestowed great labor and care. A. G.

2. *Nature of Anthers, &c.*—J. Mueller, the elaborator of the *Euphorbiaceæ* for DeCandolle's Prodromus, has published three brief papers in the Mémoires de la Société de Phys. et d'Hist. Nat. de Geneve, upon points relative to the anther which fell under his observation in the progress of his work. The first is a case in which the anther had reverted to a leaf, giving evidence that this organ is homologous with a plane lamina, its margins or line of dehiscence answering to the margins of a leaf. The second is upon the trilocular anther of *Pachystemon*, neatly showing that this (and by just analogy the three-celled anther of *Ayenia* also) is not a combination, but answers to a single leaf. The third exhibits the double flexure in the bud, of the apex of the filament in *Cephalocroton*, the anther remaining upright, as contrasted with the inverted anthers of *Croton*. This reminds us to take some notice of—

3. *An Innovation in Nomenclature in the recently issued volume of the Prodromus.* Take, for example, the genus *Cephalocroton*, established by Hochstetter, in 1841. It appears that Baillon had reduced to it two or three species upon which he had formerly constituted two other genera; and now Dr. Müller gives the genus as "*Cephalocroton* Baillon." Take next the genus *Ricinocarpus*, established by Desfontaines and adopted by the early monographer of the order, Adrien Jussieu. It happens that the *original* of the genus has been published by Sprengel under the name of *Rœperia*, and named also by Sieber *Echinosphæra.* Is it for adding these two names as synonyms that the *Prodromus* writes "*Ricinocarpus* Müll. Arg."? Evidently not, as these synonyms are given by Endlicher. Is it because of two species now first described, of which the author constitutes two new sections of the genus, the rest of the species constituting *Euricinocarpus?* No other reason is apparent. But here no one, not the author himself, ever regarded these two new plants as anything else than species of *Ricinocarpus*, that is to say, of Desfontaines' genus.

Again, Adrien Jussieu dedicated to his friend Ampere a genus of a single known species: Brongniart added a second species: Dr. Müller has now added a third, and, forming for it a separate section, has taken the genus as his own! These are fair illustrations of the plan pursued throughout the volume. The principle acted on appears to be, that whenever an author revises a genus and extends its limits, or adds any species which are not wholly homogeneous with the old ones, although in his opinion they belong to it, he may supersede the name of the founder of the genus by his own.

We suppose the rule would hold as well in case of the restriction, as of the amplification of a genus. Upon this principle how many genera would be left to Linnæus? Not *Berberis*, for it would be attributed to the botanist who first remanded the pinnate species which composed Nuttall's genus *Mahonia*. Not even *Podophyllum*, for the second species, being hexandrous, brings in an important modification of the generic character. But the volume under consideration itself exemplifies the inevitable result. Out of the seventeen admitted Linnæan or ante-Linnæan genera it comprises, nine have lost the name of the founder. Half of the eight which retain it have only from one to six species each; and most of the rest, viz., *Stillingia*, *Omphalea*, *Manihot*, and *Andrachne*, have escaped apparently through some variation of the rule, or laxity in its enforcement, the grounds of which are not clearly obvious.

The same treatment is, naturally enough, applied to species. Take a single example from those presented on almost every page of the volume. Linnæus reduced all the forms of Castor-oil plant he knew to *Ricinus communis* L. Dr. Müller does the same: but he knows many more forms, and has arranged them with exhaustive particularity under four primary divisions, sixteen varieties, and some of these into almost as many sub-varieties. So this equivalent conclusion, resulting from a survey of more materials, is represented not by *R. communis* L., but by *R. communis* Müll. Arg. Now who shall decide upon the quantity of materials to be revised, or number of synonyms to be reduced, which may entitle a writer to take this great liberty? The only case which might seem to warrant it, is when two or more species of the same author and the same date are comprehended in one under a general character. Instances of the sort are probably to be met with in the work under consideration. But *Mercurialis annua*—from which the name of Linnæus has dropped—is not a case in point, *M. ambigua* (regarded as a mere state of the former) having been published by the younger Linnæus.

Finally, there is a foot-note on p. 192, which should not pass unnoticed. For the statement, "Nomina non rite edita sunt nomina inania omnique prioritate carentia," as interpreted by the use made of it upon the occasion of the note, opens the way by which a just and well-established rule is made to operate in violation of the prevalent comity of botanists. Our own remarks upon this very point, in this Journal for March, 1864, p. 279, have been once or twice reprinted in Europe, without dissent; and we see no good reason as yet for recalling them. While the rule in regard to priority has its proper scope in maintaining that "manuscript names in collections, however public, should assert no claim as against properly published names," still, "the distribution of named specimens [and, *à fortiori*, of these in sets, widely distributed among herbaria, as were Sieber's], where and as far as they go, is held to be tantamount to publication." So of names and original observations attached to specimens in herbaria. These names are always attached antecedently to publication; and a monographer, having, as he should, free access to all herbaria within his reach, might work a deal of harm if he did not regard such names as *to him* all the same as if already published. The full recognition of an obligation to do this has sensibly quickened the advance of botany, by securing the early distribution of materials which might otherwise have been long withheld, and by widely opening herbaria to all competent working botanists, and especially to monographers, who should be the last to deprecate the system. No doubt, like other good and necessary things, it is open to abuse and may now and then work some hardship. We would only remark that, whether on the whole the custom be good or bad, it is one for the introduction and maintenance of which we are indebted to no single botanist so much as to the founder of the Prodromus. And he, of all others, would be most surprised to learn that *Leptocaulis echinatus*, &c., *Trepocarpus Æthusæ*, and *Eulophus Americanus*, were Candollian and not Nuttallian genera and species.

Upon the whole subject we would remark, in brief, that it can hardly be supposed that these innovations will pass unquestioned; that no living botanist now stands in such position that he can becomingly set aside *mero motu* recognized usages in nomenclature; that the closing volumes of the Prodromus, which for forty years has been most efficient in establishing these usages, is hardly the proper place for changing them; and that, finally, a Botanical Congress, such as that over which, last spring, the distinguished editor of the Prodromus so happily presided, would have been a proper body to consult upon subjects of such delicacy and general interest. A. G.

4. *Mémoire sur la Famille des Pipéracées*, par M. CASIMIR DECANDOLLE. 4to pamph., pp. 32, and with 7 plates. (Extr. from *Mém. Soc. Phys. and d'Hist. Nat. Genève*, XVIII, 1866.)—The younger DeCandolle, having elaborated for the Prodromus the order *Piperaceæ*, has consigned the more interesting results of his study of the anatomy and general structure of these peculiar plants to the present article, in which, also, he indicates the grounds upon which he has reduced all the proposed piperaceous genera to three. The structural and histological details are full of interest, especially what relates to the wood of the stem; but we must defer an abstract, perhaps until that portion of the Prodromus is issued. A. G.

5. *American Heather.*—The question, whether *Calluna* is or is not indigenous to the New World,—which during several years past has been repeatedly referred to in this Journal, as additional facts came to our notice,—has now taken a new turn, Dr. Seemann, in his Journal of Botany for October last, having published and neatly figured "the Newfoundland Heather" as a distinct species, *Calluna Atlantica*. He founds it upon specimens originally from Newfoundland, which have been for some years cultivated by Dr. Moore in the Glasnevin Gardens, Dublin, side by side with the common European Heather. The diagnosis attempted, Dr. Seemann admits to be as yet far from satisfactory, except as to a biological distinction observed by Dr. Moore, viz., "that whilst the Newfoundland one always suffered from frost, and turned brown during the

mild Irish winter, the common British form, growing by its side, was unaffected by cold and retained its usual green color." Although "no argument can possibly set aside" this fact, yet its value as a character has to be considered. Probably in the station from which these specimens were lately transferred, as well as in Iceland and the higher Alps, whence Dr. Seemann has the same form, the plant was accustomed to complete protection by snow from changes of temperature the whole winter through. Unfortunately we have no specimens from Newfoundland, and Dr. Seemann does not speak of the Cape Breton, Nova Scotian or New England plants. Upon examination of these, we do not find that the indicated differences in structure (mainly the naked pedicels, broader sepals, and tip of flowering branches not continued into a leafy shoot while the flowering lasts) coincide or hold out. So that as yet a second species can hardly be said to be established. A. G.

IV. ASTRONOMY.

1. *Observations of Venus near its inferior Conjunction.*—With the excellent Equatorial of the Sheffield Scientific School, made by Clark & Sons, and having 9 inches clear aperture, Venus was carefully observed, in close proximity to the Sun, both before and after her late inferior conjunction, which happened on the 11th of December. At her nearest approach (9^h 52^m A.M.), the planet was only 22′ from the Sun's northern limb, and had the conjunction occurred a day earlier, there would have been a transit.

On the 10th, the planet was seen and measured, at 3^h 30^m P.M., when only 1° 8′ from the Sun's limb, and might have been observed later, but for the risk to the eyes, (already severely tried,) from the strong sunlight, which could not well be shut off from the telescope.

On the day of conjunction, no attempt was made to find the planet. On the day following, (the 12th,) it was again seen, at 11^h 30^m A. M., being then about 1° 36′ from the Sun's limb.

Some days before the conjunction, it was apparent that the crescent formed more than a semicircle—on the 7th, full 40° more by measurement. On the 10th, it formed a *complete circle*—bright, thin and delicate (the crescent proper), on the side toward the Sun, but on the opposite side, a mere faint line of light, very difficult to be seen, on account of the strong light in the field, and the atmospheric disturbance. Yet, by glimpses, it was distinctly perceived as a ring, by several observers, and constantly as more than three-fourths of a circle.

The appearances were similar, though perhaps a little better seen, on the 12th, the day after the conjunction. Yet, the planet was then only half a degree farther from the Sun, and the full ring could be made out only in the more favorable moments with respect to light and atmosphere—particularly, when the light, both of the sun and of the planet, was partially cut off from the object glass, by the shutter of the observatory. Such a compromise between sun-light and planet-light gave generally the best views, except twice, about noon, when, fortunately, a passing cloud left the planet in sight for a few seconds, while yet the Sun was obscured. The background was then comparatively dark, and the thread of light around the limb opposite to the sun perfectly distinct and complete. The northern portion of the crescent proper, however, did not diminish uniformly in brightness, or apparent thickness, toward the cusp, but a considerable space, between 25 and 50 degrees from the vertex to the left, by estimate, was very perceptibly fainter than a like portion of the circumference next beyond toward the right, whence it gradually narrowed to the mere faint line of light before mentioned. These observations were made between half past 11 and half past 1 o'clock.

At 2^h 15^m P. M., the planet was readily found with a portable 5 foot Clark telescope of $4\frac{3}{8}$ inches aperture, by taking a position in the shadow of a chimney some 50 or 60 feet distant. The complete ring, and the faint portion of the crescent proper, just described, were both distinctly seen—better, in fact, than with the equatorial, except in the cases mentioned, when the sun was intercepted by a passing cloud.

Observations were prevented on the 13th. On the 14th, at noon, the visible cusps extended full 50° beyond a semicircle, but no irregularity in brightness was noticed, as on the 12th. On the 15th, the cusps had receded to 30°, and on the 18th, to 22°, beyond a semicircle.

These observations have a direct and obvious bearing upon the question of the atmosphere of Venus.

The powers used were from 80 to 200 on the Equatorial, and 90 on the smaller telescope.

For the measurements, a position-micrometer by Dollond was employed. C. S. L.

Sheffield Scientific School, Dec. 29, 1866.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Telegraphic Determination of Longitude between Europe and America.*—Our readers will be gratified to learn that the undertaking of measuring the longitude between the Observatory at Greenwich England, at the stations of the geodetic survey of the United States, by means of the Atlantic cable and the connecting Telegraph lines, has been successfully accomplished, under the auspices of the United States coast survey. We are informed that the preliminary computations, such as could be made during the progress of the work exhibit an unexpectedly close agreement of results. The signals transmitted by the cable possess far greater sharpness than was anticipated, and the time of transmission has been found remarkably constant. By the liberality of the Anglo-American Telegraph Company the use of both cables was freely tendered for the transmission of signals and experiments on transmission Time. The Astronomer Royal gave his co-operation in connecting the European terminus of the cable with Greenwich, and every facility was afforded by the officers of the American and Provincial telegraph lines, in a truly liberal spirit. An interesting account of the operations may be looked for at the January meeting of the National Academy of Sciences, by Dr. B. A. Gould, under whose direction the work has been executed and who occupied the terminus in Ireland. J. E. H.

2. *Mr. George Peabody's recent gifts to Science.*—The last number of this Journal contained an announcement of Mr. Peabody's gift of $150,000 to Harvard College, for the establishment of a museum of American Archæology, and Ethnology, and the same amount to Yale College for a museum of Natural History. His donations to these institutions were accompanied by the following statements of his wishes in regard to the disposition of the fund.

GIFT TO HARVARD COLLEGE.

Georgetown, October 8, 1866.

To the Hon. ROBERT C. WINTHROP, His Excellency CHARLES FRANCIS ADAMS, FRANCIS PEABODY, STEPHEN SALISBURY, ASA GRAY, JEFFRIES WYMAN, and GEORGE PEABODY RUSSELL, Esqrs.

Gentlemen,—Accompanying this letter I enclose an instrument giving to you one hundred and fifty thousand dollars ($150,000) in trust for the foundation and maintenance of a Museum and Professorship of American Archæology and Ethnology in connection with Harvard University.

I have for some years had the purpose of contributing, as I might find opportunity, to extend the usefulness of the honored and ancient university of our Commonwealth, and I trust that in view of the importance and national character of the proposed department and its interesting relations to kindred investigations in other countries, the means I have chosen may prove acceptable.

On learning of your acceptance of the trust, and of the assent of the President and Fellows of Harvard College to its terms, I shall be prepared to pay over to you the sum I have named.

Aside from the provisions of the instrument of gift, I leave in your hands the details and management of the trust; only suggesting, that in view of the gradual obliteration or destruction of the works and remains of the ancient races of this continent, the labor of exploration and collection be commenced at as early a day as practicable; and also that in the event of the discovery in America of human remains or implements of an earlier geological period than the present, especial attention be given to their study and their comparison with those found in other countries.

With the hope that the Museum, as thus established and maintained, may be instrumental in promoting and extending its department of science, and with fullest confidence that under your care the best means will be adopted to secure the end desired,

I am, with great respect, your humble servant,

GEORGE PEABODY.

I do hereby give to Robert C. Winthrop of Boston, Charles Francis Adams of Quincy, Francis Peabody of Salem, Stephen Salisbury of Worcester, Asa Gray of Cambridge, Jeffries Wyman of Cambridge, and George Peabody Russell of Salem, all of Massachusetts, the sum of one hundred and fifty thousand dollars, to be by them, and their successors, held in trust to found and maintain a Museum of American Archæology and Ethnology, in connection with Harvard University, in the city of Cambridge, and Commonwealth of Massachusetts.

Of this sum I direct that my said trustees shall invest forty-five thousand dollars as a fund, the income of which shall be applied to forming and preserving collections of antiquities, and objects relating to the early races of the American Continent, or such (including such books and works as may form a good working library for the departments of science indicated) as shall be requisite for the investigation and illustration of Archæology and Ethnology in general, in main and special reference, however, to the Aboriginal American races.

I direct that the income of the further sum of forty-five thousand dollars shall be applied by my said trustees to the establishment and maintenance of a Professorship of American Archæology and Ethnology in Harvard University; said professor shall be appointed by the President and Fellows of Harvard College, with the concurrence of the overseers, in the same manner as other professors are appointed, but upon the nomination of the founder or the board of trustees. He shall have charge of the above-mentioned collections, and shall deliver one or more courses of lectures annually, under the direction of the government of the university, on subjects connected with said departments of science.

Until this professorship is filled, or during the time it may be vacant, the income from the fund appropriated to it shall be devoted to the care and increase of the collections.

I further direct that the remaining sum of sixty thousand dollars be invested and accumulated as a Building Fund, until it shall amount to at least one hundred thousand dollars, when it may be employed in the erection of a suitable fire-proof museum building, upon land to be given for that purpose, free of cost or rental, by the president and fellows of Harvard College, the building when completed, to become the property of the college, for the uses of this trust, and none other.

The board of trustees I have thus constituted shall always be composed of seven persons, and it is my wish that the office of chairman be filled by Mr. Winthrop,—in the event of his death or resignation, by Mr. Adams, and so successively in the order I have named above. The trustees shall keep a record of their doings and shall annually prepare a report setting forth the condition of the trust and funds, and the amount of income received and paid out by them, during the previous year. This report, signed by the trustees, shall be presented to the president and fellows of the college.

In the event of the death or resignation of Mr. Winthrop, I direct that the vacancy in the number of the board be filled by the president of the Massachusetts Historical Society, who *ex officio* shall forever after be a member of the board. In the event of the death or resignation of Mr. Peabody, the vacancy to be filled by the president of the scientific body now established in the city of Salem, under the name of the Essex Institute; of Mr. Salisbury, by the president of the American Antiquarian Society; of Prof. Gray, by the president of the American Academy of Arts and Sciences; and of Prof. Wyman, by the president of the Boston Society of Natural History, all of whom shall forever after be *ex officio* members of the board.

Should the president of either of the societies I have named decline to act as a trustee, each vacancy, and all other vacancies that may occur in the number of the trustees, shall be filled by the remaining trustees, who shall, within a reasonable time, make the appointment or appointments.

I give to my said trustees the liberty to obtain from the Legislature an act of incorporation if they deem it desirable, to make all necessary by-laws, to appoint a treasurer, and to enter into any arrangements and agreements with the government of Harvard College, not inconsistent with the terms of this trust, which may, in their opinion, be expedient.

(Signed) GEORGE PEABODY.

Georgetown, Oct. 8, 1866.

GIFT TO YALE COLLEGE.

New York, Oct. 22, 1866.

To Professor JAMES D. DANA, Hon. JAMES DIXON, Hon. ROBERT C. WINTHROP, Professor BENJAMIN SILLIMAN, Professor GEORGE J. BRUSH, Professor OTHNIEL C. MARSH, and GEORGE PEABODY WETMORE, Esq.

Gentlemen,—With this letter I enclose an instrument giving to you one hundred and fifty thousand dollars ($150,000) in trust for the foundation and maintenance of a Museum of Natural History, especially of the departments Zoology, Geology and Mineralogy, in connection with Yale College.

I some years ago expressed my intention of making a donation to this distinguished institution, and convinced as I am of the importance of the natural sciences, and of the increasing interest taken in their study, it now affords me great pleasure to aid in advancing these departments of knowledge.

The rapid advance which natural science is now making renders it necessary to provide for the future wants of such a museum, as well as its present requirements, and I trust that the portion of the fund designed for this purpose will be found sufficient.

On learning of your acceptance of this trust, and of the assent of the President and Fellows of Yale College to its conditions, I shall be prepared to pay over to you the sum I have named, and I may then have some additional suggestions to make in regard to the general management of the trust.

Confident that under your direction this trust will be faithfully and successfully administered,

I am, with great respect, your obedient servant,

GEORGE PEABODY.

I hereby give to James Dwight Dana, of New Haven, Conn.; James Dixon, of Hartford, Conn.; Robert C. Winthrop, of Boston, Mass.; Benjamin Silliman, of New Haven, Conn.; George Jarvis Brush, of New Haven, Conn.; Othniel Charles Marsh, of New Haven, Conn.; and George Peabody Wetmore, of Newport, R. I., on his attaining his majority, the sum of one hundred and fifty thousand dollars, to be by them or their successors held in trust to found and maintain a *Museum of Natural History*, especially of the departments of Zoology, Geology and Mineralogy, in connection with Yale College, in the City of New Haven, State of Connecticut.

Of this sum I direct that my said trustees devote a part, not to exceed one hundred thousand dollars, to the erection, upon land to be given for that purpose, free of cost or rental, by the President and Fellows of Yale College, in New Haven, of a fire-proof museum building, adapted to the present requirements of these three departments of science, but planned with especial reference to its subsequent enlargement, the building, when completed, to become the property of said college for the uses of this trust, and none other.

I further direct that the sum of twenty thousand dollars be invested, and accumulate as a building fund until it shall amount to at least one hundred thousand dollars, when it may be employed by my said trustees, or their successors, in the erection of one or more additions to the museum building, or in its final completion; the land for the same also to be provided free of cost or rental by the President and Fellows of Yale College, in New Haven, and the entire structure when completed to be the property of Yale College, for the uses of this trust and none other.

I further direct that thirty thousand dollars, the remaining portion of this donation, be invested, and the income from it be expended by my said trustees, or their successors, for the care of the museum, increase of its collections and general interests of the departments of science already named; the part of the income remaining after providing for the general care of the museum to be apportioned in the following manner; three-sevenths to zoology, three-sevenths to geology, and one-seventh to mineralogy; the said collections, as well as the museum building, to be exclusively for the benefit of the various departments of said College.

The Board of Trustees I have thus constituted shall always be composed of seven persons, of whom not more than four shall at any one time be members of the Faculty of Yale College. They shall have the general management of the museum, keep a record of their doings, and annually prepare a report setting forth the condition of the trust and funds, and the amount of income received and paid out by them during the previous year. This report, signed by the trustees, shall be presented to the President and Fellows of Yale College, in New Haven, at their annual summer session, and be by them filed in the archives of said college.

In the event of the death or resignation of either of my said trustees, I direct that his successor be the Governor of Connecticut, who, *ex officio*, shall forever after be a member of the Board. Any other vacancy that may occur in the Board of Trustees, either by resignation or by death, shall be filled by the remaining trustees within a reasonable time after such vacancy shall have occurred.

I give to my said trustees, and their successors, the liberty to appoint a treasurer, and to enter into any agreements with the President and Fellows of Yale College, not inconsistent with the terms of this trust, which may in their opinion be expedient.

(Signed,) GEORGE PEABODY.

New York, Oct. 22, 1866.

In addition to the above donations Mr. Peabody has recently given $500,000 to the Peabody Institute established by him at Baltimore, making its present endowment $1,000,000; and has increased to $250,000 his previous gift to the Peabody Institute in his native town of Danvers, Mass. Each of these institutions will contain an extensive library, and annually provide several courses of free lectures on scientific and literary subjects. Mr. Peabody has, moreover, just made a donation of $25,000 to Phillips Academy, Andover, Mass., to provide instruction in the natural sciences and mathematics, and another of the same amount to Kenyon College, Ohio, for a similar purpose. He has also recently given $20,000 to the library fund of the Maryland Historical Society, and founded free libraries at Georgetown, Mass., and Thetford, Vt.

These munificent gifts, amounting in all to nearly $1,650,000, place the donor, already so highly honored for his other noble charities, among the foremost benefactors of science, and cannot fail to exert a most beneficial influence upon the educational interests of this country.

OBITUARY.

George W. Featherstonhaugh, the author of a geological report on the Missouri and Red rivers, published by our government, in 1834, and originator and editor of Featherstonhaugh's Geological Journal published in 1831, 1832 at Philadelphia, died at Havre on Sept. 28, in his eightieth year. He had been consul at Havre for nearly twenty years.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Geological Map of the Department of the Seine*, by Mr. Delesse.—This elaborate and beautiful Chart, the publication of which was announced in the last number of this Journal (p. 440), is worthy of a careful examination by all who are interested in the construction of maps of this kind, or in the geology of the region it embraces. It is constructed on a scale of 1 : 25000, and the method employed by Delesse is essentially the same as that used in his map of the city of Paris. The various formations, with exception of the diluvium, which is supposed to be removed, are represented by colors as in ordinary geological maps. In addition to this a new feature is introduced, which will doubtless be often employed in the future, and hence deserves more than a passing notice. By means of a system of horizontal curves, drawn at a perpendicular distances of 20 meters from each other, measured from the level of the sea, a subterranean geological map, or rather a series of maps, is formed on which the surfaces of the principal formations for each level is indicated. To obtain these curves Mr. Delesse examined all the various localities, where it was possible to make a geological section,—especially the quarries, wells, and other surface excavations, as well as the numerous subterranean works, executed within the last few years in the environs of Paris. Starting from data thus obtained, the elevation of the points, where a geological section was made, was accurately determined by leveling, and the operation repeated until a system of points was obtained sufficiently near together to admit of the tracing of horizontal curves indicating each surface. In this manner is represented the upper surface of the Cretaceous, the Plastic Clay, the White marls above the Calcaire grossier, the Travertin of St. Ouen, the Green clays, the Sandstone of Fontainebleau, and finally the under surface of the Diluvium. The intervening formations are, of course, also indicated by the same curves.

By the aid of this subterranean geological map, it is easy to determine the strata which would be struck at any given point in the vicinity of Paris; for the colors indicate the formation lying immediately under the diluvium, and, as the point selected will fall between two horizontal curves representing the surfaces of the different strata, a fourth proportional is all that is required to calculate the depth at which any one of these surfaces may be reached.

The method employed in the execution of the map facilitates, moreover, a thorough study of the formations represented, and may be advantageously used in exploring for deposits of economic value. The chart has other features of interest which will repay examination. It is probably the most elaborate geological map ever constructed, and will doubtless long be regarded as a model. O. C. M.

2. *The American Naturalist, a Popular Magazine of Natural History.*—Under this title, the Officers of the Essex Institute, Salem, Mass., propose to publish a monthly magazine, commencing early in the present year.

The object of this journal is to supply a long-existing demand for a popular illustrated magazine of Natural History, devoted to the exposition of scientific topics in a free and familiar manner, without those technicalities which often render the mass of such reading tedious and difficult.

Among the contents of the magazine, will be papers on topics of a general and special nature relating to Natural History, illustrated with appropriate wood engravings, and occasional lithographic plates; these papers will be mainly original, but compilations and translations of papers from other sources will be introduced when deemed of sufficient interest. It will also contain accounts of excursions and expeditions made for scientific purposes, with descriptions of the various objects of interest discovered—explanations of the principles of the structure, development and classification of Animals and Plants, both living and fossil, and notices of recent discoveries in Geology and Archæology—directions for collecting, preparing and arranging collections, including descriptions of the latest methods of mounting and preparing specimens—short reviews of scientific and popular works on Natural History—brief notices of the meetings of the Natural History Societies throughout the country—descriptions of scientific museums, and answers to correspondents on scientific topics.

Each number will contain 48 octavo pages of reading matter, besides advertising sheets.

Such a magazine is greatly needed in this country and will doubtless meet the patronage to which its able corps of editors and imposing list of contributors entitle it.

The editors are A. S. Packard, Jr., M.D., in connection with E. S. Morse, Alpheus Hyatt and F. W. Putnam. V.

3. *A Manual of Blowpipe Analysis and Determinative Mineralogy;* by WILLIAM ELDERHORST, M.D. Third edition, 12mo, pp. 179, revised and greatly enlarged. Philadelphia, 1866. (T. Ellwood Zell.)—The value of this useful manual on blowpipe analysis has already been recognized in this Journal in noticing the second edition. But we have failed to discover evidence of the revision and enlargement announced on the title page of the third edition.

4. *Catalogue of the Silurian Fossils of Anticosti, with descriptions of new genera and species;* by E. Billings, F.G.S. 94 pp., large 8vo. Montreal, 1866. From the Geological Survey of Canada, Sir W. E. Logan, Director.—This report on the fossils of Anticosti, by the accomplished paleontologist of the geological survey of Canada, is more than a mere catalogue, as it contains descriptions of many species, with a number of wood-cuts. We defer a further notice to another number.

5. *Lessons in Elementary Chemistry;* by Henry E. Roscoe, B.A., F.R.S., Professor of Chemistry in Owens College, Manchester. London, Macmillan & Co., 1866. 18mo, pp. viii, 398.—This book of Dr. Roscoe's, though designedly an elementary work, is written from an advanced standpoint, and, while simple and clear in its statements, it carries the student fully up to the position which the science of chemistry has now reached. Adopting the unitary system in its completeness, it spends but little time in prefatory explanations, but leaves the philosophy to be gathered from the several substances considered. We notice several chapters of great value: especially those on the physical properties of gases; on the atomicity of the elements; on crystallography; on spectrum analysis, and solar and stellar chemistry; and his chapters introductory to organic chemistry. Questions upon the sections, with exercises are given in an appendix. We are glad to see he has abolished the unsatisfactory term "anhydride" and substituted "oxide" instead: the nitr-oxygen series being "nitrous oxide, nitric oxide, nitric trioxide, nitric tetroxide, and nitric pentoxide." His "potassium oxide" seems to us less smooth than the "potassic oxide" of Williamson; and "hydric-potassium sulphate" is improved if written hydro-potassic sulphate. We commend this little volume as one of the best elementary treatises on chemistry in the English language. G. F. B.

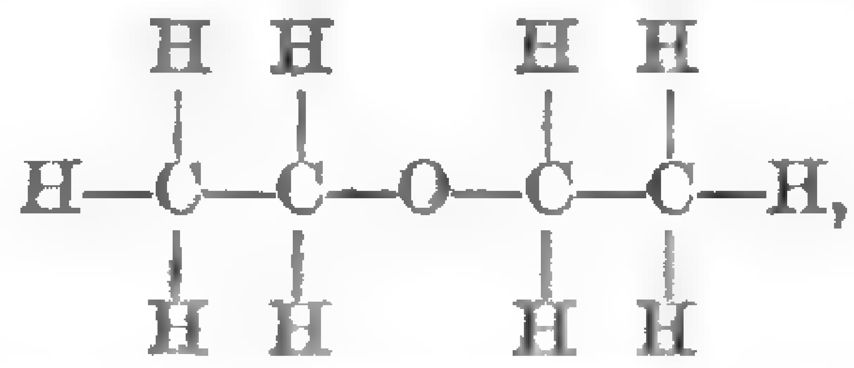
6. *Lecture notes for Chemical Students: embracing Mineral and Organic Chemistry;* by Edward Frankland, F.R.S., For. Sec. C. S., Professor of Chemistry in the Royal Institution of Great Britain, etc. London, John Van Voorst, Paternoster Row, 1866. 12mo, pp. xx, 422.—Dr. Frankland's views upon the constitution of chemical compounds are well known through his published papers. "Organic as well as inorganic compounds are most instructively represented upon the typical compounds of the most polyatomic radical they contain." Thus upon the types $SbCl_3$* and $SbCl_5$ all the compounds of antimony may be written: as $SbEt_3$ and $SbEt_4I$. And CEtI, allylic iodid, and CMe_2H_2, propylic hydrid, are formed upon the carbon types CO and CO_2. Here it is evident that the composition of these compounds is determined by the equivalence of the highest poly-equivalent radical they contain. Each of the determinants† in the above examples, however, has two equivalencies; antimony acts as a triad and a pentad, carbon as a dyad and a tetrad. Dr. Frankland considers that in the highest compound of any radical its power of combination is saturated; this he calls the point

* H=1, O=16, C=12, Sn=118, Pt=197·4, Me=(CH_3), Et=(C_2H_5), Ho=(HO), etc.

† Dr. Wolcott Gibbs proposes the term "determinant" for the highest poly-equivalent radical in a compound, "object" for the body saturating it, and "resultant" for the product. In ammonia, for example, N is the determinant, H the object, and NH_3 the resultant.

of atomic saturation. In this stage bodies can neither combine with other bodies nor replace them; and they cannot take part in any chemical change without undergoing decomposition. Below this point, however, there are in most cases certain points of comparative stability, at one of which this stability may be at its maximum, the compound undergoing decomposition less readily than when atomically saturated. Thus nitrogen atomically saturated is a pentad; but it has a trivalent and a univalent stage, of which the former is the stage of maximum stability. In this stage bodies may unite directly with or replace other bodies, thus acting like compound radicals. This fact Dr. Frankland explains by supposing that the units of attraction or *bonds* of an atom may saturate each other by pairs. Nitrogen as a pentad is $\overset{|}{=N=}$, as a triad $\overset{|}{=N}{>}$, and a monad ${<}\overset{|}{N}{>}$. The maximum number of bonds he calls the "absolute atomicity," the number of bonds united to each other "latent atomicity;" and those free to unite "active atomicity." The absolute atomicity equals of course the sum of the other two. The hexad iron forms ferrous chlorid $^{iv}Fe''Cl_2$, in which the active atomicity is two; ferric chlorid $'''Fe_2'''Cl_6$, in which it is three; and ferric acid $Fe^{vi}O_2Ho_2$, in which all the atomicity is active.

The book above mentioned is a synopsis of a course of lectures delivered at the Royal College of Chemistry in the fall of 1865–6, and is devoted to a development of these views. In all the rational formulæ it contains, the determinant is written first, printed in heavy type, thus: $\mathbf{O}H_2$, $\mathbf{Sn}O_2$, $\mathbf{Pt}Cl_4$, $\mathbf{C}OKo_2$; indicating that "it is united with all the active bonds of the other radicals, following upon the same line." With one atom of the determinant as above, formulæ are mon-adelphic; with two of equal power di-adelphic, etc. In the latter case one symbol is written below the other, connected by a bracket, thus: $\left\{\begin{matrix}\mathbf{C}H_3\\ \mathbf{C}H_3\end{matrix}\right.$. Dr. Frankland uses the bracket solely to signify that the atoms it connects exchange one bond. These atoms may be united indirectly as in methylic ether, $\left\{\begin{matrix}\mathbf{C}H_3\\ O\\ \mathbf{C}H_3\end{matrix}\right.$, where the dyad oxygen atom links them together. Speaking of rational formulæ the author says, "the formula ought to show, first, whether the hydrogen is combined with the carbon or with the oxygen; or if combined with both, it should indicate how many atoms are united with the carbon and how many with the oxygen. Secondly, the formula ought to show whether the oxygen be united with the carbon or with the hydrogen, or partly with the one and partly with the other; or, lastly, whether it be performing the function of linking hydrogen to carbon." p. 201. The representation in a formula of the mode in which the atoms are held together (and not of course their relative position in space) so necessary to explain cases of isomerism, and which cannot be given by the ordinary typical formulæ, is well obtained by those of Dr. Frankland. In aluminic oxyd, for example, $\left\{\begin{matrix}\mathbf{Al}O\\ \mathbf{Al}O\end{matrix}\right.O$, each aluminum atom exchanges one bond with its fellow, two with the dyad oxygen atom on the same line, and one with the single oxygen atom intermediate; in ethylic ether, $\left\{\begin{matrix} \mathbf{C}MeH_2 \\ O \\ \mathbf{C}MeH_2 \end{matrix}\right.$, the carbon atoms are linked by the oxygen atom, while the other three bonds of each are united respectively with one atom of Me and two of H. To farther elucidate this important fact of combination, Dr. F. makes use of the graphic notation of Crum Brown (using in lectures the glyptic formulæ of Hofmann).* Aluminic oxyd is O=Al(–O–)Al=O; and ethylic ether is



in which the mode of union of the atoms is the same as that above given. These graphic methods, used more or less by Kekulé, Wurtz, Roscoe, Foster, etc., are most happy in the clearness with which they express the manner in which the bonds of an atom are saturated. Thus Dr. F. represents a molecule of oxygen as O=O, and one of ozone as O(–O–)O. The formulæ of complex minerals given opposite pages 103 and 177, cannot fail to be of the highest value in mineralogy, if only we know enough of their constitution to say that these are their true rational formulæ.

Dr. Frankland has been remarkably successful in developing these views, and in applying them alike to mineral and organic chemistry. We notice, however, the objectionable term "anhydride" retained; while to our view the term "carbonic dioxide" of Foster (or "carbonylic oxide" CO ≻O) is far preferable. Again, we think his reason for excluding carbonic acid from the organic acids hardly sufficient. The volume deserves careful study. The novelty of many of its views, coming from so distinguished a chemist, are most suggestive, and cannot fail to exert an important influence upon theoretical chemistry. All the more important elements and compounds, with their modes of preparation, the reaction in each case, their physical and chemical properties, and their modes of decomposition, are most clearly described. And thus the object of the work, to furnish names, formulæ and reactions, and so to save to the student the time spent in copying these in the lecture room is most successfully accomplished.† G. F. B.

7. *Chemical Tables;* by Stephen P. Sharples, S.B. Cambridge, Sever & Francis, 1866. pp. 192.—We cannot give a better idea of the value of this book than by stating the heads under which the tables are arranged. Tables for the calculation of analyses; relating to specific gravity; relating to heat; for gas analysis; relating to light; miscellaneous tables. A table of logarithms closes the volume. A collection of physico-chemical constants like this cannot fail to be of great use both to the physicist and chemist. We need no higher endorsement of the work than that of Dr. Wolcott Gibbs, under whose supervision it was prepared.

* Not. Roy. Inst. of Great Britain, April 7, 1865.

† Quart. Jour. Chem. Soc., xiii, 177, and [2], iv, 372.

8. *A new Chemical Nomenclature;* by S. D. Tillman, A.M., Professor of Technology in the Am. Inst. of the city of New York. pp. 23.—This paper was read before the American Association at the Buffalo meeting last August. Prof. T. attempts to embrace both nomenclature and notation in one mnemonical method, which is certainly very ingenious, and surprisingly successful. He exhibits an accurate acquaintance with chemical facts and relations. But his system does away with the old landmarks too entirely to be received into the philosophy of chemistry.

9. *Memoirs of the National Academy*, Vol I. pp. 344, 4to. Washington, 1866.—This first volume of the Memoirs of the National Academy of Sciences contains the following papers read before the Academy in 1864, 1865:

(1.) Reduction of the observations of the fixed stars made by Joseph Le Paute d'Agelet, at Paris, during the years 1783–1785, with a catalogue of the corresponding mean places referred to the equinox of 1800·0; by B. A. Gould. (2.) On the Saturnian system; by Benjamin Peirce. (3.) On shooting stars; by H. A. Newton. (4.) On the distribution of certain important diseases in the United States; by Augustus A. Gould. (5.) On rifled guns; by W. H. C. Bartlett.

Dr. Gould's paper was noticed in this Journal in our last volume, and the principal part of Prof. Newton's appeared in vol. xxxix.

First Annual Report of the Geology of Kansas; by Prof. B. Mudge, A.M. 56 pp., 8vo. Lawrence (Kansas), 1866. Report for the year 1864.

Preliminary Report of the Geological Survey of Kansas; by Prof. G. C. Swallow, State Geologist. 198 pp., 8vo. Lawrence, 1866. Report for the year 1866.

Proceedings Bost. Nat. Hist. Soc., Vol. X.—P. 358, Formation of the excavated lake basins of New England; *N. S. Shaler.*—Vol. XI. P. 1, Anatomy and physiology of the ciliary muscle in man; *B. J. Jeffries.*—p. 3, On a cat with supernumerary digits; *B. G. Wilder.*—p. 8, Formation of mountain chains; *N. S. Shaler.*

Proceedings Acad. Nat. Sci. Philadelphia, No. 3, June, July and August, 1866.—p. 236, Introduction of American shad into the Alabama river; *W. C. Daniell.*—p. 238, Description of some new species of Diurnal Lepidoptera; *Tryon Reakirt.*—p. 251, Contributions to the paleontology of Illinois and other western states; *F. B. Meek & A. H. Worthen.*—p. 275, Remarks on the remains of a gigantic Dinosaur from Cretaceous green sand of New Jersey; *E. D. Cope.*—p. 279, Notes on the Vespertilionidæ of tropical America; *H. Allan.*

Proceedings Amer. Philosoph. Soc. Philadelphia, Vol. X, No. 75.—P. 196, Observations on skylight polarization; *P. E. Chase.*—p. 199, Practical application of diamagnetism; *J. C. Cresson.*—p. 201, Native Siamese photography; *Dubois.*—p. 203, Odjibowé-François dictionary; *G. A. Belconot.*—p. 206, The auroral display Feb. 20-21; *J. C. Cresson.*—p. 210, On Sullivant & Lesquereux's Musci Bor. Amer.; *T. P. James.*—p. 211, Obituary of Oswald Thompson; *E. K. Price.*—p. 223, On the comparative visibility of Arago's, Babinet's and Brewster's neutral points; *P. E. Chase.*—p. 227, Records of oil-borings (with map); *J. P. Lesley.*—p. 243, On some specimens of Indian pottery (with plate); *F. Peale.*—p. 246, Observations on some species of Spirifera; *J. Hall.*

Proceedings Amer. Acad. Arts and Sci., Vol. VII.—P. 2, On certain formulæ of interpolation; *Ferrell.*—p. 31, An annual variation in the daily mean level of the ocean and its causes; *Ferrell.*—p. 37, Right ascensions observed at Harvard Coll. Observatory in the years 1862-1865; *T. H. Safford.*—p. 39, Some focal properties of quadratics; *J. E. Oliver.*—p. 52, On the Nephila plumipes, or silk-spider; *B. G. Wilder.*—p. 57, The aqueous lines of the solar spectrum; *J. P. Cooke, Jr.*—p. 68, Notes on the cells of the Bee; *J. Wyman.*—p. 84, New process of organic elementary analysis for substances containing chlorine; *C. M. Warren.*

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XVI.—*On the Decrease of the Rate of Increase of Population now obtaining in Europe and America;* by HORATIO ROBINSON STORER, of Boston, Professor of Obstetrics and the Diseases of Women in Berkshire Medical College.

(Read before the American Academy of Arts and Sciences, Dec. 14, 1858.)*

IN calling the attention of the Academy to some remarkable and hitherto unexplained facts in the present history of powerful nations, bearing upon their prosperity, progress and even their future existence, I beg heed to the various steps by which I shall arrive at certain astounding conclusions, of the deepest interest to political economists, as well as to moralists.

In many countries of Europe, it has been ascertained that the "fecundity" of the population, in other words the rate of its annual increase, is rapidly diminishing.

* The above paper, as will be seen, was prepared and read nearly ten years ago. It was thought best at the time to confine its discussion to the Medical profession, that any error either in statistics or reasoning might be detected. Portions of it were accordingly published in Philadelphia under the auspices of the American Medical Association, as correlative to the report of a committee, of which the writer was chairman. The event has shown the justice of his conclusions. Not an attempt even has been made to controvert them, while evidence in their favor has been steadily accumulating of an overwhelming character. Physicians are now of one mind as to the existence of the main facts proved. This has been shown by the authoritative issue for general circulation of the late Prize Essay of the Am. Med. Association (Why Not? A Book for Every Woman), and by the publication of corroborative testimony by many practitioners, in different parts of the country. This fact and the increased interest taken in the subject by the leading political economists of Europe, would show that the time was now ripe for its discussion by the scientific world.—H. R. S.

In Sweden, it has lessened by one-ninth in sixty-one years; in Prussia, by a third in 132 years; in Denmark by a quarter in 82 years; in England, by two-sevenths in a century; in Russia, by an eighth in 28 years; in Spain, by a sixth in 30 years; in Germany, by a thirteenth in 17 years; and in France, by a third in 71 years.* Or, to reduce these fractions to decimals—in Sweden the rate of increase has lessened by a fifth, in Prussia by a fourth, in Denmark and England by a third, and in Russia, Spain, Germany and France by a half, in a single century.

For convenience sake, larger bodies of statistics existing concerning it, and from the fact that it represents the extreme of the alleged decrease, I shall take France as the basis of my comparisons.

In France at large, according to the official returns as analyzed by Legoyt,† the increase of the population, which from 1801–06 was at the rate of 1·3 per cent, annually, from 1806–46 had fallen to about ·5 per cent. The exact ratio of decrease after this period is better shown by the figures themselves. The increase from

1841–46	was	1,200,000
1846–51	"	380,000
1851–56	"	256,000

In England during the latter period, with a population of but one half the size, the returns of the Registrar-General showing a relative increase nine times greater.‡

In 37 years from 1817–54 the mean annual increase in France was not more than 156,000; yet in five years, from 1846–51, it had fallen to 76,000 yearly, and from 1851–56 to 51,200; and this, with a population ranging from 29 to 34 millions!

A comparison of these facts with those obtaining in other European states, will make the above still more evident.

TABLE I.—*Rate of increase in Europe* (according to Rau).§

		Per cent.			Per cent.
Hungary (Rohrer),		2·40	Netherlands,	1821–28	1·28
England,	1811–21	1·78	Saxony,	1815–30	1·15
"	1821–31	1·60	Baden (Hennisch),	1820–30	1·13
Prussia,	1816–27	1·54	Bavaria,	1814–28	1·08
"	1820–30	1·37	Naples,	1814–24	0·83
"	1821–31	1·27	France (Mathieu),	1817–27	0·63
Austria (Rohrer),		1·30	" more recently (DeJonnés),		0·55
Scotland,	1821–31	1·30			

A similar and corroborative table, containing additional matter, is given by Quetelet;‖ its differences from the preceding are owing to its representing a different series of years.

* Moreau de Jonnés, Eléments de Statistique, 1856, p. 202.
† Journal des Economistes, March and May, 1847.
‡ Edinb. Rev., Jan. 1857, p. 342; Med. Times and Gazette, May, 1857, p. 462.
§ Lehrbuch der Politischen Oekonomie.
‖ Sur l'Homme et le Développement de ses Facultés, tom. i, ch. 7.

Table II.—*Rate of increase in Europe* (according to Quetelet).

	Per cent.		Per cent.
Ireland,	2·45	Austria,	1·30
Hungary,	2·40	Bavaria,	1·08
Spain,	1·66	Netherlands,	0·94
England,	1·65	Naples,	0·83
Rhenish Prussia,	1·33	France,	0·63

And more recently, Legoyt* brings up these results to the close of 1846, by census, and by the annual excess of births over deaths, and is therefore more reliable.

Table III.—*Rate of increase in Europe* (according to Legoyt) *by census.*

	Per cent.		Per cent.
England and Scotland,	1·95	Holland,	0·90
Prussia,	1·84	Austria,	0·85
Saxony,	1·45	Sweden,	0·83
Norway,	1·36	France,	0·68
Sardinia,	1·08		

Table IV.—*Rate of increase in Europe* (according to Legoyt) *by annual excess of births.*

	Per cent.		Per cent.
Norway,	1·30	Saxony,	0·90
Prussia,	1·18	Hanover,	0·85
Sweden,	1·14	Belgium,	0·76
Holland,	1·03	Bavaria,	0·71
Wurtemberg,	1·00	Russia,	0·61
England and Scotland,	1·00	France,	0·50
Denmark,	0·95	Normandy,	—
Austria,	0·90		

In four departments of France, among which are two of the most thriving of Normandy, the deaths actually exceed the births.†

From the above facts the general mortality not being excessive, it is evident that the percentage of births to the whole population must be smaller in France than in most other European countries; and from the lessened annual rate of increase of the population, that the percentage of births must be decreasing in similar ratio.

From larger statistics furnished by De Jonnés, I have compiled the following table of the comparative ratios of births to the population in the different countries of Europe.

Table V.—*Annual ratio of Births in Europe.*

Venice and dependencies 1827,	1 to 23	Sardinia 1820,	1 to 26
Tuscany 1834,	"	Naples and dependencies 1830,	"
Lombardy 1828,	1 to 24	Greece 1828,	"
Russia 1835,	1 to 25	Poland 1830,	1 to 27
Wurtemberg 1821–27,	"	Ireland 1821–31,	"
Prussia 1836,	"	Germany 1828,	"
Mecklenberg 1826,	1 to 26	Switzerland 1828,	"

* Journal des Economistes, May, 1847.
† Mill, Prin. of Pol. Econ., i, p. 343.

TABLE V—continued.

Spain 1826,	1 to 27	Roman States 1836,	1 to 30
Portugal 1815–19,	1 to 27·5	Turkey 1835,	"
Sweden 1825,	1 to 28	Hanover 1835,	1 to 31
Austria 1829,	"	Sicily 1832,	"
Belgium 1836,	"	Austria 1828–30,	1 to 32
Bavaria 1825,	"	Great Britain 1821–31,	"
Two Sicilies 1831,	"	Scotland 1821–31,	1 to 34
Holland 1832,	"	England 1821–31,	1 to 35
Sweden and Norway 1828,	1 to 30	Norway 1832,	"
Denmark 1833,	"	France (1771, 1 to 25) 1851,	1 to 37

In a total population at different periods of 232,673,000, there were 8,733,000 births; whence an average on the grand scale of 1 birth to every 26·6 individuals.

In France, however, the ratio has been steadily lessening; as seen by the following table.

TABLE VI.—*Annual ratio of Births in France.*

1771–75,	1 to 25	1836–40,	1 to 34
1801–10,	1 to 30	1841–45,	1 to 35
1811–25,	1 to 32	1846–50,	1 to 37
1826–36,	1 to 33		

The position of France as compared with the rest of Europe, in respect to the ratio of births to the population at different periods can be made still more manifest.

TABLE VII.—*Comparative ratios of Births in Europe.*

1 to 23,	Venetian Provinces 1827, Tuscany 1834.	1 to 29,	Canton Lucerne 1810, Holland 1832.
1 to 23·5,	Kingdom of Naples 1822–24.	1 to 29·8,	*France* 1801.
1 to 24,	Tuscany 1818, Sicily 1824. Lombardy 1827–28, Russia 1831.	1 to 30,	Sweden and Norway 1828, Belgium 1832, Denmark 1833, Turkey 1835, States of the Church 1836.
1 to 24·5,	Prussia 1825–26.	1 to 31,	Sicily 1832, Hanover 1835.
1 to 25,	*France* 1781, Austria 1827, Russia 1835, Prussia 1836.	1 to 31·4,	*France* 1811.
1 to 26,	Sardinia 1820, Hanover, Wurtemberg and Mecklenberg 1826, Greece 1828, Naples 1830.	1 to 31·6,	*France* 1821.
1 to 27,	Spain 1826, Germany, Switzerland 1828, Poland 1830, Ireland 1831.	1 to 32,	Austria 1830, Great Britain, Switzerland 1831.
1 to 27·5,	Portugal 1815–19.	1 to 33,	*France* 1828–31.
1 to 28,	Holland 1813–24, Bavaria, Sweden 1825, Austria 1829, Belgium 1836.	1 to 34,	Norway, Holstein 1826, Scotland 1831, *France* 1834–41.
		1 to 35,	Denmark 1810, England 1831, Norway 1832.
		1 to 35+,	*France* 1851.

In Paris, strange to say, the decrease in the ratio of births to the population, though decided and steady, has not in actual proportion been as great as in the Empire at large; showing that the cause, whatever it may be, is not one depending on the influence of a metropolis alone for its existence.

From 1817–31 there averaged in Paris 1 birth to 26·87 inhabitants, and from 1846–51, 1 to 31·98.*

* Husson, Les Consummations de Paris, 1856.

The facts thus far stated are admitted by the leading statisticians and political economists of the day, ignorant as they seem of much of the evidence soon to be brought forward, and of the conclusion to which the whole matter directly and with almost mathematical exactness may be proved to tend.

"In France," remarks De Jonnés, "the fecundity of the people is restrained within the strictest limits."*

"The rate of increase of the French population," says Mill, "is the slowest in Europe. The number of births not increasing at all, while the proportion of births to the population is considerably diminishing."†

We turn now to this country, to the commonwealth of Massachusetts.

In the state of Massachusetts, it has been found of late years that the increase of the population, or the excess of the births over the deaths, has been *wholly* of those of *recent foreign origin*.‡ This in 1850, and asserted of the state at large. In 1853, "it is evident that the births within the commonwealth, with the usual increase, have resulted in favor of foreign parents in an increased ratio."§ In other words, it is found that in so far as depends upon the American and native element and in the absence of the existing immigration from abroad, the population of Massachusetts is stationary or decreasing. This is shown also to threaten, even if we allow the foreign element to enter the calculation.

In 1850, the population of Massachusetts was by census 994,665, and the births were 27,664: in 1855 they were 32,845 and the population 1,132,369. The proportion of births to the population was therefore 1 to 36 in 1850, and in 1855 1 to 34; a ratio much smaller than that obtaining in most countries of Europe, and but little over that of France, which in 1850 was 1 to 37.‖

"This result," remarks Dr. Chickering, page 49 of the pamphlet just quoted, "will doubtless surprise many, who will hardly think it possible. Is it general or is it accidental? If it be general, how has it happened? What causes have been in operation to produce it? How is it to be accounted for?" These questions have hitherto been unanswered.

Decrease in the births of a nation, its lessened rate of increase,

* Eléments de Statistique, p. 195.

† Principles of Polit. Economy, i, pp. 343, 344.

‡ Chickering: Comparative View of the Population of Boston. 1850. City Document, No. 60, p. 44.

§ 12th Registration Report to the Legislature of Massachusetts, 1853, p. 116.

‖ The present statistics and others subsequently presented, I have computed from the fourteen published Registration Reports of the State of Massachusetts. Those concerning New York I have drawn from a series of official reports, kindly furnished me by the present City Inspector, Mr. Geo. W. Morton.

must depend, according to one writer, De Jonnés, "either on physical agents, especially climate, or on the degree of civilization of a people, their domestic and social habits." "In France," he again remarks, "the climate is favorable to an increase of population, and this obstacle, this restraint, is found in its advanced civilization."*

"This diminution of births," says Legoyt, "in the presence of a constant increase of the general population and of marriages, can be attributed to nothing else than wise and increased foresight on the part of the parent."†

"The French peasant," writes Mill, "is no simple countryman, no downright '*paysan du Danube;*' both in fact and in fiction he is now '*le rusé paysan.*' That is the stage which he has reached in the progressive development which *the constitution of things has imposed on human intelligence and human emancipation.*"‡

"These facts," he again asserts, "are only to be accounted for in two ways. Either the whole number of births which nature admits of and which happen in some circumstances, do not take place; or if they do, a large proportion of those who are born, die. The retardation of increase results either from mortality or prudence; from Mr. Malthus's 'positive,' or from his 'preventive' check; and one or the other of these must and does exist and very powerfully too, in all old societies. Wherever population is not kept down by the prudence of individuals or of the state, it is kept down by starvation or by disease."§

But on the other hand, it has been forgotten by these writers that the alternative supposed does not exist in the case we have instanced. Marriages in France, unlike some other continental states, are continually increasing, and starvation and disease are yearly being shorn of their power.

If we turn to Massachusetts, these arguments acquire additional force. Amid such general thrift, abundance, wealth, in a state comparatively young and not over settled, there has been every reason for the population, general and native, as well as foreign, to increase. Want and excessive mortality are alike absent. Emigration westward and abroad, the only apparent positive check, extensive though this is, can by no means account for the evident facts. Conscription, war, despotism, restraining to a certain extent the population of France, are all unknown to ourselves. With the authors quoted, we are therefore forced to a single position, that this annual lessening of births must be owing, in great measure abroad, almost wholly with us at home, to '*prudence*' on the part of the community, not as a State, which ever encourages population, but as *individuals.*

Before proceeding, I would remark that the condition of things

* Loc. cit., pp. 194, 195.

† Journal des Economistes, 1847.

‡ Loc. cit., i, 336.

§ Ibid., i, 417.

thus far described is such as political economists, almost without exception, approve, and that in great measure it is owing to the direct influence of their doctrines.

In his well known Essay on Population, Mr. Malthus remarks, that "in the average state of a well peopled territory, there cannot well be a worse sign than a large proportion of births, nor a better sign than a small proportion."*

A host of other authorities might be quoted, but a few extracts from a later writer, standard in this country at present and taught in our universities, till very lately in that of Cambridge for instance, will suffice.

"We greatly deprecate," says Mill, "an increase of population as rapid as the increase of production and accumulation."†

"There is room in the world no doubt, and even in old countries, for an immense increase of population. But although it may be innocuous, I confess I see very little reason for desiring it."‡

"I sincerely hope, for the sake of posterity, that they will be content to be stationary long before necessity compels them to it."§

"If the opinion were once generally established among the laboring class, that their welfare required a due regulation of the numbers of their families, only those would exempt themselves from it, who were in the habit of making light of social obligations generally."‖

"The principle contended for includes not only the laboring classes, but all persons, except the few who, being able to give their offspring the means of independent support during the whole of life, do not leave them to swell the competition for employment."¶

"When persons are once married, the idea never seems to enter any one's mind, that having or not having a family, or the number of which it shall consist, is at all amenable to their own control. One would imagine that it was really, as the common phrases have it, God's will and not their own, which decided the number of their offspring."**

"In a place where there is no room left for new establishments," says Sismondi, entirely ignoring the escapes offered by emigration and the increased importation of food, "if a man has eight children, he should believe that unless *six* of them die in infancy, these and three of his own contemporaries, of each sex, will be compelled to abstain from marriage, in consequence of his own imprudence."††

Having now explained an important cause of the effects I have described, I return from the digression.

* Loc. cit., p. 313. † Loc. cit., ii, 253. ‡ Ibid., ii, 316.
§ Ibid., ii, 317. ‖ Ibid., i, 451. ¶ Ibid., i, 452, footnote.
** Ibid., i, 447. †† Nouveaux Principes d'Economie Politique, liv, vii, ch. 5.

Prudence, it is asserted, on the part of individuals checks and keeps within bounds the natural increase of the human race. We cannot well avoid allowing that this statement is true, and that it applies with even more pertinency to ourselves as a people than to nations abroad.

It will be profitable for us to go a step further, and to enquire in what way this result is effected; and though I shall be compelled to refer to matters usually thought best to keep concealed, and to present a conclusion at once frightful, astounding, degrading, I shall not shrink from the duty. For the subject is one which concerns each one of us, as philosophers, parents, as citizens, as christians.

There is no reason to suppose, as West,* Husson and DeJonnés have thought, that the rapid and constant decrease of births I have shown to exist can be attributable to any progressive lack of fecundity on the part of women, or of generative power on that of men; nor is there reason to think that the passions of the race burn less freely than formerly, or that they are more generally under control.

In a certain measure, no greater than formerly however, these needs are met by prostitution. Yet marriages and lawful connections have increased and now undoubtedly exist to a greater proportionate extent than ever before. They are confessed and easily proved, to be usually, either in whole or in great part, barren of offspring—we have only to look about us, for abundant evidence of this—while formerly, as is equally known, such was not the case.

Let all allowances be made for certain conjugal habits, existing extensively among the French, and by no means rarely imitated in this country, as unnatural and degrading as they are detrimental to the physical health of both male and female; but there exist a series of statistics, hitherto unknown, unappreciated or sedulously concealed, which prevent the increasing decrease of births from being thus, and only thus explained.

Prevention of pregnancy, to whatever extent existing, cannot account for the decrease of living births; actual pregnancies being proved fully as frequent as ever. What then can? We answer the question by another.

"Has it been sought," asks Quetelet, in his Theory of Probabilities, though he did not attempt to solve the problem, so puzzling to statistician, philanthropist and statesman, "to account for the peculiarities relating to the still-born, and to combat the causes which in certain circumstances swell their number in so deplorable a manner?"†

I shall show that nearly as many pregnancies exist as ever. We are to consider these pregnancies, not as prevented, but as terminated without the birth of a living child.

* Med. Times and Gazette, June, 1856, p. 611. † Loc. cit., p. 234.

I am aware that the evidence of statistics is received by many minds with a certain measure of doubt; but I shall endeavor so to add proof to proof, and to draw these from such authoritative sources, that no doubt can fairly remain. I base my remarks upon the following self-evident laws.

1st. That, while a result or event in *individual* instances is ever variable and uncertain, this result or event when calculated from or upon *masses* of instances becomes proportionately certain and invariable.

2d. That, to apply this principle to the case we are now considering, the *absolute* number of *living births* in a given population, in a given time, should, in the absence of an evident and sufficient disturbing cause, be always nearly the same; increasing with the increase of the population, and with the progress of medical science (which might easily be proved to be in this respect constantly advancing).

3. That the *absolute* number of *still births at the full period of pregnancy*, occurring from natural causes in a given time in a given population should be always nearly the same; increasing only in proportion to the actual increase of the population, and decreasing with the progress of medical science.

4th. That the *absolute* number of *premature* births, occurring from natural causes in a given time in a given population should be always nearly the same; increasing only in proportion to the actual increase of the population, and decreasing with the progress of medical science.

5th. That the *relative* number of *still births from natural causes*, at the full period of pregnancy and premature, as compared with the *living* births in a given population in a given time should be always nearly the same; *not* being affected by an increase of population, and constantly lessened by the progress of medical science.

6th. That the *relative* number of *still births from natural causes*, at the full period of pregnancy and premature, as compared with the *general mortality* in a given population in a given time, should remain always nearly the same, not being affected by an increase of population and but slightly by the progress of medical science.

7th. That the *relative* number of *still births from natural causes*, premature and at the full period of pregnancy, should remain always nearly the same compared with each other; neither of them being affected by the increase of population and each of them nearly equally by the progress of medical science.

It has already become manifest that the 2d of these propositions does not accord with existing facts; that the *absolute* number of *living* births in Europe and in this country does not remain the same, time and population agreeing; that instead of increasing with the increase of the latter and with the progress of medical science, it has been rapidly and steadily diminishing.

In the discord of existing facts with the remaining propositions also, I have detected and shall make evident the disturbing cause.

Since 1805, when returns were first made to the Registry of New York, the number, proportionate as well as actual, of fœtal deaths in that city has steadily and rapidly increased. With a population at that time of 76,770, the number of still and premature births was 47; in 1849, with a population estimated at 450,000 the number had swelled to 1320.* Thus while the population had increased only *six* times since 1805, the annual number of still and premature births had multiplied over *twenty-seven* times! The following table shows the rapidity of this increase.

TABLE VIII.—*Ratio of Fœtal Deaths to the population in New York.*

1805,	1 to 1633·40	1830,	1 to 597·60
1810,	1 " 1025·24	1835,	1 " 569·88
1815,	1 " 986·46	1840,	1 " 516·02
1820,	1 " 654·52	1845,	1 " 384·68
1825,	1 " 680·68	1849,	1 " 340·90

In the three years preceding 1849, there were registered in New York 400 premature births and 3,139 children still born; a total of 3,539, representing at that time a yearly average of some 1200 fœtal deaths. It is evident that though almost all the still births at the full time, even from criminal causes, are necessarily registered, but a small proportion of the abortions and miscarriages occurring are ever reported.

In the three years preceding 1857, there were registered in New York 1196 premature and 4735 still births, a total of 5931, representing a yearly average of some 2000 fœtal deaths; showing that in the short space of seven years, the number of fœtal deaths in New York, already enormous, had very nearly doubled!

I now present a table showing the ratio of still births to the living births in various countries of Europe.

TABLE IX.—*Ratio of Still to Living Births in Europe.*

Geneva 1824–33,	1 to 17	Prussia 1820–34,	1 to 29
Berlin (hospitals) 1758–74,	1 to 18	Iceland 1817–28,	1 to 30
Paris (Maternité) 1816–35,	1 to 20	Prague 1820,	1 to 30
Sweden 1821–25,	1 to 23·5	London (hospitals) 1749–81,	1 to 31
Denmark 1825–34,	1 to 24	Vienna 1823,	1 to 32
Belgium 1841–48,	1 to 24·2	Austria 1828,	1 to 49

In France at large in 1853 the ratio was 1 to 24. Department of Seine 1 to 15. In the city of Paris 1836–44, 1 to 14·3; in 1845–53, 1 to 13·8. The proportion of still births in the rural districts of France is governed by the same laws as in the metropolis. In 363 provincial towns the ratio was, in 1836–45, 1 to 19·5; in 1846–50, 1 to 18·8.

* Report of the City Inspector for 1849.

While districts more thinly populated gave, in 1841–45, 1 to 29; 1846–50, 1 to 27.*

In Belgium, during a similar period, the ratio was much the same. It was, in 1841–43, in towns 1 to 16·1, in country 1 to 29·4.†

The apparent discrepancy between city and country, noticed as equally obtaining in Belgium and France, is probably owing in great measure to greater negligence of the country officials in registering the still births.

Again, the total number of births at the full time in New York in 1856 was 17,755; of these, 16,199 were living;‡ proving that of children at the full time alone, setting aside the great number of viable children born prematurely, and the innumerable earlier abortions not recorded, 1 in every 11·4 is born dead.

From foreign statistics on a large scale, embodied in the table we have already given, it is found that the proportion of still births does not in those countries drop below 1 in 15, and this in France; ranging from that number up to 1 in 30 or 40 of the whole number of births reported.

In Geneva, out of 10,925 births occurring from 1824–33, 1,221 of them *illegitimate* and therefore to be supposed liable to a large percentage of deaths from criminal causes, there were only 646 fœtal deaths; a proportion of 1 in 17.

In Belgium, there were 29,574 *illegitimate* births from 1841–43, and of these 1,766 were born still,§ or 1 in 16·8.

In New York, from 1854–57, there were 48,323 births; and 5,931 still births, at the full time and prematurely; or in other words, 1 to every 8·1 was born dead.

In Massachusetts, the ratio of still births, at the full time and premature, as compared with the living births in 1850, was 1 to 15·5. In France it is 1 to 24, and in Austria 1 to 49. While the proportion of still births at the full time to the whole number is enormous and steadily increasing, so is the number of known abortions and premature births.

The frequency of these occurrences reported from the practice of physicians, and thus to a certain extent but not entirely, likely to be of natural and accidental origin, is as follows: in 41,699 cases registered by Collins, Beatty, LaChapelle, Churchill and others, there were 530 abortions and miscarriages. Here all the abortions were known; their proportion was 1 to 78·5.

In New York, from 1854–57, there were 48,323 births reported as at the full time and 1,196 premature. Here all the abortions were not known, probably but a very small fraction of them; the proportion was 1 to 40·4.

* De Jonnés, loc. cit., p. 239.
† Quetelet, loc. cit., p. 152.
‡ City Inspector's Report for 1856.
§ Compiled from Quetelet, p. 152.

In Massachusetts, the ratio of premature births to those at the full time, as recorded in the registration reports, during the period from 1850–56, was 1 to 26·1.

That the ratio of still births and abortions, already so frightful, is steadily increasing, is also seen by the following table; in which we have compared the still births, supposable perhaps of accidental value, with the general mortality, whose value is at least as accidental.

TABLE X.—*Ratio of the Fœtal to the general mortality in New York.**

	Total deaths.	Fœtal deaths.	Ratio.
1804–09	13,128	349	1 to 37·6
1809–15	14,011	533	1 to 26·3
1815–25	34,798	1,818	1 to 19·1
1825–35	59,347	3,744	1 to 15·8
1835–55	289,786	21,702	1 to 13·3
1856	21,658	1,943	1 to 11·1

In 1851, the ratio of fœtal deaths in Massachusetts to the general mortality was 1 to 13·3; in 1855, 1 to 10·4, larger than in New York city a year later. In a metropolis we should expect the proportion to be greater than in a state at large; it is here less.

Finally we compare the recorded premature still births of New York, with those still at the full time.

In the seventeen years from 1838–55, there were reported 17,237 still births at the full time, and 2,710 still prematurely; the last bearing the proportion of 1 to 6·3.

In the nine years from 1838–47, omitting 1842 for the reason that the reports to the Registrar for that year were confessedly imperfect, there were 632 still premature births, and 6,445 still at the full time; a yearly average of 1 to 10·2.

In the eight years from 1848–55, there were 2,078 premature still births, and 10,792 still at the full time; an average of 1 to 5; while in 1856, there were 387 still prematurely, and 1,556 at the full time; or 1 to 4·02!

On the other hand, there were recorded in Massachusetts during the 14 years and 8 months preceding 1855, 4,570 still births and 11,716 premature births and abortions,† the ratio being 1 abortion to ·3 still births; or in other words it would appear from the statistics quoted, that the comparative frequency of abortions in Massachusetts is 13 times as great as in the worst statistics of the city of New York!

We are willing however, we rejoice, to modify this statement, as in the earliest of the years quoted, returns from the city of Boston seem to have been imperfect or wanting. We therefore confine ourselves to a more recent period.

From 1850–55, the registration being much more accurate than before, and its results compiled with the greatest care, three

* Compiled from City Inspector's Reports for 1855–6.
† 14th Registration Report, 1855.

years of the five by a noted statistician, Dr. Shurtleff, there were recorded in Massachusetts 2,976 still births and 5,899 premature births and abortions, the ratio being 1 abortion to ·5 still births; in other words, the frequency of abortions as compared with still births at the full time is at least 8 times as great in Massachusetts as in the worst statistics of the city of New York.*

It is allowed by political economists, by Mill and by Malthus himself, that so much of the existing decrease as cannot otherwise be explained, must be attributed to influences generally prevalent in Europe during earlier ages, and in Asia to the present time. "Throughout Europe," says Mill, "these causes have much diminished, but they have nowhere ceased to exist."† Several of these causes, starvation, wars, disease, have been named by the authority now quoted, but the greatest of them all is left unspoken.

The wilful destruction of living children, at and before birth, history declares to have obtained, and to a very great extent, among all the earlier nations of the world, the Jews alone excepted. Aristotle‡ defends it, and Plato.§ It is mentioned by Juvenal,‖ Ovid,¶ Seneca and Cicero; and it is denounced by the early Christians.** It was common in Europe through the middle ages, and still prevails among the Mahometans, Chinese, Japanese, Hindoos, and most of the nations of Africa and Polynesia to such an extent that it may well be doubted whether more have ever perished in those countries by plague, by famine and the sword.

It is impossible that the facts I have quoted from present history can in any great measure be owing to natural causes alone. They are wholly inexplicable on any principles which do not recognize an amount of guilt at which humanity shudders.

We have seen that with us, in the absence of all influences that tend to keep down population in foreign countries, old and crowded, and under the yoke of despotism, the effects attributable elsewhere to these causes, exist and to an *extreme* degree. That the ratio of fœtal deaths to the population had swelled in New York from 1 in 1633 in 1805 to 1 in 340 in 1849, while in France at a later period, 1851, they were only 1 in 1000. That the actual number of fœtal deaths in that city had in the 7 years from 1850–57, very nearly doubled. That the fœtal deaths as compared with the total of births, elsewhere in statistics of illegitimacy alone, where the results are supposed worst and confessed chiefly from crime, being 1 in 16·8 (Belgium), had here,

* The above remarks are not to be misunderstood. In Massachusetts registration has been conducted with greater care than elsewhere. Subsequent investigations have proved that both infanticide and fœticide prevail to an equal extent in many other of our states.

† Loc. cit., i, 417.
‡ Travels of Anacharsis, v, 270.
§ Ibid., iv, 342.
‖ Satires, vi, 592.
¶ Amor., lib. 2; Heroides, epist. 2.
** Reeve's Apologies.

legitimate and natural, reached the frightful ratio of 1 in 8. That the fœtal deaths as compared with the total mortality, had increased from 1 in 37 in 1805, to 1 in 13 in 1855. That the reported early abortions, of which the greater number of course escape registry, bear the ratio to the living births of 1 in 40, while elsewhere they are only 1 in 78. And finally, that early abortions, bearing the proportion to the still births at the full time of 1 in 10 in 1846, had increased to 1 in 4 in 1856.

So far the city of New York—a metropolis, and claiming preëminence neither in morals nor religion. On the other hand in Puritan Massachusetts, in the State at large, and therefore but little affected by the statistics of its capital, which however would by themselves probably be found corroborative of the main result, we have seen that the ratio of still births at the full time and premature as compared with the living births in 1850, was 1 to 15·5. In France it is 1 to 24, and in Austria 1 to 49. That the ratio of premature births to those at the full time, during the period from 1850–56 was 1 to 26, while in New York city it is only 1 to 40. That the ratio of fœtal deaths to the general mortality was 1 to 13 in 1851, and in 1855 1 to 10·4; while in New York city a year later, in 1856, it was only 1 to 11; and that from 1850–55 the frequency of abortions as compared with still births at the full time, was at least eight times as great as in the worst statistics of the city of New York.

Few persons could have believed possible the existence of such frightful statistics, the result toward which they must be confessed inevitably to tend, or the dread cause from which they spring. Either these statistics must be thrown aside as utterly erroneous and worthless, or they must be accepted with their conclusions. We would gladly do the former, but they present too many constant quantities in other respects, as for instance, in the regularly progressive series of deaths and births as compared with the population, constant also as compared with each other, for this to be allowed. My own calculations have been made with care, and I have presented the elements on which they rest. In asserting the results, at once so awful and astounding, I desire to fix upon them the attention and scrutiny of the Academy.

These conclusions however do not rest alone on the statistics that have been presented. The experience of courts of justice, and that equally extensive tribunal, the body of physicians throughout our land, (I regret, and at the same time rejoice, Mr. President, that this assertion is not borne out by your own extended experience,)* tend to corroborate them, and other evidence of equal weight and character is at hand.

* Dr. Jacob Bigelow, then President of the Academy, was inclined at one time to disbelieve in the existence of certain customs everywhere prevalent among us. He subsequently publicly acknowledged however, that his doubts were owing to his not having personally investigated the subject.

In seeking for the *causes* of these facts, I have found much that is interesting, and somewhat that I believe to have been hitherto unpresented.

The immense proportion of living births to the pregnancies in the foreign as compared with the native and protestant population of Massachusetts, already referred to, is to be explained by the watchful protection exercised by the Catholic church over fœtal life. However we may regard the dogma on which this rests, the sanctity of infant baptism, there can be no question that it has saved to the world millions of human lives. But of the various corroborative testimony to which I have alluded, and of other matters pertaining to this subject I shall elsewhere speak.*

Were mankind, in following the advice that has been quoted from past and present authorities in political economy, content merely to practice greater abstinence and greater prudence in sexual matters, less blame could justly be laid. But when we find infanticide and criminal abortion thus justified, rendered common and almost legitimated, we may well oppose to the doctrine of these cruel teachers the words of the indeed admirable Percival, "To extinguish the first spark of life is a crime of the same nature, both against our Maker and society, as to destroy an infant, a child, or a man."†

ART. XVII.—*Research on the Ethers of Silicic Acid;* by C. FRIEDEL and J. M. CRAFTS.

THE determination of the atomic weight of silicium has given rise to more discussion than that of any other element; nor does this astonish us, when we consider the number and complicated nature of the compounds of silicium and the peculiar properties which separate it from all the other elements.

Even at the present day chemists and mineralogists are not agreed whether to write silica SiO_2 or SiO_3, and recently Scheerer‡ has published a paper, in which he brings up the old arguments in favor of the latter formula, and adds to them some new ones, based on the study of the action of silicic acid on carbonate of soda at a red heat, as well as on Wöhler's research on leucon.§ We will not discuss these arguments, as we think that a sufficient reply to them will be found in the facts brought to light by this research, facts which are impossible to reconcile with the opinion of Prof. Scheerer.

* North American Medico-Chirurg. Review; Philadelphia, Jan. 1859, et seq.
† Med. Ethics, p. 79.
‡ Journ. für praktische Chemie, xci, 415.
§ Ann. der Chem. u. Pharm., cxxvii, 257.

It is not our intention to enter into the history of the discussion of the true atomic weight of silicium; but it will perhaps be useful to recall some of its principal phases. In the memorable series of investigations by which Berzelius, without following any fixed rule, but with an accuracy of perception all the more remarkable, established the greater part of the atomic weights, he assigned to silicic acid the formula* SiO_3 (Si=21, O=8). He deduced this result from the analyses of various silicates, particularly of orthoclase, relying upon an analogy which he supposed to exist between silicic and sulphuric acids.

Dumas, when he called the attention of chemists in his classical memoir† to the importance of the determination of the density of vapors and its value in establishing chemical formulæ, gave, among other examples, that of the chlorid of silicium. According to him this body ought to have the formula $SiCl_2$, and consequently silicic acid SiO (Si=7, O=8, Cl=17·75). The chlorids of tin and titanium follow the same law.

Some years later Gaudin,‡ among other remarkable deductions from the law of Ampère, obtained the formulæ $SiCl_4$ and SiO_2 for the chlorid of silicium and for silicic acid. At the same time he noticed the analogy between silicic and carbonic acids. These ideas do not appear to have attracted the attention they merited, because they were too far in advance of those received at the time, and those who have since taken them up have doubtless been unintentionally unjust in not quoting their author.

Ebelmen employed the atomic weight for silicium as established by Dumas, and wrote the formula of silicic ether,

$$SiO, C_4H_5O, (Si=7, O=8, C=6, H=1).$$

This is the most simple expression for the result of his analysis, but his formula is not in accordance with that of Dumas for silicic acid; for in order to correspond with it, silicic ether should be written $SiO, C_4H_{10}O$, as if it contained two atoms of ethyl.§ Indeed Ebelmen's formula implies a hypothesis quite distinct from that, founded on the vapor-density of chlorid of silicium, for, to use the nomenclature of the present day, the first formula represents silicium as monoatomic, and the second as diatomic.

Gmelin‖ wrote the chlorid of silicium and silica $SiCl_2$ and SiO_2 (Si=14, Cl=35·5, O=8), and these formulæ were adopted by the greater number of chemists, and they found a new argu-

* Essai sur la Théorie des proportions Chimiques, p. 134; Paris, 1819.

† Ann. de Chim. et Phys., [2], xxxiii, 367; 1826.

‡ Ann. de Chim. et Phys., [2], lii, 113; 1833. We will add that in this memoir Mr. Gaudin gives the definition of atom and molecule which is received at the present day. And we are happy in being able to render justice to an acute intellect, whose penetration has not been sufficiently recognized.

§ Ann. de Chim. et Phys., [3], xvi, 141; 1846.

‖ Handbuch der Chemie, ii, 339; Heidelberg, 1844.

ment in their favor in the brilliant researches of Marignac on the isomorphism of fluosilicates, fluotitanates, and fluostannates.*

When the progress of organic chemistry forced the chemists, after Gerhardt, to double the atomic weights of oxygen and carbon, leaving that of hydrogen =1, which was nothing else than returning to the old relations of Berzelius and Dumas, the question arose, whether silica ought to be written

$$Si\Theta\ (Si=14,\ \Theta=16)\ \text{or}\ Si\Theta_2\ (Si=28).$$

Gerhardt answered the question implicitly in favor of the latter formula, when he wrote silicic ether† $4(SiO), 4(C_4H_5O)$, and without doubt his only motive for retaining the atomic weight of Ebelmen (Si=7) was the same, which prevented him from changing those of carbon and oxygen in his work on organic chemistry. In order to have been consistent with his own theoretic views, he need only have gone back to the formula of Gaudin. Odling‡ has done this, and writes silica $Si\Theta_2$, and considers $SiH_4\Theta_4$ as the normal hydrate of silicic acid, to which the ethers correspond.

Odling, as well as Gerhardt and Gaudin before him, have deduced these formulæ from the consideration of the vapor-density of the chlorid of silicium and of silicic ether. This must be regarded as an important argument in their favor, and to deny its value it would be necessary to forget the admirable order introduced by Gerhardt in the classification of organic compounds in the place of the confusion which reigned before the vapor-density was employed as a criterion to determine the molecular weight of compounds. It would be necessary, also, to ignore the important results obtained by various chemists, particularly by Wurtz§ and Cannizzaro,‖ in the fixation of molecular weights according to the same law.

Nevertheless we must remember that the ideas of Avogadro and Ampère are nothing more than a physical hypothesis; and although this hypothesis has been fruitful in accurate conclusions, even from the stand-point of a chemist, it must yield before purely chemical considerations in the determination of the relative weights of atoms and molecules. This conviction has led us to study the organic compounds of silicium in the hope of obtaining results which would enable us to resolve, on entirely chemical grounds, the question of the true atomic weight of silicium, and we must also admit, with the hope of confirming by our research the conclusions drawn from the law of Ampère.

* Ann. des Mines, [5], xv, 221. † Traité de Chimie Organique, ii, 363.
‡ Philosophical Magazine, xviii, 368.
§ Leçons de Philosophie Chimique; Paris, 1864.
‖ Sunto di un Corso di Filosofia Chimica; Pisa, 1858.

We believe that we have succeeded in demonstrating that the most simple formulæ possible for silicic acid and the normal silicic ether are $\mathrm{Si}\Theta_2$ and $\mathrm{Si}, 4(\text{Ɛ}_2\mathrm{H}_5\Theta)$, and in consequence, that the true atomic weight of silicium is 28.

*Silicate of ethyl.**—We chose as point of departure for our research the silicic ether, discovered and studied by Ebelmen. In regard to this body we have little to add to the facts recorded by him. The ether was prepared as recommended by him, taking care to use absolute alcohol, and to add it in small quantities at a time to the chlorid of silicium. When the alcohol is perfectly anhydrous, the quantity of ether obtained is almost equal to the theoretical; however, a small quantity of chlorid of silicium is always carried off by the hydrochloric acid gas which escapes.

Silicic ether, purified by repeated distillation, boils at 165°·5. We determined its density at 0° C. =0·9676. Ebelmen gives the density at 20° C. =0·933. The moisture of the air transforms it rapidly into a solid body, silicic acid; a piece of which, after being kept three years, became hard enough to scratch glass. Notwithstanding its decomposability by moisture, the ether remains unaltered for some time under water, and when it is distilled with water, only traces of silica remain behind in the vessel. These facts must be attributed to its nearly complete insolubility in water, for aqueous alcohol transforms it immediately into a polysilicate, as Ebelmen has already observed. All the water contained in the alcohol does not react immediately upon the ether, for when it is heated during a long time in a closed tube with aqueous alcohol, a larger quantity of polysilicate is obtained than when the two liquids are merely distilled together.

Assigning, like Gerhardt and Odling, the formula $\mathrm{Si}, 4(\text{Ɛ}_2\mathrm{H}_5\Theta)$ to silicic ether, we are naturally led to think that it would be possible to replace one-quarter of the ethyl and oxygen $(\text{Ɛ}_2\mathrm{H}_5\Theta)$ by chlorine; as in the diethylic lactic ether an atom of peroxyd of ethyl $(\text{Ɛ}_2\mathrm{H}_5\Theta)$ can be replaced by chlorine with formation of chlorolactate of ethyl.

Diethylic lactic ether.	Normal silicate of ethyl.
$\left.\begin{matrix}\text{Ɛ}_3\mathrm{H}_4\Theta\\ 2(\text{Ɛ}_2\mathrm{H}_5)\end{matrix}\right\}\Theta_2$	$\left.\begin{matrix}\mathrm{Si}\\ 4(\text{Ɛ}_2\mathrm{H}_5)\end{matrix}\right\}\Theta_4$
Chlorolactate of ethyl.	**Monochlorhydrine of silicic ether.**
$\left.\begin{matrix}\text{Ɛ}_3\mathrm{H}_4\Theta\\ \text{Ɛ}_2\mathrm{H}_5\end{matrix}\right\}\Theta$ Cl	$\left.\begin{matrix}\mathrm{Si}\\ 3(\text{Ɛ}_2\mathrm{H}_5)\end{matrix}\right\}\Theta_3$ Cl

In case of silicic ether, we ought to be able to go further, and not only replace one but several atoms of peroxyd of ethyl by chlorine, and obtain the bodies

* The atomic weights used are $\mathrm{Si}=28$, $\Theta=16$, $\text{Ɛ}=12$, $\mathrm{H}=1$.

Dichlorhydrine of silicic ether.		Trichlorhydrine of silicic ether.
$\left.\begin{matrix} Si \\ 2(C_2H_5) \end{matrix}\right\} O_2$ Cl_2	and	$\left.\begin{matrix} Si \\ C_2H_5 \end{matrix}\right\} O$ Cl_3

Monochlorhydrine of silicic ether.—This ether was obtained by heating in a sealed tube during one hour at 150° C. three molecules of normal silicic ether with one molecule of chlorid of silicium. The reaction is

$$SiCl_4+3\left(\left.\begin{matrix} Si \\ 4(C_2H_5) \end{matrix}\right\} O_4\right) = 4\left[\left.\begin{matrix} Si \\ 3(C_2H_5) \end{matrix}\right\} O_3 \atop Cl\right].$$

On distilling the contents of the tube we noticed that there was no free chlorid of silicium remaining. The liquid commenced to boil at 145°, and almost the whole product passed between 153°–160°. After several fractionated distillations, we analyzed the product boiling at 155°·7–157°.

I.	Substance weighed,	- -	0·3785 gr.
	CO_2,	- - - -	0·5005 "
	H_2O,	- - - -	0·2545 "
II.	Substance, weight,	- -	1·4545 "
	AgCl,	- - - -	1·0650 "
	SiO_2,	- - - -	0·4355 "

We will also give here the result of an analysis of monochlorhydrine prepared by the action of chlorid of acetyl on silicic ether, and boiling 155°–157°.

III.	Substance, weight,	- -	0·2190 gr.
	CO_2,	- - - -	0·2935 "
	H_2O,	- - - -	0·1525 "

		I.	II.	III.	Theory.
C	=	36·06		36·55	36·27
H	=	7·46		7·74	7·55
Si	=		13·95		14·10
Cl	=		18·11		17·88

The determination of silicium and chlorine was made by decomposing the body in a flask with an alcoholic solution of ammonia, distilling the alcohol and heating the flask in order to render the silica easy to wash upon a filter. The chlorine was determined in the filtrate from the silica. The alcohol carries over with it on distillation a little NH_4Cl, and it must be carefully condensed and evaporated slowly and the residue added to the filtrate from the silica.

The monochlorhydrine of silicic ether is a colorless liquid, which does not fume in the air, but is rapidly decomposed by moisture or by water with evolution of HCl. It reacts easily on alcohol; HCl is given off and normal silicic ether is formed. It burns with a green flame due to chlorine and with a smoke composed of silicic acid.

Its density at 0° compared with that of water at the same temperature =1·0483. Its vapor density was found to be 7·05. The theory of a condensation to two vols. requires 6·87.

The data for the determination are:

Difference between two weights of bulb,	1·1975 gr.
Temperature of the balance, - -	12°
" " oil-bath, - -	230°
Height of barometer, - - - -	762·8 mm.
Capacity of bulb, - - - -	323 cc.
Air remaining in bulb, - - - -	2 cc.

We obtained the same chlorhydrine by heating for about one hour at 170°–180° one molecule of chlorid of acetyl with one molecule of silicic ether. The products of the reaction are acetic ether and the monochlorhydrine, and the reaction may be represented by the equation:

$$\left.\begin{matrix}\mathrm{Si}\\ 4(\text{Є}_2\mathrm{H}_5)\end{matrix}\right\}\Theta_4+\text{Є}_2\mathrm{H}_3\Theta,\mathrm{Cl}=\left.\begin{matrix}\mathrm{Si}\\ 3(\text{Є}_2\mathrm{H}_5)\\ \mathrm{Cl}\end{matrix}\right\}\Theta_3+\left.\begin{matrix}\text{Є}_2\mathrm{H}_3\Theta\\ \text{Є}_2\mathrm{H}_5\end{matrix}\right\}\Theta.$$

40 grams of silicic ether, heated with 24 grams of chlorid of acetyl, gave 25 grams of acetic ether, nearly pure, and boiling at 75°–80°. The theory requires 27 grams. Almost the whole of the remainder of the product passed at 155°–158°.

The experiment was undertaken with the object of obtaining an aceto-silicate of ethyl, supposing that the reaction would take place according to the equation:

$$\left.\begin{matrix}\mathrm{Si}\\ 4(\text{Є}_2\mathrm{H}_5)\end{matrix}\right\}\Theta_4+\text{Є}_2\mathrm{H}_3\Theta,\mathrm{Cl}=\left.\begin{matrix}\mathrm{Si}\\ 3(\text{Є}_2\mathrm{H}_5)\\ \text{Є}_2\mathrm{H}_3\Theta\end{matrix}\right\}\Theta_4+\text{Є}_2\mathrm{H}_5\mathrm{Cl},$$

but no trace of such a body was formed.

The monochlorhydrine of silicic ether is also formed when the ether is heated with the perchlorid of phosphorus; there is formation of a small quantity of oxychlorid of phosphorus and of other more volatile compounds containing phosphorus. A large quantity of chlorid of ethyl is given off. The product obtained in this reaction and boiling at 155°–158° was used to prepare the triethylic mono-amylic silicic ether. See below.

The dichlorhydrine of silicic ether is obtained by a reaction analogous to that which gives monochlorhydrine, by heating together one molecule of silicic ether and one molecule of chlorid of silicium.

$$\mathrm{SiCl}_4+\left.\begin{matrix}\mathrm{Si}\\ 4(\text{Є}_2\mathrm{H}_5)\end{matrix}\right\}\Theta_4=2\left\{\left.\begin{matrix}\mathrm{Si}\\ 2(\text{Є}_2\mathrm{H}_5)\\ \mathrm{Cl}_2\end{matrix}\right\}\Theta_2\right\}.$$

It can also be prepared by heating monochlorhydrine with the chlorid of silicium.

$$SiCl_4 + 2\left[\begin{array}{c} Si \\ 3(\text{Є}_2H_5) \\ Cl \end{array}\right\}\Theta_3\Bigg] = 3\left[\begin{array}{c} Si \\ 2(\text{Є}_2H_5) \\ Cl_2 \end{array}\right\}\Theta_2\Bigg].$$

The reaction takes place somewhat less readily than the one which gives rise to the monochlorhydrine, and it is necessary to heat the sealed tubes longer and to separate the product by a larger number of fractionated distillations. While manipulating the chlorhydrines the utmost care must be taken to prevent exposure to the moisture of the atmosphere, which decomposes them the more readily the more chlorine they contain. The vases containing the different products were always kept in a glass jar, which had the bottom covered with sulphuric acid and a glass cover fitting air-tight.

The dichlorhydrine boils at 136°–138°. Analyses gave:

I.	Substance, weight, - - - -	0·3480 gr.
	$\text{Є}\Theta_2$, - - - - - -	0·3270 "
	$H_2\Theta$, - - - - - -	0·1675 "
II.	Substance, weight, - - - -	0·7005 "
	AgCl, - - - - - -	1·0635 "
III.	Substance, weight, - - - -	0·3250 "
	$Si\Theta_2$, - - - - - -	0·1000 "

	I.	II.	III.	Theory.
C,	25·62	....	....	25·39
H,	5·35	....	....	5·29
Cl,	....	37·54	....	37·56
Si,	....	....	14·35	14·81

The vapor-density is 6·76; theory 6·545. Data:

Difference of 2 wts. of bulb,	0·8695 gr.	
Temperature of balance, -	22°	
" " oil-bath, -	213°	Air thermometer 211°·5
Height of barometer, -	766·9 mm.	
Capacity of bulb, - -	229·6 cc.	
Air remaining in bulb, -	0·3 cc.	

The density at 0° of the dichlorhydrine is 1·144. This body resembles the monochlorhydrine in all its physical properties.

The trichlorhydrine of silicic ether is obtained by heating for several hours at 150°, either the silicic ether or the two preceding chlorhydrines, with an excess of chlorid of silicium, and separating the products by a large number of fractionated distillations. The precautions that were taken to keep the other chlorhydrines from contact with moisture are still more necessary in the case of the trichlorhydrine. It boils at 103°–105°. Analyses gave:

I.	Substance, weight, - - - -	0·3995 gr.
	$\text{Є}\Theta_2$, - - - - - -	0·1976 "
	$H_2\Theta$, - - - - - -	0·1040 "

II. Substance, weight,	- - - -	0·5945 gr.
AgCl,	- - - - - - -	1·4190 "
III. (Boil. point =104°–106°.)	Substance, wt.,	0·4235 "
$Є\Theta_2$,	- - - - - - -	0·2100 "
$H_2\Theta$,	- - - - - - -	0·1070 "
IV. Substance remaining in the bulb after the determination of the vapor-density, weight,	- - - - -	0·5465 "
$Si\Theta_2$,	- - - - - - -	0·1790 "

	I.	II.	III.	IV.	Theory.
C,	13·46		13·52		13·41
H,	2·89		2·80		2·78
Cl,		59·07			59·33
Si,				15·27	15·58

The vapor-density =6·378; theory 6·216.

Difference between two weights of bulb,	-	0·9317 gr.
Temperature of the balance,	- - -	22°·5
" " oil-bath,	- - -	163°·5
Barometric pressure,	- - - -	766·6 mm.
Capacity of bulb,	- - - - - -	231·5 cc.
No air remaining.		

The density at 0° =1·291.*

The boiling points of the above compounds, in which a portion of the atoms of the peroxyd of ethyl are replaced by chlorine, represent a series, in which the secondary differences are nearly constant.

Silicate of ethyl, - -	165°·5		
		8°·5	
Monochlorhydrine, - -	157		11°·5
		20	
Dichlorhydrine, - -	137		13
		33	
Trichlorhydrine, - -	104		12
		45	
Chlorid of silicium, -	59		

Triethylic monoamylic silicic ether.—The monochlorhydrine served to prepare this mixed ether, which is nothing else than a normal ethylic silicate, in which one atom of ethyl is replaced by amyl. To obtain it, it is sufficient to bring together a molecule of monochlorhydrine and one of amylic alcohol. The reaction takes place immediately with evolution of HCl.

$$3(Є_2H_5)\left.\begin{matrix}Si\\ \\ Cl\end{matrix}\right\}\Theta_3+\left.\begin{matrix}Є_5H_{11}\\ H\end{matrix}\right\}\Theta=3(Є_2H_5)\left.\begin{matrix}Si\\ \\ Є_5H_{11}\end{matrix}\right\}\Theta_4+HCl.$$

The liquid commenced to distil at 205°, and almost all passed below 230°. The greater part boiled at 216°–225°. The analysis of different products gave—

* The density of chlorid of silicium at the same temperature we determined =1·522.

I.	(Boiling point 216°–225°.)	Substance, wt.,	0·2875 gr.
		CO_2, -	0·5560 "
		H_2O, -	0·2620 "
II.	(Boiling point 223°–230°.)	Substance, wt.,	0·7015 "
		SiO_2, -	0·1625 "
III.	(215°–220°.)	Substance, wt.,	0·2215 "
		CO_2, -	0·4280 "
		H_2O, -	0·2070 "
IV.	(215°–220°.)	Substance, wt.,	0·3845 "
		SiO_2, -	0·0940 "

Another preparation where an excess of amylic alcohol had been employed—

V.	(214°–220°.)	Substance, wt.,	0·3795 gr.
		CO_2, -	0·7480 "
		H_2O, -	0·3640 "

	I.	II.	III.	IV.	V.	Theory.
C,	52·74		52·73		53·78	52·80
H,	10·13		10·38		10·75	10·40
Si,		10·80		11·40		11·20

Analysis number V, and those of products boiling above 230°, indicated the presence of a mixed ether, containing more amyl than the one we sought to obtain. This fact awakened our attention, and induced us to make some researches on the action of alcohols upon the ethers of acids, which showed us that an alcohol can act directly upon an ether and that an interchange of the two radicals takes place;* thus when an excess of amylic alcohol is employed, it acts upon the triethylic mono-amylic silicic ether and an ether containing more amyl is formed.

Triethyl monoamyl silicic ether is a colorless, somewhat oily liquid, with a feeble odor like that of all amylic compounds. It is not entirely decomposed by treatment with an alcoholic solution of ammonia, and it is necessary to employ a solution of caustic soda in alcohol to make the determination of silica. Ebelmen made the same observation in regard to the silicate of amyl. Density at 0°=0·926.

The mixed ether on distillation, even in vacuo, has a tendency to decompose with formation of diamylic diethylic ether, and doubtless at the same time of normal ethylic silicic ether. A product which had been prepared from the monochlorhydrine without an excess of amylic alcohol, after several distillations at 100°–110°, under a pressure =3–5 millemeters of mercury, had a composition between that of the mono- and the di-amylic mixed ether.

Substance, weight, - -	0·2805 gr.
CO_2, - - - -	0·5640 "
H_2O, - - - -	0·2750 "

* This Journal, xl, 34.

	I.	$Si, 3(C_2H_5), (C_5H_{11})O_4$.	$Si, 2(C_2H_5), 2(C_5H_{11})O_4$.
C,	54·88	52·80	57·53
H,	10·91	10·40	10·96

Diethylic diamylic silicic ether was prepared in the same way as the preceding by treating the dichlorhydrine with amylic alcohol. The portion boiling at 245°–250° was analyzed.

I.	Substance, weight, - - - -	0·2115 gr.
	CO_2, - - - - - -	0·4495 "
	H_2O, - - - - - -	0·2095 "
II.	Substance, weight, - - - -	0·3980 "
	SiO_2, - - - - - -	0·0780 "

	I.	II.	Theory.
C,	57·89		57·53
H,	10·99		10·96
Si,		9·15	9·59

The density at 0°=0·9150.

Monoethylic triamylic silicic ether was obtained in the same way as the preceding with the trichlorhydrine and amylic alcohol. It boils at 280°–285°.

I.	Substance, weight, - - - -	0·2410 gr.
	CO_2, - - - - - -	0·5350 "
	H_2O, - - - - - -	0·2425 "
II.	Substance, weight, - - - -	0·4820 "
	SiO_2, - - - - - -	0·0875 "

	I.	II.	Theory. $SiC_{17}H_{38}O_4$.
C,	60·51		61·08
H,	11·18		11·37
Si,		8·47	8·38

This ether resembles in its properties the silicate of amyl. The density at 0°=0·913.

All these mixed ethers can only be prepared from the pure chlorhydrines, as they are decomposed on distillation, and therefore cannot be purified in that way.

Polysilicates of ethyl.—Ebelmen describes, besides the normal silicate, two others, the one containing twice as much silicic acid, and the other four times as much, and calls them bisilicate and quadrisilicate of ethyl.

He obtained the bisilicate, to which he gives the formula

$$2SiO, C_4H_5O \quad (Si=7, C=6, O=8, H=1),$$

by treating the chlorid of silicium with alcohol containing one equivalent (16 per cent) of water. One equivalent of alcohol was added to two equivalents of chlorid.

To quote his memoir, "when the product is distilled, the temperature of the liquid, contained in the retort, rises from 160° to 350° without a considerable quantity of the product distilling.

At this moment the mercury thermometer is taken away, the receiver is changed, and on continuing to heat, soon an abundant colorless product passes. * * * The liquid, distilled above 350°, was rectified with a thermometer placed in the retort; a very small quantity of a product, which distilled below 350°, was collected by itself, then the thermometer was removed, and the distillation continued, and in a few instants almost the whole contents of the retort passed over into the receiver. It did not appear doubtful to me, that a body, which distills with so great rapidity could be other than a definite product, having a fixed boiling point near 350°." According to Ebelmen the bisilicate can also be obtained by adding to the protosilicate alcohol, containing the requisite quantity of water.

As for the quadrisilicate, he says that it is obtained by adding a little aqueous alcohol to the bisilicate, and remains in the retort after the distillation of the latter. It appears to be decomposed into bisilicate and silica at a temperature a little above that at which the bisilicate distills. The existence of these two ethers, if we give them the formulæ

$$\left.\begin{matrix}\text{Si} \\ 2(\text{C}_2\text{H}_5)\end{matrix}\right\}\Theta_3 \quad \text{or} \quad \left.\begin{matrix}2\text{Si} \\ 4(\text{C}_2\text{H}_5)\end{matrix}\right\}\Theta_6 \quad \text{and} \quad \left.\begin{matrix}2\text{Si} \\ 2(\text{C}_2\text{H}_5)\end{matrix}\right\}\Theta_5,$$

accords perfectly with what is known of the formation of condensed bodies. Wurtz* has observed the formation of polyethylenic alcohols, which are nothing but the anhydrids of glycol, anhydrids formed by the condensation of several molecules into a single one. He has since 1862† applied to the hydrates of silicic acid the same theory, by means of which he explained the formation of polyethylenic compounds. Wurtz and Friedel‡ have shown that the theory of condensations is applicable to acids as well as to alcohols, and several researches, among others those of Hugo Schiff,§ have confirmed this view. It results from this, that if, in order to take the most simple case, we take the hydrate of silicium, corresponding to the chlorid, in which the 4 atoms of chlorine are replaced by 4 equivalents of the body $\text{H}\Theta$,

$$(1.) \qquad \text{Si}\left\{\begin{matrix}\Theta\text{H} \\ \Theta\text{H} \\ \Theta\text{H} \\ \Theta\text{H}\end{matrix}\right. = \text{Si}, 4(\Theta\text{H}).$$

We can derive from this hydrate, which with Odling we call normal, the following hydrates containing less water.

First, without condensation:

* Bulletin de la Société Chimique, [1], i, 82; December, 1859.
† Répertoire de Chimie pure, ii, 449.
‡ Ann. de Chim. et Phys., [3], lxiii, 111; 1861.
§ Comptes Rendus de l'Académie des Sciences, liv, 1075; 1862.

(2.) 1st anhydrid, $$\mathrm{Si}\left\{\begin{array}{l}\Theta\mathrm{H}\\ \Theta\\ \Theta\mathrm{H}\end{array}\right. = \mathrm{Si}, \Theta, 2\Theta\mathrm{H}.$$

The silicate which Odling calls metasilicate corresponds to this hydrate.

Secondly, with condensation:

(3.) 1st anhydrid, $$\begin{array}{c}\mathrm{Si}\left\{\begin{array}{l}\Theta\mathrm{H}\\ \Theta\mathrm{H}\\ \Theta\mathrm{H}\end{array}\right.\\ \Theta\\ \mathrm{Si}\left\{\begin{array}{l}\Theta\mathrm{H}\\ \Theta\mathrm{H}\\ \Theta\mathrm{H}\end{array}\right.\end{array} = 2(\mathrm{Si}\Theta), 6(\Theta\mathrm{H}).$$

This hydrate is the type of Odling's intermediate silicates, bodies which it would be better to call disilicates.

(4.) 2d anhydrid, $$\begin{array}{c}\mathrm{Si}\left\{\begin{array}{l}\Theta\mathrm{H}\\ \Theta\mathrm{H}\\ \Theta\mathrm{H}\end{array}\right.\\ \Theta\\ \mathrm{Si}\left\{\begin{array}{l}\Theta\\ \Theta\mathrm{H}\end{array}\right.\end{array} = 2\mathrm{Si}, 2\Theta, 4(\Theta\mathrm{H}).$$

(5.) 3d anhydrid, $$\begin{array}{c}\mathrm{Si}\left\{\begin{array}{l}\Theta\mathrm{H}\\ \Theta\end{array}\right.\\ \Theta\\ \mathrm{Si}\left\{\begin{array}{l}\Theta\\ \Theta\mathrm{H}\end{array}\right.\end{array} = 2\mathrm{Si}, 3\Theta, 2(\Theta\mathrm{H}).$$

Without giving other formulæ of possible hydrates, we will observe, that the three ethers of Ebelmen would come under the case (1), (2) or (4) and (5). Ebelmen does not speak of any ether corresponding to the formula (3), but this is the only one that we have been able to obtain in a state of purity, and every repetition of Ebelmen's experiment has given negative results, in spite of the most persevering efforts to prepare his bisilicate and quadrisilicate.

Hexethylic disilicic ether.—Having operated upon several pounds of chlorid of silicium, and prepared large quantities of silicate of ethyl with alcohol, which was not perfectly anhydrous, a considerable portion of the product boiled at a higher temperature than the normal silicate. We collected all the products of different preparations, and on submitting them to a fractionated distillation, we observed that a much larger amount of liquid distilled at about 240°, than at any other point above or below between 170° and 320°. In one preparation where 800 grams of chlorid of silicium were employed, we obtained, beside the normal silicate, 80 grams of a product boiling at 230°–240°. An analysis gave:

I.	Substance, weight,	0·3860
	$\text{Є}\Theta_2$,	0·5940
	$H_2\Theta$,	0·3100

Not succeeding well at first in obtaining a compound boiling at a fixed temperature, we submitted all the products, whose boiling point was higher than that of the normal silicate, to a series of distillations in vacuo. This operation can be conducted without difficulty, thanks to the tubes and corks of india-rubber now manufactured,* and the labor of working the air-pump during several days in succession was rendered much less disagreeable by the employment of one of Bianchi's rotary pneumatic machines, with the aid of which we could maintain an atmosphere exercising a pressure equal to only 3–5 millimeters of mercury during all the operations.

After eight fractionated distillations (pressure 3–5 mm.), the product distilling at 125°–130° was analyzed.

II.	Substance, weight,	0·7260
	Silica,	0·2550
III.	Substance, wt. (boiling point =126°–130°),	0·3675
	$\text{Є}\Theta_2$,	0·5690
	$H_2\Theta$,	0·2970

This portion (125°–130° in vacuo), distilled in the air, passed almost entirely at 233°–238°. An analysis of this gave:

IV.	Substance, weight (boiling point 233°–238°),	0·1775
	$\text{Є}\Theta_2$,	0·2745
	$H_2\Theta$,	0·1395
V.	Substance, weight,	0·3750
	$Si\Theta_2$,	0·2005

	I.	II.	III.	IV.	V.	VI.	VII.	Theory. $2Si, 6(\text{Є}_2H_5), 7\Theta$.
C,	41·96		42·22	42·16				42·11
H,	8·92		8·97	8·74				8·77
Si,		16·38			16·28	16·53	16·59	16·38

All these numbers agree with the formula $\left.\begin{matrix}Si_2\\(\text{Є}_2H_5)_6\end{matrix}\right\}\Theta_7$, which belongs to one of the ethers of disilicic acid, if this name be given to the hydrate, which results from the condensation of two molecules of the normal hydrate with elimination of the smallest quantity possible of water, i. e., one molecule.

The reaction which gives rise to the ether above analyzed is expressed by the equation

$$2\left[\left.\begin{matrix}Si\\(\text{Є}_2H_5)_4\end{matrix}\right\}\Theta_4\right]+H_2\Theta=\left.\begin{matrix}Si_2\\(\text{Є}_2H_5)_6\end{matrix}\right\}\Theta_7+2\left(\begin{matrix}\text{Є}_2H_5\\H\end{matrix}\Theta\right).$$

* Vulcanized india-rubber becomes less pervious to air after it has been boiled with a weak solution of caustic potash sufficiently long to extract most of the sulphur.

As this ether, which may be named hexethylic disilicic ether, was not obtained by Ebelmen, we have used great care in assuring ourselves, that it is really a distinct compound, and rely as proof upon the following facts. The boiling point after repeated distillations remains constant at a temperature too remote from that of the boiling points, which Ebelmen indicates for the normal ether and for his bisilicate, to make it possible to consider it as a mixture of these two compounds. We succeeded in obtaining the ether almost pure by treating chlorid of silicium with alcohol containing the requisite quantity of water. The product of this experiment was distilled under a pressure of 3–5 mm., and distilled almost entirely at 126°–130°.

This product, boiling at 126°–130° in vacuo, furnished the material for the determinations of silica VI and VII given above.

VI.	Substance, weight,	0·7305
	$Si\Theta_2$,	0·2585
VII.	Substance, weight,	0·9370
	$Si\Theta_2$,	0·3330

We thought at first that the compound was decomposed by heat, and that its boiling point changed after a large number of distillations in the air, and this indeed was the reason, that we undertook the series of distillations in vacuo; but this idea proved afterwards to be erroneous, for a portion, distilled in vacuo after having been heated seven hours at 230°–235° in a sealed tube did not change its boiling point. With silicic ethers as with the chlorhydrines great care must be taken to exclude the moisture of the atmosphere during the protracted operations necessary to effect a large number of fractionated distillations, and if the boiling points changed, it was because the ethers had been decomposed by moisture.

The vapor density of hexethylic disilicic ether corresponds with the formula given above. The first determination was made with an impure product, and the number 13·5 instead of 11·86 was found; but this only came from a portion of an ether having a higher boiling point, which remained in the bulb. This we satisfied ourselves of by making a determination of silicic acid of the liquid remaining in the bulb.

I.	Substance, weight,	0·8875
	$Si\Theta_2$,	0·3205

Si=16·82 instead of 16·38, the theoretical number. If we suppose that the excess of silica came from an admixture of a body having the composition of the bisilicate of Ebelmen, the liquid remaining in the bulb must have contained one-tenth its weight of that compound.

A second determination made with a product redistilled several times and boiling at 233°–234° gave 12·025, a number which corresponds very closely with the theoretical 11·86.

Difference between the weights of bulb,	1·6595 gr.
Temperature of balance, - - -	12°·5
" " oil-bath (mercury thermom.),	296°
Height of barometer, - - - -	757·8 mm.
Capacity of bulb, - - - - -	320 cc.
Air remaining (measured), - - -	26 cc.

11° temperature and 756·8 mm. barometric height.

A determination of silica was made from the liquid remaining in the bulb.

Substance, weight, - -	0·4670
SiO_2, - - - - - -	0·1655

Si=16·48; theory=16·38. The density of the hexethylic disilicic ether is at 0° =1·0196, at 19°·2 =1·0019.

The ether is a colorless liquid of slightly oily consistency, with a rather agreeable odor, scarcely differing from that of the normal silicate. It burns with a smoke composed of silicic acid like all of this class of compounds.

Aqueous alcohol transforms it into products having a higher boiling point. It is not so easily acted on by moisture as the normal silicate.

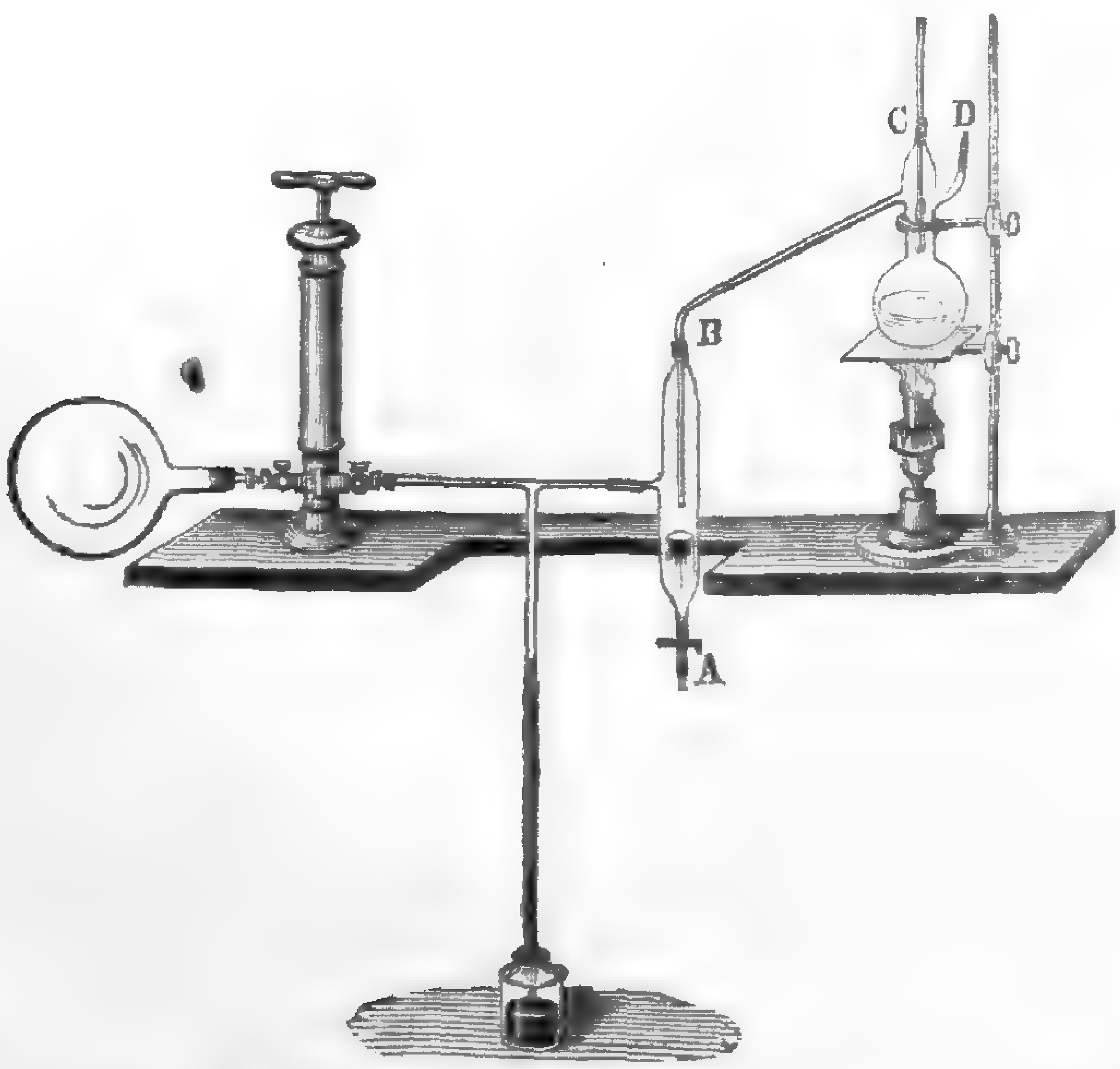
After we had demonstrated the existence of the above body we attempted to obtain the bisilicate of Ebelmen in order to determine whether it corresponds to the first anhydrid of silicic acid or to the second anhydrid of disilicic acid, if this latter exists; but all the experiments undertaken failed to give this body, whose existence seemed so probable on theoretical grounds and whose preparation seemed so easy according to the statements of Ebelmen. We have submitted to a great number of fractionated distillations in the air, under a diminished pressure and in vacuo, the products boiling above 240°, without being able to observe any point, at which a particularly large quantity distilled; and it will be seen by our analyses, that the quantity of silicic acid contained in the higher products, was greater than that required by theory for the bisilicate of Ebelmen. The temperature also, which was measured in vacuo by a mercury thermometer, corresponds to 450° in the air, a point much higher than that at which Ebelmen supposed his compound to boil. It may be of use to give the results of our experiments as they teach us something concerning the nature of the condensed silicates containing more silicic acid than the ether just described.

In order to determine the difference in boiling point due to a diminution of pression, and to ascertain what reliance could be placed on the constancy of boiling points in vacuo, we distilled, under a pressure of 3–5 millimeters, the normal silicate of ethyl having a fixed boiling point at 165°·5 in the air. Platinum wire and a piece of charcoal were put in the flask to make the ebullition as quiet as possible, but without any very marked effect.

The normal ether began to boil at 55° and the thermometer rose rapidly to 72°–73° and remained nearly stationary at this temperature (in another experiment at 74°–75°) during the distillation. When the distillation was interrupted and recommenced, ebullition commenced always at a much lower point than 73°. According to this, the diminution of pressure to 3–5 mm. lowers the boiling point of the ether in question from 165°·5 to about 73°. We have seen that the hexethylic disilicic ether, which distilled at 233°–8°, in the air distilled at 226°–230° under a pressure of 3–5 mm. For this latter product, the limits of temperature within which the thermometer varies during a distillation in vacuo, are much less than for normal ether.

The ebullition is much more regular under a somewhat greater pressure, and for this reason and also because we hoped that the change of pressure might facilitate the separation of the products, as Roscoe has observed in the case of hydrates of acids, we made another series of distillations under a pressure of 60 millimeters of mercury.

These distillations were made with an apparatus which permitted us to operate almost as rapidly as when distilling in the air, and it only requires a small hand pump, when no better is to be procured.



The opening B has an india-rubber tube through which is passed the glass tube leading from the flask containing the substance. At C a thermometer is introduced in the same way. The lower end, A, of the receiver has a tube, which is closed during the distillation, and is opened to draw off the product when required. It is not necessary to surround the receiver with water, as the specific heat of the silicic ether is very small. The opening D, which is closed with a piece of glass rod fitting into an india-rubber tube, serves to add a new quantity of liquid when required. The object of the other parts of the apparatus is obvious. The balloon at the extremity only serves to augment the volume, so that a constant pressure may be more easily obtained; its communication with the distilling apparatus is closed when it becomes necessary to open the latter. All the connections were made with india-rubber tubes boiled in potash, and used double, the inner one coated with tallow, and when the apparatus was left to itself the pressure only varied a few millimeters in twenty-four hours, and could easily be kept perfectly constant by a few strokes of the air pump during a distillation. We will give the results of several series of distillations made with the same material under different pressures.

[To be concluded.]

ART. XVIII.—*Remarks on the Cretaceous rocks of the West known as No. 1, or the Dakota Group;* by F. V. HAYDEN.

THE Cretaceous rocks of the Upper Missouri have been separated into five divisions, which have been designated, for the sake of convenience, by Nos. 1, 2, 3, 4, and 5.* They have also received special geographical names indicating points where they are shown in their largest development.† The Dakota group or Formation No. 1, lies at the base of this series, and either as an outcropping or underlying rock extends over a large portion of Nebraska, Dakota, Minnesota, Kansas, and even reaches far southward into New Mexico. It is more distinctively defined along the Missouri river between Omaha City and the Big Sioux, where it exhibits its typical characters.

The lithological characters of this group have been so often described in former memoirs by Mr. Meek and the writer, that they scarcely need to be repeated here. The principal object of this article is to present such additions to our knowledge of it as may have been obtained since our last papers were published. It is not intended to discuss in detail any differences of opinion, or to make any criticisms, but to present certain facts and statements gathered by Professors Capellini and Marcou in their tour to Nebraska in 1863, and the results of the investigations of Prof. Heer derived from the study of the flora of this group.

* Memoirs Am. Acad. Arts and Sci., vol. v, new series, also numerous papers by F. B. Meek and F. V. Hayden.

† Proceedings Acad. Nat. Sci., Dec. 1861.

In order that the geological relations of the Dakota group may be better understood, I have given a brief summary of the contiguous formations.

In ascending the Missouri river we find near Fort Leavenworth exposures of limestone which, up to the present time, we have regarded as belonging to the upper Coal-measures. The beds are all nearly horizontal, with a slight, almost imperceptible, dip toward the northwest. As we continue up the Missouri, layer after layer of these Coal-measure rocks pass from view beneath the water level of the river, and when we reach Fort Lisa they have entirely passed from sight and are overlapped by a bed of variegated friable sandstone. The sandstone undoubtedly exists, or has existed, as an underlying rock considerably lower down the river than Fort Lisa, probably nearly to Omaha City, but has either been removed by erosion, or concealed by the great thickness of superficial recent deposits which cover this country, sometimes entirely hiding from view the underlying basis rocks over large areas. Ascending the Platte valley we have the true Upper Carboniferous limestone nearly to the mouth of the Elkhorn. Before reaching that point, however, we observe a portion of No. 1 resting directly upon the limestones, as the following section will show.

1. Gray compact siliceous rock, passing down into a coarse conglomerate, an aggregation of water-worn pebbles, cemented with angular grains of quartz; then a coarse grained micaceous sandstone (lower portion of Dakota group), 25 feet.

2. Yellow and light gray limestone of the upper coal-measures containing numerous fossils, *Spirifer cameratus*, *Spirigera subtilita*, *Fusulina cylindrica*, *Productus*, *Chonetes*, and abundant coral and crinoidal remains.*

At the mouth of the Elkhorn, the Carboniferous limestones have passed from view beneath the Cretaceous sandstones. The intermediate Permo-carboniferous and Permian rocks, as well as the variegated and gypsiferous marls and clays which are quite conspicuous westward from Fort Riley, are wanting in this region. The Dakota group as seen along the Missouri passes beneath the bed of the river about 30 miles above the mouth of the Big Sioux. How far up the Big Sioux it extends is not yet known; but at a point 40 miles up the valley, the seam of earthy Lignite, which is seen just above the Omaha reserve, crops out, and is exciting some attention among the farmers.

The researches of Prof. Hall have extended this group northward from the Missouri river into Minnesota 130 miles or more. In an interesting memoir read before the American Philosophical Society at Philadelphia, Prof. Hall, after describing numerous exposures of the variegated quartzites from St. Peters to Fort

* Trans. Amer. Phil. Soc. 1861.

Ridgely, says: "Proceeding westward from Fort Ridgely, I had no opportunity of seeing any other formation than the prairie for about thirty miles. At this point near where we crossed the Big Cottonwood River, there is an exposure of rock in the bank of the stream; and at a short distance farther on, some explorations had been made for coal, and a shaft had been sunk to the depth of more than one hundred feet. The materials thrown out of this shaft consisted of a dull greenish argillaceous sand, with calcareous nodules, together with irregularly laminated sandstone containing vegetable remains. The order of deposits, as given to me by Mr. Morin, who superintended a part of the working, was as follows:

1. Ironstone; 1 ft. 6 inches.
2. Sand, clay, etc.; 40 ft.
3. Earthy coal;* 1 ft. 8 inches.
4. Sand, clay, etc.; 3 ft.
5. Sandstone in irregular and diagonally laminated layers, with sometimes calcareous concretions, and containing plant remains; 5 ft.
6. A Calcareous sandy clay of variable color and character; 20 ft.
7. Sandstone in loose thin layers of three or four inches; 4 ft.
8. Clay with coaly seams near the bottom; 16 ft.
9. Clay; 13 ft.
10. Loose quicksand to bottom of shaft.

"In the river bank, at a quarter of a mile distant, and at a level 30 or 40 feet below the ground where the shaft began, there is the following exposure:

1. Loose ironstone† in nodules and irregular concretions, more or less mixed with drift and pebbles; 1–2 ft.
2. Calcareous clay; 6–8 ft.
3. Earthy coal; 8 inches.
4. Clay as above coal; 4 inches.
5. Yellow or ferruginous sand and clay; 3–3½ ft.
6. Ferruginous sandstone in irregular layers and diagonally laminated to level of river; thickness unknown.

"This sandstone appears to be the same as that containing the vegetable remains met with in the shaft; and though I did not find plants in it at this point, I was informed that specimens had been found there; and at another place on the Cottonwood I found them to be quite common. Near the previous exposure,

* An analysis of this coal, by Prof. T. Sterry Hunt, gave the following results:

Fixed carbon,	26·1
Volatile "	25·7
Ash "	48·2=100·0

In the sections of strata near the mouth of the Redwood river, there is a stratum of similar earthy coal three feet thick.

† This ferruginous layer does not appear to belong to the regularly stratified deposits, as it overlies, irregularly, the edges of the successive beds, and has been deposited after the denudation had taken place.

and partly from an old digging, I obtained a similar section. At still another point I noticed a similar exposure, leaving no doubt of the character and order of arrangement of the materials composing this formation.

"The character of the vegetation obtained from the sandstone of the shaft and elsewhere, resembling the leaves of Salix, Poplar, Liriodendron, Tupelo, etc., induced me to refer this formation to the Cretaceous period. A single indistinct shell was the only animal fossil I was able to obtain. In aspect the calcareous concretions are similar to those from the Cretaceous formation of the upper Missouri; and the green argillaceous clay is likewise similar."

At Redwood Falls, also, Prof. Hall obtained another section of this group with a seam of earthy coal three feet in thickness. There is little doubt that this group will be found extending far northward, either as a continuous formation or in isolated patches, perhaps even into the British possessions.

In September, 1863, Mr. Marcou and Prof. Capellini of the University of Bologna, Italy, made an excursion up the Missouri river to a point near the mouth of the Big Sioux. It seems that both of them studied with care the different geological formations along the river under quite favorable circumstances. Prof. Capellini made quite an extensive collection of fossil plants at different localities, principally from Tekama, Blackbird Hill and Big Sioux. These plants he placed in the hands of Prof. O. Heer of the University of Zurich, Switzerland, who described them in a small but carefully prepared memoir with four plates, 4to. Mr. Marcou also published the results of his examinations in the Bulletin of the Geological Society of France. He there acknowledges that the rocks, which have hitherto been included in No. 1 or Dakota group are Cretaceous. Capellini and Heer came to the same conclusion, and thus one disputed point in regard to the geology of the West may be regarded as forever set at rest. I would remark just here, that I have personally examined the greater part of the territories of Kansas, Nebraska, Dakota, Montana, Idaho, and Colorado, and I feel confident that, although future investigations may perhaps modify, they will not essentially change, the published results.

After examining the Carboniferous limestones as far as Bellevue, Nebraska, Mr. Marcou* continued up the Missouri and examined the sandstones of the Dakota group. In this red sandstone he found a rich flora of well preserved leaves of Laurel, Poplar, Sassafras, Walnut, Oak, Willow, Tulip, a flora which

* Reconnaissance géologique au Nebraska, par Jules Marcou: Extrait du Bulletin de la Société Géologique de France, 2d série, t. xxi, p. 132, Jan. 18th, 1864, and Les Phyllites Crétacees du Nebraska, par MM. les Prof. J. Capellini et O. Heer, tirage a part des Mémoires de la Société Helvétique des Sciences Naturelles.

Prof. Heer regards as Miocene, and has more the aspect of upper Miocene or even Pliocene than of the lower Tertiary epoch. Nevertheless, the flora is not even Tertiary but really lower Cretaceous. It is found in a fresh-water formation at the bottom of the White Chalk of the Missouri Basin. It was Dr. Hayden who first collected these dicotyledonous plants at Blackbird Hill, at the Omaha Mission, where a quarry was opened for the purpose of erecting the mission house. Mr. Heer who saw the designs of the first collection made at Blackbird Hill by Dr. Hayden, declares that this flora is not Cretaceous, but that on the contrary it has a very close analogy with the lower Miocene or Oligocene of Europe. But notwithstanding these facts, Mr. Marcou saw superimposed upon the rocks with dicotyledonous leaves at Pilgrim Hill and on the banks of the Big Sioux, beds of chalk containing *Inoceramus problematicus*, *Ostrea congesta*, &c., and that too without any indications of faults or disturbances of strata. "I yield to the opinion of Mr. Hayden and regard these beds as Cretaceous. But I make one reservation; that all the Cretaceous beds of Nebraska, and of the upper Missouri in general, are very recent and correspond, as also those of New Jersey, to the Senonien of d'Orbigny, and perhaps also to his Turonien."

From his observations in Nebraska, Mr. Marcou arrives at the following conclusions.

1. "The rules and laws of paleophytology hitherto adopted and followed must be greatly modified, since we find here a flora, regarded as Miocene in Europe, at the base of the Chalk period. On this account I may be permitted to add that, in the geographical distribution of the existing flora, I have discovered contrasts much greater than those in the distribution of the existing fauna. One of these contrasts which surprised me most is that of the elevated plateaus of New Mexico, Texas, Arizona and California, which is certainly more different from the flora of the States bordering upon the Atlantic and the basin of the Mississippi under the same conditions of temperature and latitude, while on the other hand it does not differ from the Tropical flora of Florida, the Antilles and Panama. After this discovery I could see no serious objection which would have weight in the mixture of Carboniferous plants and Belemnites at Petit-Couer in Laventaire, since in Nebraska we have Miocene plants underneath 500 or 600 feet of white chalk containing *Inoceramus*, *Ammonites*, and *Baculites*.

2. "The new red sandstone and more especially the lower portion or dyas occupies a very important place in the geology of Nebraska, as I announced it in 1855 to the Geological Society of France, in my geological chart of the United States and in the explanatory résumé which accompanied it.

3. "The dyas of Nebraska is composed of two members, as in Russia and Germany, one of which corresponds to the Rothliegende and the other to the Zechstein."

Prof. Capellini in a short but very interesting article confines his observations mostly to the rocks of the Dakota group and remarks that he does not hesitate to regard the observations of American geologists as entirely just. The following remarks close the article of Prof. C.

"After all we have observed in relation to the environs of Sioux City, it is easily seen that a stratigraphic series so complete throws a clear light upon the isolated facts first noticed at Tekamah and Blackbird Hill, and indicates the exact position of the rocks with dicotyledonous leaves, analogous to the Tertiary leaves of Europe but belonging in reality to the Chalk.

"It may be estimated that the thickness of these Cretaceous strata in the environs of Sioux City is about 40 meters. They may be divided into two distinct parts, one rich in leaves, a fresh-water formation; the other truly chalky with fishes and Inoceramus, of marine origin—both are probably not older than the chalk of Maestricht. This has been my opinion from the time I admitted that the dicotyledonous leaves of the Big Sioux and Tekamah were Cretaceous.

"Once the age of the Mollasse with leaves established by the aid of the stratigraphy and the animal fossils, it would be interesting if it were possible to arrive at the same results by the vegetable remains. On this account, Prof. Heer came to my aid and investigated the specimens I collected in my explorations. More than a dozen species were recognized among the leaves from Tekamah, Blackbird Hill, and Big Sioux, but it was especially the first locality which furnished the best specimens. We are convinced that when observations are exact and determinations made from careful examination of specimens, there is never any disagreement between stratigraphical and paleontological laws."

The remarks of Prof. Heer which preface his descriptions of the fossil plants collected by Prof. Capellini, are so interesting and important that we copy them entire.

"The collection of Mr. Capellini contains 16 species; 4 are badly preserved; 12 are determinable. Nevertheless, of the latter, several are but fragments, so that their determination is difficult and not sufficiently positive. This is especially the case with the Phyllites which I have referred to the genera Platanus and Andromeda. It is certain that all the leaves found by Mr. Capellini are dicotyledons and with great probability one may be referred to the genus Ficus, one to Salix, one to Diospyrus, two to Populus and two to Magnolia, although there are no accompanying fruits or other parts to confirm these determinations. These genera are yet living and they are also found in the Tertiary formations.

"If we compare these plants of Nebraska with the Cretaceous plants of Europe, we find no identical species among them. I sent drawings of them to Dr. Debey of Aix la Chapelle, who discovered in that locality a Cretaceous flora. He has written to me that he has not found one species identical. Even the greater part of the genera are different. There is but one Cissites (*C. aceroides* Debey) which recalls slightly the *C. insignis* (Plate IV, fig. 5). The Cretaceous plants of Henant, Belgium, those of Blankenburg and Quedlinburg are also very different.

"Prof. Schenk has recently sent to me, a collection of plants of Quedlinburg for determination. Besides conifers and ferns characteristic of the chalk, it contains dicotyledons, but no forms like those of Nebraska.

"The Cretaceous flora of Moletein, Moravia, which I have lately studied, exhibits more resemblance. It contains two species of Ficus which much resemble the Ficus of Nebraska, two superb species of Magnolia, one with a fruit cone. There is a relationship between the flora of Nebraska and that of the upper Chalk of Europe, although identical species are wanting. But to the present time no characteristic genus of the Cretaceous flora of Europe has been found in Nebraska.

"If we compare the plants of Nebraska with the Tertiary plants we find no identical species, but 7 genera, (Populus, Salix, Ficus, Platanus, Andromeda, Diospyrus and Magnolia) are also Miocene and likewise living. It then appears that the Nebraska flora is related more to the Tertiary than to the Cretaceous flora of Europe, a fact which struck me when I first saw drawings of the former. But it should be remarked that we know but a very small number of American species, and on the other hand, the European Cretaceous flora has more relationship with the Tertiary flora than I at first supposed. I have found in the Cretaceous flora of Moletein, Moravia, species of Ficus and Magnolia which resemble Tertiary species; a Myrtacea, which is a near neighbor to the *Eucalyptus rhododendroides*, Mass, of Mt. Bolca; a Juglans and a Laurinea, which also have their analogues in the Tertiary flora; a Pinus and two other conifers which belong to the genus Sequoia, which was extensively distributed in Europe and America in the Miocene epoch and which is now only found in California.

"As the Cretaceous fishes are more nearly related to the Tertiary than to the Jurassic fishes, the upper Cretaceous flora is also entirely different from the Jurassic and more nearly allied to the Tertiary floras, and it appears that in America the relation between the Tertiary and Cretaceous flora is yet more intimate than in Europe.

"It is remarkable that the plants of Nebraska (as Magnolia and Liriodendron) present relations with the existing flora of America, whilst the Cretaceous flora of Europe has more of an Indo-Australian character. It thus appears that since the Cretaceous epoch, the American flora has not undergone a change so great as the European flora. While the Cretaceous flora of Europe is entirely different from the existing European flora, that of Nebraska contains 8 genera yet found in America, and it is the more remarkable that the greater part are yet found in a country under the same latitude."

Prof. Heer describes the following species of plants from this group in this memoir: *Populus litigiosa, P.? Debeyana, Salix nervillosa, Betulites denticulata, Ficus primordialis, Platanus? Newberryana, Proteoides grevilleæformis, P. daphnogenoides, P. acuta, Aristolochites dentata, Andromeda Parlatorii, Diospyrus primæva, Cissites insignis, Magnolia alternans, M. Capellini, Liriodendron Meekii, Phyllites Vanonæ.*

Both Mr. Marcou and Prof. Capellini agree in regarding this sandstone in which the dicotyledonous leaves are found as a fresh-water formation. I would simply say that I have always regarded it as marine and I am sure this has been the opinion of my friend Mr. Meek. At any rate we have found mingled with the leaves at Sioux City quite well preserved casts of *Pharella? Dakotaensis, Axinæa Siouxensis* and *Cyprina arenacea*, shells peculiar to marine deposits.

The question has arisen, whether this period had a fauna corresponding to its flora? Besides the Mollusca already alluded to, no remains of land animals have yet been discovered which could be positively identified. On the eastern slope of the Big Horn mountains, I saw in 1859, a series of beds holding a position between No. 2 Cretaceous and the Jurassic rocks below, which I referred without hesitation to this group. In these rocks were beds of earthy Lignite, large quantities of petrified wood, and numerous large uncharacteristic bones which doubtless belong to some Saurian. No remains of strictly land animals have ever been found.

Although I have endeavored to give the substance of Mr. Marcou's memoir in this article, I do not wish to be regarded as endorsing all that he has said in regard to the existence of "Dyas" and "Mountain limestone." In the autumn of 1856, while descending the Missouri river, I saw some peculiar local beds near St. Stephen's, Nebraska, from which I obtained *Myalina perattenuata, Pleurophorus occidentalis* and *Lyonsia concava*, which were sufficient to indicate that they were either Permian or the transition beds which we have called Permo-carboniferous. These questions have been most ably and exhaustively discussed by Mr. F. B. Meek in an article in this Journal, Jan., 1866, to which the reader is referred. The main object of the present article is to place before those American readers of this Journal, who may not have access to foreign Journals, such views and important geological facts as Profs. Marcou and Capellini obtained in their field investigations, as well as those of Prof. Heer from the study of the fossil plants.

University of Pennsylvania, Philadelphia, Jan. 8th, 1867.

ART. XIX.—*Researches on Solar Physics;** by WARREN DE LA RUE, Esq., Pres. R.A.S., BALFOUR STEWART, Esq., Superintendent of the Kew Observatory, and BENJAMIN LOEWY, Esq., Observer and Computer to the Kew Observatory.

First Series.—On the Nature of Sun-spots.

1. THERE is a marked difference between our luminary and our satellite, as far as regards our knowledge of their physical aspect and constitution. Many parts of our own globe are not so well known, or so correctly mapped, as certain regions in the moon; and could we imagine an observer transported into the neighborhood of Tycho or Copernicus, he would probably be better prepared for the appearance presented to him, than he would be if placed suddenly in equatorial Africa or central Australia. But with regard to the sun the case is very different; for although the progress of science has enabled us to detect the presence of certain familiar substances in the atmosphere of our luminary, it has hitherto only shrouded in deeper mystery than ever the origin of that wonderful outpouring of light and heat which is the sun's most prominent characteristic, and to this very day it has not been finally decided whether this luminosity proceeds from the sun's solid body, or from an envelope which surrounds it. Indeed so strange and so unaccountable are many of the features presented to us, not only by our own sun, but by many of the stars, that it has even been conjectured that these bodies exhibit instances of the operation of some force of the nature of which we are yet ignorant. If we accept this view of the case, the study of our luminary becomes one of very great importance, but one in which we must be very careful to be guided by observation alone. We must obtain numerous and accurate representations of the sun's surface, and study these carefully and minutely, before we attempt to generalize.

§ I. *Methods of observation.*

2. There are two methods of accomplishing this. (1.) Eye-observations of the sun's surface may be made by means of a

* From a memoir printed for private distribution.

telescope, and the appearance carefully mapped by the observer. (2.) Or we may call to our aid that art which has already proved of signal service in many branches of science, and, by means of photography, obtain autographs of our luminary, which we may measure and examine carefully at our leisure.

Each of these has its advocates, but it is not our design to discuss the comparative merits of the two methods; on the contrary, as each has its own special advantages, we are willing to adopt them both, and to avail ourselves of all those materials which our own observations or the kindness of friends may have put into our hands.

§ II. *Historical sketch.*

3. The most important knowledge which we possess regarding the physical appearance and structure of our luminary is derived from the following sources.

4. *Sun's rotation.*—We are, in the first place, indebted to Galileo, if not for the first discovery of sun-spots, at least for the first attempt to ascertain through their means the period of rotation of our luminary.

5. *Nature of sun-spots.*—The next great advance in solar physics is due to Alexander Wilson, Professor of Astronomy at Glasgow, who in 1773, communicated a paper to the Royal Society, describing certain phenomena with regard to spots, which, in his opinion and in that of many others, appear to indicate that spots are cavities in a luminous photosphere which surrounds the sun.

The accuracy of this conclusion has recently been questioned; but whatever may be said regarding the theory, there can be no doubt regarding the importance of the fact which was first revealed by Wilson.

6. *Their periodicity.*—The next step is due to Hofrath Schwabe, of Dessau, who has shown, as the result of nearly forty years' laborious observations, that the number of spots which break out on the sun's surface is not the same from year to year, but has a maximum about every ten years—a remark which led General Sabine to observe that the various epochs of maximum spot-frequency were also those of maximum magnetic disturbance in our own globe.

7. *Their proper motion, &c.*—Carrington is the next observer who has greatly extended our knowledge of this subject. In a large and most remarkable work recently published, and containing the result of many years' observation, he has shown that sun-spots have a proper motion of their own, those near the solar equator moving faster than those near the poles; and he has also made interesting remarks on the distribution of spots in solar latitude for different years. In addition to these new

facts, he has furnished us with very accurate data regarding the sun's rotation.

8. *Gradations in their luminosity.*—We ought also to mention the discovery by Dawes, that what is regarded as the umbra of a spot consists in many cases of two well-defined and separate parts,* the exterior part being less luminous than the interior; so that we have often connected with the same phenomenon not less than five degrees of luminosity: these are—(1.) The faculæ. (2.) The ordinary photosphere. (3.) The penumbra. (4.) The borders of the umbra. (5.) The very dark central nucleus.

Mr. Dawes's discoveries are mainly due to his employing, with an eye-piece of his own invention, the full aperture of the telescope; but it is necessary to recall the fact that Sir William Herschel, in earlier times, was fully aware of the importance of not contracting the aperture of the objective. Moreover, we must not forget that Sir W. Herschel contributed to solar physics a theory which still holds its ground.

9. *Red flames.*—But there is another phenomenon connected with our luminary, not less curious than solar spots. We allude to the red flames, or protuberances which are seen to surround the sun's disk on the occasion of a total eclipse. Airy and Arago were the first to conjecture that these belonged to the sun. In the total eclipse of 1851, the former of these observers, by combining his observations with those of O. Struve, showed it to be probable that these flames do not change *during the moon's motion.* Great credit is also due to this observer for organizing the Spanish expedition of 1860; and it was here that Mr. De la Rue, by means of the Kew heliograph, set the matter completely at rest. Mr. De la Rue, from the pictures which he obtained, was able to show that the flames only change apparently, not really, by the moon's motion over them, that is, by covering one portion and disclosing another, and do not otherwise undergo any alteration; so that when the clock of his instrument was adjusted to the sun's motion, that portion of the flames not covered by the moon stood still. He also showed that the angular motion of the red flames, with respect to the moon, corresponds to the theory of their fixation in the sun.

These results were verified by Secchi, who also obtained photographs of the same phenomenon, which were compared in Rome by Mr. De la Rue and Father Secchi with Mr. De la Rue's photographs. The forms of the red prominences were found identical in both, so that no change occurs in their form during an interval much longer than the duration of totality observations in a solar eclipse.

* In some cases, however, it is fair to assume that the appearance of lighter portions of the umbra may be caused by the floating across of portions of the brighter part of the sun's surface.

10. *Willow-leaves.*—We may be allowed to mention here that very lately Mr. James Nasmyth, during the course of his observations of the sun's surface, has come to the conclusion that, when the circumstances of observation are very favorable, the whole surface will be found to be composed of separate luminous bodies, of a great similarity of figure, interlacing one another; and he has given the name of *willow-leaves* to these appearances. The existence of these is still disputed; but some of our best observers in this country have seen them under very favorable atmospheric conditions, and they have been seen more frequently by Secchi and other Italian observers.

11. *Other observations of the sun's surface.*—Chacornac, the eminent French observer, has noticed a behavior of those portions of the sun's surface around a spot, which seems to imply the existence of a downward current. More recently Lockyer, in this country, has made a very important observation of a similar kind. A tongue of faculous matter projecting over a spot was observed to lose its brilliancy very rapidly, so as ultimately to seem less brilliant than any portion of the penumbra. At the same time it seemed to be "giving out," as it were, at its end, and a portion of the umbra between it and the penumbra appeared to be veiled with a stratus cloud evolved out of it.

We ought likewise to mention the excellent and numerous observations of Pastorff, preserved in the library of the Royal Astronomical Society, also those of Captain Shea, both of which the Council of that Society have placed at our disposal. Professor Wolf, of Zurich, has collected data for establishing the periodicity of sun-spots before the commencement of Schwabe's observations. Also, the Rev. J. Howlett, in this country, has produced a large series of drawings of the sun's surface on a large scale, and of exquisite delicacy of delineation, which will no doubt prove of much value; and, finally, this field of research is one that has been occupied by many observers in all parts of the world, so that we may hope with some confidence for a speedy increase of our knowledge in this very important branch of physical astronomy.

12. *Composition of solar atmosphere.*—Before concluding this very brief historical sketch, we ought to allude to the discovery of Kirchhoff and Bunsen, who, by means of the spectroscope, have proved that many familiar substances, such as sodium, iron, magnesium, &c., exist in the atmosphere of our luminary in the state of vapor.

§ III. *Materials at the author's disposal.*

13. We now proceed to describe what materials we have at our disposal for the purpose of these investigations.

In the first place, Mr. Carrington has very kindly put into our hands all his original drawings of sun-spots. These extend from November, 1853, to March, 1861; and in them the sun's disk is represented on the scale of one foot in diameter, while, for each spot, the apparent position on the disk, as well as the proportion in size to the whole surface, is accurately delineated. We hope, in our investigations (as far as spots are concerned), to make much use of these pictures by Carrington; they do not, however, afford us any information with regard to faculæ.

More recently we have received into our hands the magnificent collection of drawings of the sun made by Hofrath Schwabe, of Dessau, during the course of about forty years,—this distinguished observer having generously placed these in the possession of the Royal Astronomical Society, for the use in the meantime of the Kew Observatory.

Our materials are, moreover, derived from the pictures taken by the Kew heliograph. This instrument, with its various adjustments, has already been described by Mr. De la Rue in the Bakerian Lecture for 1862; and it is therefore unnecessary to give a further description of it here. A few pictures were taken by this instrument at the Kew Observatory in the years 1858 and 1859. In July, 1860, it was in Spain, doing service at the total eclipse. In 1861, a few pictures were taken at Kew; while, from February, 1862, to February, 1863, the instrument was in continuous operation at Mr. De la Rue's private observatory at Cranford; and from May, 1863 until the present date, it has been in continuous operation at Kew, under Mr. De la Rue's superintendence. It is right to mention that for the perfection of these pictures much credit is due to the late Mr. Welsh and to Mr. Beckley, under whose immediate supervision the pictures at Kew have been taken by a qualified assistant, Miss Beckley.

§ IV. *Method of reduction.*

14. These are the materials at our disposal; and it may here be desirable to state in a few words the principle by which we shall be guided in our reduction of these materials. In the progress of this branch of knowledge, observers have been led to recognize certain laws, which represent the average behavior of sun-spots; but to each of these laws there are individual exceptions. In this state of things it is probable that our knowledge of the subject will ultimately be advanced, not only by a study of those groups which behave in a normal manner, but also by a study of those which are exceptions in their behavior to the general rule; and on this account it has been thought desirable to publish the results in such a way that any one may be able as far as possible to study the appearance and behavior, in fact, the whole history of any one group. Setting aside, in the meantime, Schwabe's drawings for future consideration, we propose

to adopt the following plan of publication for Carrington's pictures and for those of the Kew heliograph. In discussing Carrington's observations, we shall of course adhere to the numbering of his different groups, which he has given; and as he has also exhibited a pictorial history of each of these groups in his published volume, in which the spots are represented, though on a smaller scale than in his original drawings, all that is necessary on our part is to accompany any remark we may make regarding one of Carrington's groups with the number of that group as given by him.

Next with regard to the Kew pictures. Beginning with the first picture in 1858, it is our intention to number each group of spots in the same manner as Carrington, calling the first No. 1, and so on upwards to the present date. It is also our intention ultimately to publish carefully copied representations of each of the Kew groups; but these are not yet ready. We think it well, however, to give at once the numbers of the groups, coupled with the dates at which each group was first seen, and also to make use of these numbers in our present paper in anticipation of the forthcoming pictorial representations, which, when they appear, will enable our readers to judge for themselves of the truth of our remarks.

[The table and some comparisons of the Kew observations with those of Schwabe are omitted.]

§ V. *Two classes of investigations.*

18. Our investigations may be divided into two classes:

(1.) Those in which remarks are made regarding the behavior and appearance of spots and faculæ, and generalizations deduced therefrom, which do not involve accurate measurements.

(2.) There are, however, certain results in order to obtain which it is necessary to make use of accurate measurements of the position of spots: such are those from which Carrington has deduced the proper motion of spots on the sun's surface. Probably for this class of observations no better method can be adopted than that so ably pursued by him; but since we have materials at our disposal embracing accurate photographic delineations, we are perhaps called upon to attempt corrections which he has not applied.

19. *Correction for solar atmosphere.*—The most important of these is the correction due to the refraction of the solar atmosphere, which Carrington has indicated, but without applying it, in his large volume. There are evident proofs of the existence of such an atmosphere; for

(1.) In the Kew photographs the central portion of the disk uniformly indicates a greater luminosity than the borders, as if the rays at the borders had to pass through a large extent of atmosphere. It is worthy of remark that the temperature of this atmosphere must be lower than that of the photosphere; otherwise the absorption which it occasions would be counterbalanced by its radiation.

(2.) The beautiful discovery of Kirchhoff leads to the same conclusion, since, in order to account for the dark lines of the solar spectrum, it is necessary to suppose the existence of a solar atmosphere of a lower temperature than the source of light.

(3.) The red flames which are visible during a total eclipse, and which have been proved to belong to the sun (Art. 9), indicate the existence of a solar atmosphere extending in some instances as far as 72,000 miles above the photosphere. This is confirmed by the nature of the light which these flames emit. Mr. De la Rue has found that this light is very rich in actinic rays, so much so that he was able to photograph at least one protuberance which was not visible to the eye. Now it is precisely this description of light which characterizes the electric discharge in which gaseous matter appears in a highly heated state.

20. Let us now endeavor to show the nature of those corrections which are rendered necessary by solar refraction.

(1.) A solar atmosphere will make the sun's photosphere to appear larger than it really is; but the angular distance between two points, each near the center of the visible disk, will not be appreciably altered. This will introduce a slight error into the calculated position of any point, since in such a calculation we make use of the sun's apparent angular diameter, which is greater than his true diameter.

(2.) Apart from this, an error will be introduced into the calculation of the solar latitude and longitude of a point, this error depending upon its position in the visible disk, and being greater for those points which are at a distance from the center.

§ VI. *Questions to be answered in the present paper.*

21. In the present paper we shall attempt to answer the following questions:—

(I.) Is the umbra of a spot nearer the sun's center than its penumbra? or, in other words, is it at a lower level?

(II.) Is the photosphere of our luminary to be viewed as composed of heavy solid, or heavy liquid matter? or is it rather of the nature of a cloud? A short explanation will render evident the meaning of this question. There are two types, either of which we may conceive as representing the solar photosphere: we may, in the first place, suppose it to be a solid or liquid plane more or less uneven, with a heavy atmosphere above it. This atmosphere may be composed either of quite different materials from those of the liquid plane, or it may contain some of the materials of the plane in a state of vapor. Our own ocean is an example of this type, the air above it being composed chiefly of materials different from those of the ocean, but containing also aqueous vapor. On the other hand, we may imagine the sun's photosphere to resemble a cloud, the characteristic of which is solid or liquid particles of a greater or less size existing in a gaseous atmosphere, composed to a greater or less extent of the materials of the cloud. These points must be determined by observation alone. We must ask if the appearances presented by the sun's photosphere lead to the conclusion that it is an uneven plane of heavy liquid or solid matter, or do they induce us to imagine that it is rather of the nature of a cloud?

(III.) Is a spot, including both umbra and penumbra, a phenomenon which takes place beneath the level of the sun's photosphere or above it?

22. In the first place, therefore, and to answer the first question, let us see what will happen if the umbra of a spot be nearer the sun's center than the penumbra?

If the umbra be lower than the penumbra, when a spot passes over the sun's disk, the umbra will always appear to encroach upon that side of the penumbra which is directed toward the visual center of the sun's disk; and this effect will be lessened through the refraction caused by a solar atmosphere, but we cannot conceive that it will be wholly obliterated. If therefore the umbra is appreciably at a lower level than the penumbra, we are entitled to look for an apparent encroachment of the former upon the latter on that side which is nearest the visual center of the disk. This in fact was the phenomenon which Wilson observed, and which led him to the belief that the umbra was nearer the sun's center than the penumbra.

23. In the following six sub-tables the effect of foreshortening is estimated in the direction from left to right, this being the direction in which spots advance across the visible disk by rotation; and for this purpose the whole surface of the sun has been divided into six portions, comprising 30° each.

[These sub-tables are omitted, the general results from them being given in the following summaries.]

Result of TABLE II_a. *Showing the effect of foreshortening in the direction left and right of the central line.*

a. Giving the mean ratios between the two sides of the penumbra.

Left of central line.					
Within 30° from left limb.		Between 30° and 60° from left limb.		Within 30° from central line.	
No. of spots observed.	The penumbra on the *right* side of a spot being equal to unity, that on the *left* is equal to	No. of spots observed.	The penumbra on the *right* side of a spot being equal to unity, that on the *left* is equal to	No. of spots observed.	The penumbra on the *right* side of a spot being equal to unity, that on the *left* is equal to
130	1·8	119	1·4	88	1·2

Result of TABLE IIa.—continued.

Right of central line.					
Within 30° from central line.		Between 30° and 60° from right limb.		Within 30° from right limb.	
No. of spots observed.	The penumbra on the *left* side of a spot being equal to unity, that on the *right* is equal to	No. of spots observed.	The penumbra on the *left* side of a spot being equal to unity, that on the *right* is equal to	No. of spots observed.	The penumbra on the *left* side of a spot being equal to unity, that on the *right* is equal to
91	1·2	77	1·3	100	1·6

b. Giving the percentage of cases, out of 530 observations in all, which are in conformity with the assumption, that the umbra is nearer to the center of the sun than the penumbra, and of cases which are against it.

Left of central line.											
Within 30° from left limb.				Between 30° and 60° from left limb.				Within 30° from central line.			
For.		Against.		For.		Against.		For.		Against.	
No.	Per cent.	No.	Per cent.	No.	Per cent	No.	Per cent.	No.	Per cent.	No.	Per cent.
119	92·3	10	7·7	99	90·0	11	10·0	55	86·1	9	13·9
Right of central line.											
Within 30° from central line.				Between 30° and 60° from right limb.				Within 30° from right limb.			
For.		Against.		For.		Against.		For.		Against.	
No.	Per cent	No.	Per cent	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Percent.
46	74·2	16	25·8	55	79·7	14	20·3	82	85·4	14	14·6

The whole number of cases observed is 605; excluding herefrom 75, where the penumbra is equal on both sides, there remain 530, of which 456, or 86·04 per cent are *for*, and 74, or 13·96 per cent are *against* the assumption.

Result of TABLE IIb.

Showing the effect of foreshortening in the direction above and below the Equator.

Above the equator.					Below the equator.				
The lower part of the penumbra of each spot being equal to unity, the upper part is equal to	For assumption.		Against assumption.		The upper part of the penumbra of each spot being equal to unity, the lower part is equal to	For assumption.		Against assumption.	
	No. of cases.	Per cent.	No. of cases.	Per cent.		No. of cases.	Per cent.	No. of cases.	Per cent.
1·54	42	87·5	6	12·5	1·33	30	73·2	11	26·8

The whole number of cases considered is 89, of which 72, or 80·9 per cent, are for, and 17, or 19·1 per cent, against the assumption, that the umbra is nearer to the center of the sun than the penumbra.

In table IIb, since the relative disposition of umbra and penumbra is estimated in directions parallel to circles of solar longitude, only spots having a higher solar latitude have been considered.

It will be seen that the results of tables IIa and IIb are decidedly in favor of Wilson's hypothesis.

24. Let us now endeavor to answer the second question—"Is the photosphere of our luminary to be viewed as composed of heavy liquid or solid matter, or is it of the nature of a cloud?" One characteristic of the sun's surface is the appearance (especially in connexion with spots) of faculæ, or patches of a brightness greater than that of the photosphere immediately around them, this difference in brightness being much more conspicuous near the limb than near the center. One explanation of these phenomena would be, that the luminous matter of the sun has been thrown up to a great elevation in order to form faculæ. This would account for the greater comparative luminosity of faculæ near the border. For we have already mentioned (Art. 19) that the absorbing effect of the solar atmosphere is very perceptible near the border, where the light reaching us has to travel through a greater thickness of atmosphere; and hence, if the luminous matter be thrown up to a great elevation, it will, near the border, escape a great portion of this atmosphere, and will therefore appear relatively much brighter than the surface around it. On the other hand, very little will be gained when the matter is thrown up near the visual center, where we may imagine the atmospheric absorption to be comparatively small. The idea that faculæ are portions of the photosphere raised above the general surface, appears to be confirmed by stereoscopic pictures of spots obtained by Mr. De la Rue, where the faculæ appear as elevated ridges surrounding the spots. Accepting this conclusion, we next remark that faculæ often retain the same appearance for several days together, as if their matter were capable of remaining suspended for some time.

Now if we suppose that such faculæ represent the ordinary luminous matter of the sun, the facts above recorded would appear to throw much light upon the nature of the solar surface, since we cannot imagine faculæ to be the most elevated positions of a liquid ocean, which has been pushed high up into the solar atmosphere, or to be portions of matter projected from such an ocean. Such an hypothesis would appear to be inconsistent with the fact that the faculæ retain their appearance unchanged for days together. At any rate we venture to think that such an hypothesis would not readily be received, and that, according to the rules which ought to guide our judgment in a case like the present, it ought to be set aside if we can find a more plausible explanation. Such an explanation would appear to consist in supposing that faculæ, and, indeed, the whole photosphere of our luminary, are more of the nature of a cloud. A cloud has been defined by Sir J. Herschel to consist of solid or liquid matter, formed from the condensation of a vapor not *floating* in æquilibrio, but sinking in a gaseous medium of less specific gravity than itself—sinking, however, with extreme slowness, owing to the minuteness of its particles, and consequent (relatively) enormous resistance of the air. This illustrious savant is disposed to think that the consideration of Cagniard de Latour's experiments on the vaporization of liquids under high pressure would incline us to regard the solar faculæ as large aggregations of *bonâ fide solid matter* of a high degree of fixity, and in masses like gigantic soot-flakes of any form and magnitude, which, when formed, settle down to such a level as corresponds to their density when they rest *in æquilibrio* in a gaseous fluid of their own specific gravity. We do not wish either to accept or to reject this hypothesis, but would frame the following statement, which also includes this view of the case: *Solar faculæ consist of solid or liquid bodies of a greater or less magnitude, either slowly sinking or suspended in æquilibrio in a gaseous medium.*

25. In connection with this part of our subject it will be well to investigate the relative position of spots and their accompanying faculæ; and this is done in the following table for all the Kew pictures available for this purpose.

[Table III is omitted.]

Result of Table III.

Facula entirely or mostly *left* of spot.		Facula entirely or mostly *right* of spot.		Facula *all round* or between the spots.	
No. of cases.	Per cent of the whole.	No. of cases.	Per cent of the whole.	No. of cases.	Per cent of the whole.
584	51·4	45	4·0	508	44·6

26. It appears from the result of table III, that out of 1137 cases 584 have their faculæ either entirely or mostly on the left, while 508 have it nearly equally on both sides, and only 45 mostly on the right. Hence we see that faculæ are on an average to the left of their accompanying spots. The most obvious explanation of this would be that the faculæ of a spot have been uplifted from the very area occupied by that spot, and have fallen behind to the left from being thrown up into a region of greater velocity of rotation. All this is quite in accordance with our hypothesis regarding the nature of faculæ. We would likewise here remind our readers that we know from the observations of Kirchhoff that the sun's atmosphere contains vapors of substances, such as iron, which are condensed into the liquid or solid state at a comparatively high temperature. Now is it not natural to suppose that in the sun's photosphere we do really see such vapors so condensed, and very unnatural to imagine that such vapors are seldom or never condensed, and that what we really see is an incandescent plain underlying these vapors?

27. Let us now attempt to answer the third question: Is a

spot including both umbra and penumbra a phenomenon which takes place beneath the level of the sun's photosphere or above it? To decide this question, let us state that there are a good many instances in which a spot breaks up in the following manner. A bridge of luminous matter of the same apparent luminosity as the surrounding photosphere, and unaccompanied by any penumbra, appears to cross over the umbra or center of a spot. There is good reason to think that this bridge is really above the spot; for were the umbra an opaque cloud, and the penumbra a semiopaque cloud, both being above the sun's photosphere, it is unlikely that the spot would break up in such a manner that the terrestrial observer should not perceive some penumbra accompanying the luminosity. Again, detached portions of luminous matter appear to move across a spot without producing any permanent alteration. We are on these accounts disposed to think that a spot including both umbra and penumbra is a phenomenon which takes place beneath the level of the brighter part of the sun's photosphere.

28. Let us here recapitulate the answers we have given to our three questions.

(1.) The umbra of a spot is nearer the sun's center than its penumbra, or, in other words, it is at a lower level.

(2.) Solar faculæ, and probably also the whole photosphere, consist of solid or liquid bodies of greater or less magnitude, either slowly sinking or suspended *in æquilibrio* in a gaseous medium.

(3.) A spot including both umbra and penumbra is a phenomenon which takes place beneath the level of the sun's photosphere.

§ VII. *Concluding remarks.*

29. It would thus appear that the central part of a spot is nearer the sun's center than the penumbra, and that both the umbra and penumbra are probably beneath the general level of the surrounding photosphere. Now the umbra or lowest part of a spot is much less luminous than the general photosphere. But what does this probably imply, according to the laws with which we are acquainted? It implies that in a spot there is probably some matter of a lower temperature than the photosphere. For is it not now recognized as a law, that if a substance, or combination of substances, of indefinite thickness and surface of small reflecting power have all its particles at a certain fixed temperature, this substance will give out nearly all the rays of heat belonging to that temperature? Now the sun, even when we look into a spot, is certainly a substance of indefinite thickness; and since a spot appears much less luminous than the ordinary surface, ought we not to conclude either that we there view matter of a lower temperature than the ordinary

surface, or that the matter which appears within a spot has a very high reflecting power compared to the ordinary matter of the photosphere? This last supposition is an unlikely one, and the probability is that in a spot we view matter of a lower temperature than the photosphere.

30. Presuming this to be the case, it appears to imply one of three things.

(1.) Either the general body of the sun at the level of the bottom of a spot is of a lower temperature than the photosphere;

(2.) Or the lower temperature is produced by some chemical or molecular process which takes place when a spot is formed;

(3.) Or it is produced by matter coming from a colder region.

The first of these suppositions will not be generally received unless we are fairly driven to accept it.

The second hypothesis has already been started to account for the lower temperature of a spot; but we think that, according to the laws by which we should be guided in receiving or rejecting an explanation in a case of this nature, this idea ought to be rejected.

No doubt, if we knew of a case of the production of low temperature, and had at the same time an independent proof of some chemical or molecular process, such as evaporation, it would be quite allowable for us to associate the chemical or molecular process with the production of cold as at any rate the most likely hypothesis; but we do not advance in our explanation of the low temperature by attributing it to an imaginary process of the existence of which we have no proof, and which is equally mysterious with the phenomenon for which it is supposed to account. Rather let us see if this reduction of temperature can be explained by any other phenomenon of the existence of which we have independent evidence. This leads us to consider the third hypothesis, which supposes that the reduction is produced by matter coming from a colder region. Now, in the first place, we have such a region in the atmosphere above the photosphere, which (Art. 19) we have shown to be of a lower temperature than the photosphere itself. Again, the observations of Chacornac and Lockyer on the behavior of the matter surrounding a spot appear to suggest the existence of a downward current, which is therefore a current from the colder regions above.* On the other hand, the proper motion of spots observed by Carrington is in favor of this hypothesis, since a current coming from a region of greater to a region of less absolute velocity of rotation would be carried on forward, and most so nearest the equator; and this is precisely the motion of

* Does not the observation by Lockyer of the facula "giving out" appear also to indicate that the lower regions of a spot are in reality hotter than the surface, leaving the inferior luminosity to be accounted for by the downrush of a cold atmosphere from above?

spots observed by Carrington. Again, we have seen (Art. 26) that the faculæ fall behind; so that we may imagine two currents to be engaged in the formation of a spot,—the one an ascending current carrying the hot matter behind, the other a descending current carrying the cold matter forward. One advantage of this explanation is that all the gradations of darkness, from the faculæ to the central umbra, are thus supposed to be due to the same cause—namely, the presence to a greater or less extent of a comparatively cold absorbing atmosphere.

31. It is but just to ourselves and to M. Faye, to mention that both have imagined the phenomenon of sun-spots to be due to ascending and descending currents. M. Faye's hypothesis was published a little before ours; but we shall readily be believed when we state that an idea of this kind presided over the construction of table III, in which we have proved that the faculæ are, on an average, to the left of their accompanying spots. It was not, however, until a short time before the publication of the abstract of this paper by the Royal Society, that, by discussing the subject together, we had matured our views so far as to connect the descending current, not only with Carrington's proper motion, but also with the presumed lower temperature of a spot. In this last respect our hypothesis differs entirely from that of M. Faye, who does not imagine that the inferior luminosity of a spot indicates the presence of matter at a lower temperature than the photosphere.

32. In conclusion, we would venture to suggest that if the photosphere of the sun be the plane of condensation of gaseous matter, this plane may be found to be subject to periodical elevations and depressions in the solar atmosphere. It may be that at the epoch of minimum spot-frequency this plane is uplifted very high in the solar atmosphere, so that there is comparatively little cold absorbing atmosphere above it, and therefore great difficulty in forming a spot. If this were the case we might expect a *less* atmospheric effect or gradation of luminosity from the center to the circumference at the epoch of minimum than that of maximum spot-frequency. Perhaps on some future occasion we may be able to produce evidence of this, and even of the unequal atmospheric effect of the two limbs of the sun at the same time; but in the meantime we shall content ourselves with suggesting this to the observers of our luminary as a simple inquiry that may possibly prove productive.

33. We are especially desirous of bringing under the early notice of the scientific world the accumulation of observations we are making, in order that others may put forth their own conjectures in elucidation of solar physics. In venturing the opinions we have stated, we do so with some reserve, and with the conviction that possibly they may hereafter require modifications.

ART. XX.—*On the Subterranean Sources of the Waters of the Great Lakes;* by GEORGE A. SHUFELDT.

IF we take down the map of North America, and follow around the borders of our chain of Great Lakes, we find that the tributaries for supplying the mighty torrent of water which pours in immense volumes over the Falls at Niagara, and thence through the St. Lawrence to the sea, are few in number and insignificant in effect. Lake Superior, the largest body of fresh water in the world, has an area of 32,000 square miles and a mean depth of one thousand feet. There are a few small streams, none worthy of the name of rivers, which find their outlet in this lake—the St. Louis and Ontonagon are the largest of these; but there is probably not water enough discharged into the lake to make up for the atmospheric absorption and evaporation. The entire State of Wisconsin, even from the very borders of Lake Superior, is drained by rivers, which flow into, and are tributaries of the Mississippi. These are, in chief, the Wisconsin River, the Black, Chippewa, Fox and Rock Rivers, the waters of which all flow southward, to the Gulf of Mexico. The whole State of Minnesota with its thousands of lakes and streams may be called the mother of the Father of Waters—for all of her waters which do not gather into the great Red River of the North are discharged into the Mississippi, and do not contribute to keep up the supply of Lake Superior; and on the northern shore of the lake, in the British possessions, there are no rivers which flow in this direction. Here the current is the other way and the streame find their way to Hudson's Bay and other more northerly seas. The outlet of Lake Superior is the River St. Mary's—a stream of considerable magnitude—which discharges the surplus waters of the Lake in the direction of Lake Huron. Lake Superior is 627 feet above the sea level.

If we examine the surroundings of Lake Michigan we shall find the evidences of this theory still more striking. This lake has an area of 22,400 square miles, and a mean depth of 900 feet. It is above the sea level 578 feet or forty-nine feet below Lake Superior. It is also an immense body of water, whose sole apparent sources of supply are found in a few small streams which flow into it from the State of Michigan.

The largest of these are the Grand and Manistee rivers; from Wisconsin there is only one small stream, the Milwaukee river at Milwaukee. From Illinois there is only the Chicago river, a sluggish stream without a current; and indeed there is, at only ten miles distance from the banks of the lake south and west, the water-shed called the Summit, which separates the waters which flow into the St. Lawrence from those which flow into the Gulf of Mexico, and from the southern slope of this Summit, flowing southward, is the Aux Plaines river, a tributary of the Illinois. So that Lake Michigan gets no water from Illinois, but a trifle from Wisconsin, and very little from Michigan. And yet the straits of Mackinaw carry off a large quantity of water from this lake, and Lake Michigan furnishes its due proportion of the great current which passes over the Falls of Niagara. Now the question arises, whence comes this great volume and mass of running water?

Geologists are tolerably familiar with the subject of underground streams and water courses. They know that the crust of the earth is full of these streams, and although from the fact that they are generally concealed from sight, there must be considerable speculation concerning them, yet there are cases, such as in the Mammoth Cave, Kentucky, the Adelsberg mountains in Switzerland, and numerous artesian wells scattered all over the world, the lost rivers on our western prairies, &c., from which a positive knowledge may be derived concerning the nature and history of these rock-bound rivers.

The artesian wells in London furnish now about 12,000,000 of gallons of water daily. This is the seepage of the valley in which the great city is located. The water from the whole country surrounding finds its way along the tilts and inclinations of the broken strata, below the chalk beds, in among the sands and gravel, whence it is taken by boring into the ground to the depth of about 600 feet. It does not appear probable that there are any considerable streams in this vicinity, for the entire of the underlying gravel beds seem, as it were, saturated with water, which is reached at any point of perforation.

These remarks apply to the wells of Grenelle and of Passy, in the basin of Paris, with the exception in the case of the latter that they struck an amazing stream of water eighteen hundred feet below the surface which discharges nearly six millions of gallons per day, rushing to the surface with great power and velocity. This is strong evidence, certainly, of a great underground stream at this point. The great wells of Kissingen in Bavaria, at Munden in Hanover, at Louisville in Kentucky, Charleston, S. C., and hundreds of others, many of which are two thousand feet deep, discharging great volumes of water—all tend to demonstrate the fact that the crust of the earth is penetrated in all directions and at all depths with these streams and water courses.

Adopting this as a conceded fact, let us once more turn to the map of North America and note particularly the point where the thirty-second degree of west longitude crosses the forty-fourth parallel of north latitude. Within a radius of five hundred miles, of which this is the center, will be found the great water producing region of the West. In this elevated and comparatively uneven surface of the country, nearly all of the great rivers of the West have their sources and fountain-heads. First the Missouri, with its innumerable branches and tributaries, among which are the Yellowstone and the North Fork of the Platte, the Arkansas, the Red River, the Rio Grande, all flowing from the eastern and southern slopes of the Rocky Mountains and finding their way through thousands of miles of country to the Gulf of Mexico. On the western slope is the Rio Colorado, which empties into the Gulf of California, and which is formed by the union of the Grand and Green rivers, the sources of which are also within the territory above mentioned. The same statement is true of the Columbia river flowing through the State of Oregon into the Pacific, and of the other great streams and rivers which flow northward and westward into the Pacific and the Northern oceans. Thus the knowledge we already possess of the surface streams of this great extent of territory all tends to demonstrate the truth of the theory in relation to the water producing region, its location, extent and capacity, and also that on the surface there is but comparatively a small amount of this water which finds its way into our Great Lakes.

It is a well-known fact to travellers on our western plains, that large streams, often rivers in size, suddenly disappear, falling away into great fissures and chasms, sometimes reappearing, but more frequently lost forever; where and in what manner does this water find an outlet? What becomes of the mass of water which falls upon the earth and is absorbed by the soil and the rocks below the beds of rivers and streams? The crust of the earth abounds in water to unknown depths, and from the nature of the element, it must create for itself ways and courses of travel, as plainly beneath as upon the surface. And now, if the Great Lakes are not supplied by means which are upon the the surface and apparent to the eye, it follows as a natural consequence that their sources of supply must be underneath the ground. The outlet of these lakes discharges an enormous quantity of water, the visible inlets are mere trifles in comparison—and thus there seems to be no other conclusion on the subject but that the water supply comes from below the surface of the ground. This water probably finds inlets at different points on the bottoms of the lakes, and maintains the supply with as much certainty and regularity as if the streams were running on the surface of the ground. This theory is further, and I think more particularly demonstrated by the great mass and volume of water which is now being discharged by the Chicago artesian wells. These are over seven hundred feet deep—nearly penetrating the earth to a line parallel with the bottom of Lake Michigan—are located in no great valley or depression, such as the basins of Paris or London. The water has a head of nearly one hundred and twenty-five feet above the level of the lake; is much colder than the mean temperature of the location of the wells, being now 57 degrees Fahrenheit; these facts tending to show that it must come from a more elevated region of country, and also from a higher latitude. There are two other facts corroborative of this point. When the water was first struck the temperature was 59 degrees Fahrenheit; it has fallen now two degrees, or to 57. Then, the first analysis of the water exhibited 72 grains to the wine gallon of mineral matter held in solution; the second analysis, made only one year afterwards, showed only 56 grains of the same matter. These facts, taken in connection with the great head of the water, seem to establish exclusively that it comes from some remote region of the north or northwest.

It is also probable that the great under-ground stream, penetrated by these wells, once discharged its waters into the bottom of Lake Michigan; but this outlet was closed by the upheaval of the earth's crust, which is visible at the point of the location of these wells, and at the present time there is no outlet except the artificial one made by the drill. This supposition is proved by the head and the great force and power of the water, for if it had a lower outlet, anything like the size of the stream, it would not show a head much, if any, above the surface of the ground, and it is also sustained by the facts mentioned above—the decrease of the temperature of the water from fifty-nine degrees to fifty-seven degrees, and the diminution in quantity of mineral matter held in solution—the latter fact seeming clearly to prove that prior to the time when the drills penetrated the stream, the water had dissolved and absorbed a large quantity of the soluble matter of the rocks with which it came in contact in its state of rest. As soon as an opening or outlet was made, and a quantity of water was discharged, this mineral matter decreased in proportion, and the probability now is that the water will become softer and purer as the amount discharged becomes greater, and that eventually, and probably at no distant day, the water will come from its fountain-head, simply filtered and purified by its passage through the sandstone and gravel beds.

That the outlet of this stream into Lake Michigan was closed by the upheaval of the earth's crust, is a probable conclusion, which can be verified by an inspection of the grounds on which these wells are located. The surface here is only some seven or eight feet above the level of the surrounding prairie; but geologically or stratigraphically, it is nearly one hundred and fifty feet above the common level of Chicago, that is, at about one mile distant eastward and into the city. We bore into the soil nearly one hundred and fifty feet before reaching the same rock, which is here exposed upon the surface, and at the well bored at the Chicago Distillery Company's premises on the North Branch, they penetrated the Joliet marble at a depth, I believe, of one hundred and eighty-six feet, which, at the other point is only twenty-nine feet from the surface; this and various other facts show the nature and extent of this convulsion, and that it was no difficult feat of nature to dam up this comparatively trifling underground stream, and leave its waters pent up in the rocks and caverns for the future use and benefit of man.

I do not know that these speculations will be of sufficient interest to be made public, but they may have the effect of directing some abler pen to the solution of the problem as to the sources whence the Great Lakes derive their supply of water.

Chicago, November, 1866.

ART. XXI.—*Experiments on the Influence of various Organic and Inorganic Bodies upon Germination and Vegetation;* by M. CAREY LEA, Philadelphia.

THE following experiments were made to determine how far the germination of seeds, and subsequent vegetation of the plants, would be controlled or influenced by the action of acid, alkaline and neutral bodies in solution in the water with which the seeds were moistened. It will be seen that the action of the strongest of our acids is insufficient to prevent germination when sufficiently dilute. And that the same may be said with respect to some of our most powerful oxydizing and reducing agents.

The experiments were made by tying pieces of very thin muslin over glass vessels filled so full that the muslin dipped into the liquid. Grains of wheat were placed on this muslin, an equal number (20 perfect grains) on each. The capacity of the glasses was in every case 12½ ounces, and the water was replaced as fast as it evaporated. There was added respectively to each as follows:

No. 1. 1 drop sulphuric acid.
2. 2 drops nitric acid.
3. 3 " hydrochloric acid.
4. 5 grs. bicarbonate of potash.
5. 5 " dry carbonate of soda.
6. 10 drops of rather weak liquid ammonia.
7. 5 grs. bromid of ammonium.
8. A pair of zinc and copper plates connected above the surface by a wire, and plunged in plain water.

No. 9. Same, acidulated 3 drops hydrochloric acid.
10. Plain water for comparison.
11. 5 grains sulphite of soda.
12. " " chlorate of potassa.

The results were as follows. At the end of

48 *hours*—Germination evident in all. Most advanced, 4, 10, 11; medium, 2; least, 1, 3, 5, 6, 7, 8, 9, 12.
3 *days*—Most advanced, 4, 10, 11; medium, 5, 7, 8, 9, 12; least, 1, 2, 3, 6.
4 *days*—Most advanced, 4, 10, 11; medium, 5, 7, 12; less, 2, 6, 8, 9; least, 1, 3.
5 *days*—Most advanced, 4, 10, 11; medium, 5, 6, 7, 8, 12; less, 1, 9; least, 2, 3.
6 *days*—Most advanced, 4, 10, 11; a little less, 5, 6, 7, 8; much behind, 1, 2, 3, 9.

Some curious deductions are to be drawn from these results. *Nitric acid* did not at first very strongly affect the growth, less than seven other substances, then eventually its influence became much more felt.

Bicarbonate of potash was the least injurious of all the substances tried, next came *sulphite of soda,* and next *carbonate of soda.*

No saline or other substance included acted in any way as a stimulant, the product of the plain water as an average was fully up to any of the rest, though as will hereafter be seen, the largest plant was formed in another vessel.

In the observations just made I have endeavored to show the daily course of action; in the following table I have summed up the total effects at the end of seven days, when experiment was discontinued.

Total results at the end of seven days.

	Proportion of substance in 100 of water.	No. of seeds that germinated out of 20.	Average height of young plants.	Total amount of vegetation.	Proportional amount of vegetation, taking that in plain water as 100.
1.	SO_3, 0·016,	18	·3	5·4	16·8
2.	NO_5, 0·033,	14	·2	2·8	8·7
3.	HCl, 0·050,	3	·3	·9	2·8
4.	$KO\ 2CO_2$, 0·083,	16	2·	32·	100·
5.	$NaO\ CO_2$, 0·083,	14	1·5	21·	65·6
6.	Ammonia,	13	1·5	19·5	60·9
7.	NH_4Br, 0·083,	11	1·4	15·4	48·1
8.	Zn and Cu plates,	16	1·3	20·8	65·0
9.	Same with 3 drops HCl.	8	·4	3·2	10·
10.	Plain water,	16	2·	32·	100·
11.	$NaO\ SO_2$, 0·083,	12	2·	24·	75·
12.	$KO\ ClO_5$, 0·083.	13	·5	6·5	20·3

This table shows:

That an oxydizing agent, chlorate of potash (12), is not more injurious than a reducing one, sulphite of soda (11), to germination, but after germination it kept down vegetation to one-fourth.

That free acids are much more injurious than alkalies, especially hydrochloric acid (3).

That the presence of an electric pair did not check germination, but reduced vegetation by one-third.

That the presence of free sulphuric acid had no injurious influence upon germination, actually a larger proportion of seeds started than with pure water, whereas with hydrochloric acid only three seeds germinated out of twenty. But sulphuric acid reduced vegetation to one-sixth, hydrochloric to 2·8 per cent.

With bicarbonate of potash, precisely the same number germinated as with plain water, and attained precisely the same height.

In (9) the HCl acted less energetically than in (3), doubtless because it was rapidly taken up by the zinc.

Plants in the sulphite of soda attained the same height as those in plain water. But the number germinating was one-fourth less.

A second set of trials was made, in which a number of other substances were experimented upon, and at the same time sulphuric acid was added in much smaller quantity, and sulphite of soda in much larger. Capacity of the vessel as before, 12½ oz.

No. 1, Plain water.
2, Cane sugar, 30 grains.
3, Gum, 30 grains.
4, Glycerine, 1 fluid drachm.
5, Sulphuric acid, ¼ drop.
No. 6, Citric acid, 5 grains.
7, Sulphite of soda, 20 grains.
8, Permanganate of potash, 2 grains.
9, Nitrate of ammonia, 20 grs.

The object of this series was to include in the experiments certain organic substances such as the three first on the list, a vegetable acid, and some salts whose influence might be active and characteristic.

At the end of thirteen days, during which the weather was very cold (Dec. 10 to Dec. 23), the following was the condition of affairs.

Nos. 2 and 4 (cane sugar and glycerine) were as far advanced as the plain water (No. 1), but no further. These substances therefore had not stimulated either germination or early vegetation in the wheat seeds.

In 3 (gum solution) fewer seeds germinated than in either of the foregoing, but the most advanced plants were *fully one-half higher* than any in 1, 2, or 4.

Nos. 7 and 9 (sulphite of soda and nitrate of ammonia) were somewhat in advance of those in plain water, but not very much.

In 6 (citric acid) a large number germinated, and appeared healthy, but they did not obtain one-fourth the height of those in No. 1, and what was very remarkable, they *formed no roots at all.*

In 5 (sulphuric acid) the plants were more advanced than in the citric acid, and had healthy roots extending down into the liquid.

In 8 (permanganate of potash) the condition of affairs most resembled that in the citric acid. In both the seeds had germinated and produced healthy looking plants an inch in height. But *no roots whatever* had been formed in either case.

Some of the above sets of seeds were allowed to vegetate for a month, and developed curious results.

Those plants which grew in the vessels containing solutions of cane sugar, gum, and glycerine respectively, grew as fast and flourished as well as those in plain water, but it could scarcely be said that at the end of the month they presented any superiority.

But whilst the roots of the plants in plain water, in gum, and in glycerine, reached to the very bottom of the vessel, becoming four to five inches long, those in the cane sugar did not exceed an inch in length, just dropping below the surface of the water, which had become lowered by spontaneous evaporation, and this although the plants were as high as in the others just mentioned, viz., six to eight inches, and as numerous and healthy in every respect. This would seem to indicate that they received their nutriment in a more concentrated form, if it were not that these plants, though equally large and healthy as those in plain water, exhibited no superiority over them.

ART. XXII.—*Contributions from the Sheffield Laboratory of Yale College.*—XIII. *On Native Crystallized Terpin;* by S. W. JOHNSON.

IN October, 1866, the writer received from Wm. M. Gabb, Esq., of the Geological Survey of California, a small quantity of crystals found in "cavities near the core of a semi-decomposed pine stump that was buried three or four feet below the surface in Shasta Co., California." The crystals were discovered by Mr. Voy of San Francisco.

At the request of Mr. Gabb I have examined these crystals, which, in the sample received, were still partly adhering to a fragment of pine, where they were associated with another crystalline substance of a yellowish color and resinous aspect.

The crystals were colorless and transparent, the largest individual was three-eighths of an inch long, one-eighth of an inch wide and one-sixteenth of an inch thick. They were of brilliant luster and well terminated at the free ends. From their occurring in buried pine wood and from their general appearance, it was at once suspected they might be identical with crystallized terpin. Their faint resinous taste and odor, not to be distinguished from that of the artificial substance, confirmed this view.

To obtain full information regarding the crystallometrical characters of the substance, I applied to my friend, Mr. John M. Blake of New Haven, to make a comparison between the native crystals and those of artificial preparation from the chemical cabinet of the Sheffield Scientific School. Some of the highly interesting results of these investigations are communicated by Mr. Blake in the paper that follows, and leave no doubt of the identity of the two substances, although their crystals are not developed in the same manner, and exhibit other physical differences which, as he states, disappear when both are recrystallized from the same solvent.*

After Mr. Blake had finished his examinations, a combustion was made on nearly the whole available substance. The hydrogen determination was lost by the fracture of the CaCl tube, but the estimation of carbon fully confirmed the conclusions previously arrived at. The combustion was effected in a tube partly filled with oxyd of copper and in a stream of oxygen, the substance itself being placed in a tray of platinum. On application of heat it swelled and afterwards vaporized completely, without blackening and without leaving a weighable residue. On the cold parts of the tube silky crystals of anhydrous terpin condensed. This deportment is characteristic of terpin.

The amount of substance burned was but 0·0975 grm. The increase in weight of the potash bulbs and tube was 0·225 grm. This gives carbon 62·93 *per cent.* The calculated quantity is 63·16 *per cent.*

The substance is therefore hydrated terpin or crystallized turpentine camphor $C_{20}H_{20}O_4+2aq$. Perhaps we should say it is one of the terpins, since, according to Berthelot, the different oils of turpentine, on hydration, yield crystals of different degrees of solubility.

The formation of this substance in the buried tree presents no difficulties, since we know on the authority of Dumas, Deville and others, that oil of turpentine in contact with water, combines with the latter in absence of acids or other powerful agents of chemical change.

Prof. Brewer, who is familiar with the timber of California, is of the opinion that the wood to which the crystals were attached is that of a pitch pine, *Pinus ponderosa.*

This appears to be the first recorded instance of the occurrence of crystallized terpin, native.

November, 1866.

* Mr. Blake has measured and figured both the native and artificial crystals and has in reserve some other valuable observations which it is to be hoped he will shortly publish.—S. W. J.

ART. XXIII.—*On the crystallization of natural Hydrated Terpin from California;* by JOHN M. BLAKE.

SOME crystals, from a buried pitch-pine log, were handed me for examination by Prof. S. W. Johnson, of the Sheffield Scientific School.

A comparison of these crystals with terpin of artificial preparation leaves no doubt that the natural substance is hydrated turpentine camphor. The natural and artificial crystals agree closely in their angles, and have the same cleavage. The position and separation of the optical axes is alike in both, and experiment shows that the two substances are supercrystallizable.

Certain observations made at first, suggested that the two specimens might not be absolutely identical, but rather isomeric hydrates, such as were supposed by Berthelot to result from isomeric oils, derived from the same or different trees. Thus, hemihedrism constantly occurred on the natural crystals, which has not been observed on the artificial. The proportional development of the planes was strikingly different. The two specimens manifested opposite pyro-electric characters, in so far that the *free-growing* extremities of the natural crystals were antilogue poles, (developed negative electricity on heating,) while those of the artificial crystals, first examined, were the reverse, or analogue poles.

On further investigation, these points of difference disappeared. By recrystallizing from alcohol and other solvents, much variation was produced in the planes. The peculiar development of the natural crystals was not indeed reproduced on the artificial, but the attachment of the latter to the support by the analogue pole, as with the natural crystals, was obtained. On recrystallizing from alcohol, natural terpin lost its hemihedral character, and in case of crystals grown radiating from a support, presented the analogue pole to the solution, like the artificial substance when deposited from the same solvent. Crystals of each, when free-growing in alcoholic solution, had the same development of the planes, and with each there was the same perceptible difference in the proportions of the planes at the two ends of a crystal, by which the poles could be distinguished; but no corresponding difference could be detected in the angles of these terminal planes.

Art. XXIV.—*On the Objects and Method of Mineralogy;* by T. Sterry Hunt, F.R.S.

(Read before the American Academy of Sciences, Jan. 8, 1867).

Mineralogy, as popularly understood, holds an anomalous position among the natural sciences, and is by many regarded as having no claims to be regarded as a distinct science, but as constituting a branch of chemistry. This secondary place is disputed by some mineralogists, who have endeavored to base a natural-history classification upon such characters as the crystalline form, hardness, and specific gravity of minerals. In systems of this kind, however, like those of Mohs and his followers, only such species as occur ready formed in nature are comprehended, and the great number of artificial species, often closely related to native minerals, are excluded. It may moreover be said in objection to these naturalists, that, in its wider sense, the chemical history of bodies takes into consideration all those characters upon which the so-called natural systems of classification are based. In order to understand clearly the question before us, we must first consider what are the real objects, and what the provinces, respectively, of mineralogy, and of chemistry.

Of the three great divisions, or kingdoms of nature, the classification of the vegetable gives rise to systematic botany, that of the animal to zoology, and that of the mineral to mineralogy, which has for its subject the natural history of all the forms of unorganized matter. The relations of these to gravity, cohesion, light, electricity, and magnetism, belong to the domain of physics; while chemistry treats of their relations to each other, and of their transformations under the influences of heat, light, and electricity. Chemistry is thus to mineralogy what biology is to organography; and the abstract sciences, physics and chemistry, must precede, and form the basis of the concrete science, mineralogy. Many species are chiefly distinguished by their chemical activities, and hence chemical characters must be greatly depended upon in mineralogical classification.

Chemical change implies disorganization, and all so-called chemical species are inorganic, that is to say unorganized, and hence really belong to the mineral kingdom. In this extended sense, mineralogy takes in not only the few metals, oxyds, sulphids, silicates, and other salts, which are found in nature, but also all those which are the products of the chemist's skill. It embraces not only the few native resins and hydrocarbons, but all the bodies of the carbon series made known by the researches of modern chemistry.

The primary object of a natural classification, it must be remembered, is not like that of an artificial system, to serve the purpose of determining species, or the convenience of the student, but so to arrange bodies in genera, orders, and species as to satisfy most thoroughly natural affinities. Such a classification in mineralogy will be based upon a consideration of all the physical and chemical relations of bodies, and will enable us to see that the various properties of a species are not so many arbitrary signs, but the necessary results of its constitution. It will give for the mineral kingdom what the labors of great naturalists have already nearly attained for the vegetable and animal kingdoms.

Oken saw the necessity of thus enlarging the bounds of mineralogy, and in his Physiophilosophy, attempted a mineralogical classification; but it is based on fanciful and false analogies, with but little reference either to physical or chemical characters, and in the present state of our knowledge is valueless, except as an effort in the right direction, and an attempt to give to mineralogy a natural system. With similar views as to the scope of the science, and with far higher and juster conceptions of its method, Stallo, in his Philosophy of Nature, has touched the questions before us, and has attempted to show the significance of the relations of the metals to cohesion, gravity, light, and electricity, but has gone no farther.

In approaching this great problem of classification, we have to examine—first, the physical condition and relations of each species, considered with relation to gravity, cohesion, light, electricity, and magnetism; secondly, the chemical history of the species; in which are to be considered its nature, as elemental or compound, its chemical relations to other species, and these relations as modified by physical conditions and forces. The quantitative relation of one mineral (chemical) species to another, is its equivalent weight, and the chemical species, until it attains to individuality in the crystal, is essentially quantitative.

It is from all the above data, which would include the whole physical and chemical history of inorganic bodies, that a natural system of mineralogical classification is to be built up. Their application may be illustrated by a few points drawn from the history of certain natural families.

The variable relations to space of the empirical equivalents of non-gaseous species, or in other words, the varying equivalent volume, (obtained by dividing their empirical equivalent weights by the specific gravity,) shows that there exist in different species very unlike degrees of condensation. At the same time we are led to the conclusion that the molecular constitution of gems, spars, and ores, is such that those bodies must be represented by formulas not less complex, and with equivalent weights far more elevated than those usually assigned to the polycyanids, the alkaloids, and the proximate principles of plants. To similar conclusions, conduce also the researches on the specific heat of compounds.

There probably exists between the true equivalent weights of non-gaseous species, and their densities, a relation as simple as that between the equivalent weights of gaseous species and their specific gravities. The gas, or vapor of a volatile body constitutes a species distinct from the same body in its liquid or solid state; the chemical formula of the latter being some multiple of the first, and the liquid and solid species themselves, often constituting two distinct species, of different equivalent weights. In the case of analogous volatile compounds, as the hydrocarbons and their derivatives, the equivalent weights of the liquid or solid species approximate to a constant quantity, so that the densities of those species, in the case of homologous or related alcohols, acids, ethers and glycerids, are subject to no great variation. These non-gaseous species are generated by the chemical union, or identification, of a number of volumes or equivalents of the gaseous species, which varies inversely with the density of these species. It follows from this, that the equivalent weights of the liquid and solid alcohols and fats must be so high as to be a common measure of the vapor-equivalents of all the bodies belonging to these series. The empirical formula, $C_{114}H_{110}C_{12}$, which is the lowest one representing the tristearic glycerid, ordinary stearine, is probably far from representing the true equivalent weight of this fat in its liquid or solid state; and if it should hereafter be found that its density corresponds to six times the above formula, it would follow that liquid acetic acid, whose density differs but slightly from that of fused stearine, must have a formula and an equivalent weight about one hundred times that which we deduce from the density of acetic acid vapor, $C_4H_4O_4$.

Starting from these high equivalent weights of liquid and solid hydrocarbonaceous species, and their correspondingly complex formulas, we become prepared to admit that other orders of mineral species, such as oxyds, silicates, carbonates, and sulphids, have formulas and equivalent weights corresponding to their still higher densities, and we proceed to apply to these bodies the laws of substitution, homology, and polymerism, which have so long been recognized in the chemical study of the members of the hydrocarbon series. The formulas thus deduced for the native silicates and carbon-spars show that these polybasic salts may contain many atoms of different bases, and their frequently complex and varying constitution is thus rendered intelligible. In the application of the principle of chemical homology, we find a ready and natural explanation of those variations, within certain limits, occasionally met with in the composition of certain crystalline silicates, sulphids, etc., from which some have conjectured the existence of a deviation from the law of definite proportions, in what is only an expression of that law in a higher form.

The principle of polymerism is exemplified in related mineral species, such as meionite and zoisite, dipyre and jadeite, hornblende and pyroxene, calcite and aragonite, opal and quartz, in the zircons of different densities, and in the various forms of titanic acid and of carbon, whose relations become at once intelligible if we adopt for these species high equivalent weights and complex molecules. The hardness of these isomeric or allotropic species, and their indifference to chemical reagents, increases with their condensation, or in other words, varies inversely as their empirical equivalent volumes; so that we here find a direct relation between chemical and physical properties.

It is in these high chemical equivalents of the species, and in certain ingenious, but arbitrary assumptions of numbers, that is to be found an explanation of the results obtained by Playfair and Joule, in comparing the volumes of various solid species with that of ice; whose constitution they assume to be represented by HO, instead of a high multiple of this formula. The recent ingenious but fallacious speculations of Dr. Macvicar, who has arbitrarily assumed comparatively high equivalent weights for mineral species, and has then endeavored, by conjectures as to the architecture of crystalline molecules, to establish relations between his complex formulas and the regular solids of geometry, are curious, but unsuccessful attempts to solve some of the problems whose significance I have here endeavored to set forth. I am convinced that no geometrical groupings of atoms, such as are imagined by Macvicar, and by Gaudin, can ever give us an insight into the way in which nature builds up her units, by interpenetration and identification, and not juxtaposition of the chemical elements.

None of the above points are presented as new, though they are all, I believe, original with myself, and have been, from time to time brought forward, and maintained, with numerous illustrations, chiefly in the American Journal of Science, since March, 1853, when my paper on the Theory of Chemical Changes and Equivalent Volumes, was there published. I have, however, thought it well to present these views in a connected form, as exemplifying my notion of some of the principles which must form the basis of a true mineralogical classification.

ART. XXV.—*The Repsold Portable Vertical Circle;* by CLEVELAND ABBE.

THE progress of practical astronomy in the United States has already been distinguished by the suggestion of quite new ideas, as well as by improvements upon methods and instruments in use in Europe. It seems that a part of our national mission is to give a full and free development to whatever of good can be transplanted here from abroad; it is therefore unpardonable in us to neglect any opportunity of acquainting ourselves with the results of the experience of the astronomers of the Eastern hemisphere. The history of the brilliant life of F. G. W. Struve, to whom the world is indebted for the observatories of Dorpat and Poulkova, is doubtless familiar to all. The school of practical astronomy and geodesy that grew up under him at these two places, and is now officially established at the Central Observatory for the benefit of the Imperial Military Academy and other departments of the government, has, by the extent of the astronomical and geodesical works executed, made its influence felt far beyond the dominions of the Russian Czar. A residence of nearly two years at this Observatory has impressed the writer most deeply with the correctness of that general opinion, which for years has instinctively pointed to this magnificent institution as the head-quarters of the practical astronomy of the present day.

The extent of the territory of the United States, and the oft-recurring demand for accurate topographical maps, will increase the interest with which we study the levels, barometers, base apparatus, universal instruments, vertical circles, prime vertical and extra-meridional transits, with which the Russian astronomers have sought to meet the demands made upon them. With them, as with us, celerity is of equal importance with accuracy. The extent of their territory must forbid them, as that of ours does us, from contemplating a minute triangulation of its entire superficies—such as the smaller and more densely populated territories of the British Isles and the central European states both allowed and demanded. Our national government has rightly apprehended the importance of having the most accurate charts possible to be made of our extended Eastern and Western borders; of similar importance is the survey of our inland fresh-water lakes, now in the hands of the engineers of the War Department; of great value also is the accurate survey of international boundary lines,—but the general survey and mapping of the interior presents a problem not dissimilar from that which is being solved by the Russian geographers for their own land.

It was early seen that if astronomical determinations of *relative* position could be made accurate to within one or two seconds of arc, the central points of reference being referred with much greater accuracy to each other and to a very few zero points, then would these relative positions, as derived from astronomical observations combined with an accurate knowledge of the figure of that portion of the earth's surface covered by these stations, suffice as groundwork for supplying the present wants of geographers and topographers. Inspired by the magnitude of the work, and supported by an interested military government, Struve and Tenner, co-working with the Norwegian and Swedish governments, carried out the astronomical and geodetical work recorded in the "Arc du Méridien de 25° 20′ entre le Danube et la mér Glaciale"—at present under the authority of O. Struve and General Baeyer, co-working with Great Britain and Belgium; the field operations connected with the measurement of the arc of longitude between Valentia and Orsk are being rapidly pushed forward and will be finished in the summer of the present year. These two great works, and the similar ones that may be expected to follow in future years, when the surveys of the immense regions of Asiatic Russia come to be connected with the surveys now being carried on by the British government, furnish the necessary determination of the figure of the earth for that portion of the globe: they find their counterparts in the geodetic astronomic works in progress or already executed upon our Atlantic and Pacific sea-board, which will afford us determinations of arcs of latitude between the parallels of 26° and 48° north, and ought to be extended to the measurement of arcs of longitude of 60° on our northern, and 40° on our southern boundaries, or possibly one of 45° between Washington and San Francisco. Up to the present decade it must be conceded that the attention of geodesists has been perhaps too exclusively directed to the measurements of degrees of latitude; it is now become important to determine also arcs of longitude, and the present European international undertaking is one worthy of emulation. It is indeed with peculiar pleasure that we notice the comparatively slight expense that would attend the junction of the present and proposed triangulations of the lake survey and of the coast survey, by a triangulation from Buffalo to Albany, leading thereby to the measurement of an arc of 18° on the parallel of 42° north between Chicago and the extremity of Cape Cod. At some future time the junction of the northwest end of Lake Superior and Cape Breton will become equally feasible, whence will result an arc of 33° on the parallel of 46° north. By the junction of the coast survey operations on the gulf of Mexico with the Pacific coast, taking advantage of the labors performed by the Mexican Boundary Survey we may be led to an arc of 33° on the parallel of 31° north, and the continuation westward of the survey of the lakes, or rather the completion of the labors of N. W. boundary survey should lead to the determination of an arc of 55 to 60 degrees of longitude—the largest probably that will ever be measured on this continent. In former years the difficulties in the way of accurate longitude determinations may well have prevented such undertakings as those here suggested,—but at present the telegraph and chronograph and the use of accurate extra-meridional transits have undoubtedly removed those obstacles; as regards latitudes, it is probable that the Repsold portable vertical circle will long suffice for measurement of vertical angles. It is, however, imperatively necessary in determinations of longitude, that not only the observers be exchanged, but also with them their transits, their relay batteries, chronometers and chronographs, and all apparatus used at either end.

The quadrangular area of the United States (whose natural nucleus is probably found in St. Louis or Omaha City—even as for the present state of population Cincinnati may be regarded as a central point), offers the same variety of hills and mountains, plains and plateaus as is found in Russia, and by its extent requires that the curvature of its surface be determined independently of the investigations made in the eastern hemisphere. Until this is done, the topographical surveys made by the land commissioners and surveyors of the Federal government, and by the several states, ought to be considered as plane table sheets whose fundamental points (the secondary points of a triangulation), can only be properly fixed by geodetic and astronomic measurements.

The accurate, convenient, speedy and economical determination of the positions of as many of these *secondary* stations as are needed for topographical maps that do not pretend to a pedantic accuracy is the present problem;—and assuming that the coast survey will give us a sufficient knowledge of the curvature of our portion of North America, we shall arrive at a solution of our present problem by selecting central or primary astronomical stations at convenient points—for instance, one to three in each of the states east of the Mississippi, and traversed by several railroads or navigable rivers. The astronomical latitude of these primary points, and their longitudes relative to each other and to the zero point—Washington Observatory—are to be determined with all attainable accuracy. Expeditions starting from one such point (and consisting of one observer, one vertical circle, five to twenty-five chronometers, including one non- and one over-compensated, one barometer, &c.), visiting in the course of five to twenty-five days five, ten, twenty secondary stations, and returning to the same or another primary station, will be able to furnish the relative position of all the secondary points visited to within two seconds of arc; or to be more definite, to within 0″·5 in latitude and 0s·1 in longitude, and to give equally approximate determinations of the relative vertical heights. That this is practically done by the Russian geodesists (the first expedition dates 1846), and that in our own easily traversed country it can be better done than in theirs, is sufficient reason for calling attention to the work of Colonel Smyssloff, mentioned below, where "are fully detailed the different astronomico-geographical methods of determining position, which, by the influence of the Poulkova Observatory, have been introduced into the geodetic work of the Russian empire, and which with perfect success supplant the far more tedious and costly triangulation."*

In the wilds of Central Asia and Siberia, as in some portions of our own territory, preliminary surveys based on observations made with the pocket chronometer and Pistor and Martin's patent sextant, may supply our present need of information; but eastward to the Ural and Caucasus, it has been found practicable to transport the Repsold vertical circle and the Brauer's extra-meridional transit. The methods of using these two instruments are fully given in the two following publications:

Repsoldov Krug, Chronometri, Chronometretscheska Expedaitsir, 1859, goda. P. Smyssloff, S. Peterbourg, 1863.

Die Zeitbestimmung, vermittelst des Tragbaren Durchgangs Instruments im Verticale des Polarsterns, von W. Döllen, St. Petersburg, 1863.

A third memoir by Colonel Smyssloff (now Director of the Observatory at Wilna),

Opuity dla sravnayteljnoi otsjenkay raslaytschnech sposoboff telegraphay-tscheskoi peredatschay vraymayne pray opredjelaynie rasnoste dolgote Poulkovskoi ay Moskovskoi Observatorie. P. Smyssloff, St. Petersbourg, 1865,

gives the details of the latest and telegraphic determination of the difference of longitude between the observatories of Poulkova and Moscow. This determination was made previous to the completion of the new portable transits by Brauer, and is valuable on account of the comparison of the three methods of communicating and observing the telegraphic signals.

The excellencies of the method given in the above quoted memoir by Mr. Döllen have during the past three years found confirmation in the observations conducted by the military officers studying with him. It merits a wide circulation in our own land, which I hope to secure by a published translation with appropriate tables; questions of secondary importance seem to have prevented its exclusive adoption in the longitude determinations needed for the arc of 68° 54′ on the parallel of 52° north latitude. The surprising reliability of the portable transits made by Mr. Brauer, the mechanic of the Central Observatory, now independently established in St. Petersburg, has shown them to be adapted to the highest requirements of the present state of

* Otto Struve, Jahresbericht, June 14, 1863.

geodesy, whilst the great saving of time when they are used in the vertical of Polaris gives these instruments a remarkable superiority over the meridian transit, affording a full confirmation of the thesis propounded on page 13 of the above named memoir by Mr. Döllen, "under all circumstances, the determination of time for any given instant will be best made by mounting the portable transit, not in the plane of the meridian, but in the vertical of the pole star." Mr. Brauer has intimated to me his intention to place his sixth transit on exhibition at the Paris Exposition. Nor can I here refrain from expressing my conviction of the great importance to the interests of our astronomy and surveying to be attached to the establishment in this country of a mechanical institute, which, under the charge of a person of the experience of Brauer and the Repsolds, shall be able to furnish us with measuring instruments comparable with the objectives produced by our opticians, and fitted to do the fine work in which the astronomer and geodesist are so much interested.

For the determination of latitude the same portable transit, by being established in the plane of the prime vertical, yields zenith distances whose accuracy is in general much greater than that of the declinations of the stars observed, since these are in general faint ones. The portable prime vertical transit loses therefore somewhat of its importance, excepting for determinations of latitude where the highest accuracy is sought, and when by the coöperation of fixed observatories, special simultaneous investigations into the declinations of the stars observed can be obtained.

In general, the use of the prime vertical transit restricts one to the observation of a limited number of faint stars situated in a narrow belt. The use of the Talcott zenith telescope demands more accurate declinations of faint stars than are generally accessible, and the increased size of the telescope as well as the time required for making a large number of observations on favorable nights, constitute objections to the use of both those ingenious methods in latitudes greater than 45° (Poulkova is in latitude 60° N.), where the period favorable for field operations is comparatively short, and distinguished by long twilight.

The observations of azimuths or of zenith distances are adapted to the determination of time and latitude; and if we adopt the principle that a small number of accurate observations is preferable to a larger number of less accurate ones, it becomes necessary to restrict our attention to the three or four hundred brighter stars whose present places are known with considerable accuracy. The portable vertical circle offers itself to us as an instrument equally applicable in all latitudes to the determination of latitude, and fit for the determination of time for secondary stations between 70° of latitude and the equator, if accurately constructed as by Repsold, and used so as to eliminate constant or systematic errors. By reason of the ease with which it is put in position, and the brightness of the stars observed, as well as by the accuracy of its divided circles, level and microscopes, there is no time lost nor money expended in building stations, nor in waiting for nightfall, nor in tedious repetition of observations. Some of the principles embodied in the Repsold construction of this instrument may be found introduced into other instruments previously constructed for Struve by these artists, by Ertel, by Brauer, &c.; but the first of those on the perfected pattern now adopted was constructed in 1851, from designs furnished† by His Excellency, Otto Struve, the present Director of the Central Observatory. This one belonged to the topographical staff of the Imperial Military Academy, and was destined to be used in the surveys of the Caucasus; it could therefore only be once used in the new revision of the latitudes of the thirteen principal points of the Russian-Scandinavian arc; the results for that one station, Kilpi Mäki, 1852, afforded, however, a very satisfactory proof of the quality of the instrument. The considerable number of these instruments already made by the Messrs. Repsold, (and especially the fine one ordered for the hydrographical staff, and into which were introduced a number of minor improvements suggested by Mr. Brauer), have by their continual use and their successive improvement, led to the belief that the vertical circle has as yet but begun its course of usefulness, and will, with further improvements, eventually be entirely depended on for doing the work that it is so admirably fitted to accomplish,—and farther, that the principles carried out in its construction, i. e., compactness, high magnifying powers, reversibility, &c., have received authoritative confirmation as to their correctness.

The first of the memoirs of Colonel Smyssloff above quoted gives a detailed description of the instruments used and the work done in a chronometric expedition carried out by himself in 1859, in the neighborhood of Poulkova, in which seventeen points were accurately determined between the 18th of June and the 31st of July. We shall here give a brief account of the vertical circle used and of the plan of the expedition.

The aperture of the telescope used was $1\frac{1}{3}$ inches with a focal length of 20 inches—these dimensions, especially the aperture, have in later instruments been somewhat increased. The conical tube holding the objective is $9\frac{1}{2}$ inches long, being screwed to the cube containing the prism of total reflection whose center is 5 inches distant from the two Ys in which the pivots of the axis rest, and $9\frac{1}{2}$ inches distant from that end of the steel axis that carries the two parallel wires midway, between which the observed star is to be brought. The opposite end of the axis being perforated admits light for the illumination of the field.

† See Arc du Meridien. Introd., p. xxxviii.

The bisection of a star by a single wire presents serious disadvantages in attempting observations in strong twilight on faint stars, and is not generally attempted. The wires are stretched across the end of a cylindrical tube, whose independent connection with the axis isolates it as far as possible from the exterior and protecting cylinder carrying the ocular. On either side of the cube and clamped to it by outer plates are the two circles having each 8 spokes and divided silver arcs of 11 inches diameter.

The supporting arms, whose extremities form the Y's, branch from a conical column 6 inches high; this is hollow, and within is the vertical axis on which the reversion takes place from circle and observer east to circle and observer west, or *vice versa.* This vertical axis rests upon three horizontal legs through whose extremities pass the foot screws with divided heads. The distance from the foot screws to the center axis of the instrument is about 7 inches; the whole height from the ground to objective when pointed to the zenith being two feet and two inches. The weight of the instrument is probably about forty pounds.

A horizontal finding circle with two verniers and slow-motion screw is attached to the vertical column just above the plane of the horizontal legs. The vertical circle on the side of the cube opposite to the ocular is used as a finding circle and for giving the slow vertical motion; it is provided with two pointers at the opposite ends of a horizontal bar which rests upon the horizontal axis of revolution just within the pivot, and which is held in position by a suspended vertical frame held by an adjusting screw six inches below the axis. A similar horizontal bar similarly placed near the other pivot carries the level and the two reading microscopes which are perpendicular to the plane of the circle.

In observing, therefore, the eye being directed through the telescope ocular, one has the microscopes on the left and right in a horizontal line, distant from the eye some 5 or 6 inches, whilst the level is directly in front, which convenient compactness greatly facilitates the observations.

The heads of the micrometer screws of the microscopes are divided into 60 parts each representing 2″; the level divisions have the same value. The microscopes are about 6 inches long, having single lenses of aperture 0·2 inches for their objectives, and a magnifying power of 20–25 diameters, that of the telescope being 60–65 diameters. In the present construction of the microscopes, following a suggestion of Mr. Marth in his article on the Greenwich Transit Circle, each micrometer screw is made to carry two pairs of parallel wires, the centers of the pairs being distant 1½ revolutions of the screw from each other. The image of the divided limb, which is formed in the plane of the micrometer threads, is enlarged about 3·5 times, corresponding therefore to a circle whose radius is the same as the focal length of the telescope objective.

By comparing these dimensions with those of the four times larger Ertel vertical circle of the Central Observatory, it is evident that the portable instrument, for which the actual probable accidental error of a meridian zenith distance resulting from two pointings, one circle east and one circle west, is $\pm 0''\cdot 5$, has derived a decided advantage from its small size and proportionately higher magnifying power.

Recognizing the principle that in an astronomical measurement the fewest possible assumptions must be made,—and that computed probable errors give a very unreliable or perhaps no indication of the extent to which the constant or systematic errors introduced by assumptions as to the condition of the instrument, &c., may have vitiated our results,—it is necessary not only to examine thoroughly the instrument itself, but also in using it to still farther reduce the influence of its imperfections. Therefore a zenith distance is made to depend upon eight pointings of the telescope (or 4×8 pointings of the microscope micrometers), the four in one position of the circle being preceded and succeeded by two in the opposite position; the whole series requiring from sixteen to twenty-four minutes for its complete observation. A latitude or a time determination depends upon a pair of stars observed on opposite sides of the zenith at the same zenith distance; or upon sixteen pointings whose result is sensibly free from any assumption as to the zenith point, flexure or refraction.

The examination of the instrument used by Colonel Smyssloff leads to the following results.

The error of bisecting the interval between the two wires of either pair in the field of view of the microscope by a division of the limb of the circle, the error arising from accidental errors of the screw and the divisions of the screw head, and the error of reading these divisions, combine to affect the mean of four measurements with the microscopes, $\pm 0''\cdot 17$

The probable accidental error of a division of the divided circle, $\pm 0''\cdot 46$, affects the mean of four, $\pm 0''\cdot 23$

The probable accidental error of a reading of the two ends of the level bulb, $\pm 0''\cdot 12$

The combination of these gives

$$\sqrt{(0''\cdot 17)^2+(0''\cdot 23)^2+(0''\cdot 12)^2}=\pm 0''\cdot 31.$$

The probable accidental error of pointing on a star may be afterward investigated,—but if we assume that it equals an apparent visual angle of 1′, this will correspond to an arc of $\pm 0''\cdot 67$. Whence

$$\sqrt{(0''\cdot 31)^2+(0''\cdot 67)^2}=\pm 0''\cdot 74.$$

A zenith distance depending on one pointing, circle right, and one, circle left, may therefore be expected to be affected with an accidental error of

$$\frac{\pm 0''\cdot 74}{\sqrt{2}} = \pm 0''\cdot 52;$$

and for one depending on eight pointings we have a probable accidental error, $\pm 0''\cdot 26$. A latitude or time determination depending on two such zenith distances has accordingly the probable accidental error of observation, $\pm 0''\cdot 18$.

The influences of refraction, clock correction, flexure, periodic errors of division, still remain. The latter have not, to my knowledge, as yet been specially investigated,—the circles are divided with the same machine used in dividing the small circles investigated by Struve in Dorpat. See his "Beschreibung der Breite Gradmessung," and the "Description de l'Observatoire Central." The combined influence of all disturbing causes can be investigated by a series of determinations of the latitude of any known station,—the zenith point of the divided circle being successively altered by arcs of 30° or 45°. Sixteen determinations of the latitude of Poulkova afford an example of this investigation which should be entered into by each observer for his own instrument. Using the declinations given in the British Nautical Almanac, there results the following series of values of the latitude of the station, which was the northeast small dome on the grounds at Poulkova, and whose latitude, by reference to that of the Ertel vertical circle as deduced by Dr. Peters, is +59° 46′ 20″·02. Each of the following values of φ results from one observation consisting of eight pointings upon the respective stars.

Zenith point of the circle =0°.

	Star observed.	Meridian zen. dist.	Resulting latitude. 59° 46′	Means by pairs.
1.	β Urs. Minoris	−14° 58′	18″·77	19″·89
	α Cygni	+15 0	21 ·01	
2.	β Urs. Min.	−14 58	18 ·64	19 ·55
	α Aurigæ	+13 55	20 ·46	
3.	Polaris	−31 41	20 ·27	20 ·43
	α Coronæ	+32 35	20 ·59	
4.	Polaris	−31 41	19 ·72	19 ·98
	α Coronæ	+32 35	20 ·24	
5.	β Urs. Min. s. p.	−45 30	21 ·66	20 ·50
	α Tauri	+43 33	19 ·35	
6.	β Urs. Min. s. p.	−45 30	21 ·44	20 ·46
	α Tauri	+43 33	19 ·47	
7.	α Aurigæ s. p.	−74 23	21 ·92	20 ·53
	α Virginis	+70 12	19 ·14	
8.	α Aurigæ s. p.	−74 23	21 ·46	19 ·88
	α Virginis	+70 12	18 ·29	
	Mean of 8 pairs,			20 ·15

Zenith point of the circle =90°.

	Star observed.	Meridian zen. dist.	Resulting latitude. 59° 46′	Means by pairs.
9.	β Urs. Min.	−14° 58′	19″·54	20″·86
	α Cygni	+15 0	22 ·19	
10.	β Urs. Min.	−14 58	18 ·73	18 ·98
	α Aurigæ	+13 55	19 ·24	
11.	Polaris	−31 41	20 ·31	20 ·04
	α Coronæ	+32 35	19 ·78	
12.	Polaris	−31 41	19 ·13	19 ·34
	α Coronæ	+32 35	19 ·54	
13.	β Urs. Min. s. p.	−45 30	22 ·24	20 ·88
	α Tauri	+43 33	19 ·51	
14.	β Urs. Min. s. p.	−45 30	21 ·48	20 ·24
	α Tauri	+43 33	19 ·01	
15.	α Persei s. p.	−70 52	22 ·98	20 ·15
	α Virginis	+70 12	17 ·32	
16.	α Persei s. p.	−70 52	21 ·73	20 ·20
	α Virginis	+70 12	18 ·66	
				20 ·08

Mean of 16 pairs,	+59° 46′ 20″·12
By reference to the Ertel circle,	59 46 20 ·02
Difference,	0 ·10

Assuming the 16 values resulting from the 16 pairs to be free from flexure, there results a probable error of latitude from one pair $= \pm 0''\cdot 35$.

The difference of the latitudes resulting from the two stars of each pair depends upon the flexure of the tube and the error in the declinations, as well as upon any systematic error in the refraction or the graduation, though this is probably insensible. Assuming the latitude to be $59^\circ\ 46'\ 20''\cdot 00$, we find the differences from this to be represented by the formula

$$\text{(A.)} \qquad +3''\cdot 16 \sin (z - 30^\circ\cdot 3);$$

applying this to each of the thirty-two observations, there results a probable error of a latitude from two stars $\pm 0''\cdot 34$. From the sixteen values of the flexures we derive a probable error resulting from the error in the ephemeris and the error of pointing and reading; this is $\pm 0''\cdot 31$. And subtracting the latter source of error, there results $\pm 0''\cdot 25$ as the probable error of the declination in the British Nautical Almanac.

The investigation of flexure might also be made by means of observations in the prime vertical, but here we probably have a complicated combination of flexure and personal equation. Eight determinations of time made by Colonel Smyssloff (each depending upon eight pointings on each of a pair of stars observed in the prime vertical), compared with simultaneous observations by Wagner at the Ertel transit gave

$$\text{Wagner–Smyssloff} = -0^s\cdot 02 \pm 0^s\cdot 03;$$

the probable error of a single determination resulting $= \pm 0^s\cdot 09$; or, if we allow equal accuracy to each instrument, the probable error of a clock correction given by the vertical circle $= \pm 0^s\cdot 06$.

A series of comparisons between Messrs. Smyssloff, Bolscheff and Demetrieff, in which each observed four of the eight pointings gave,

$$\text{S.–D.} = -0^s\cdot 098, \ \text{S.–B.} = -0^s\cdot 046, \ \text{B.–D.} = +0^s\cdot 132;$$

and the probable error of a determination of time $= \pm 0^s\cdot 06$, which in the latitude 60° corresponds to a vertical angle of $\pm 0''\cdot 45$.

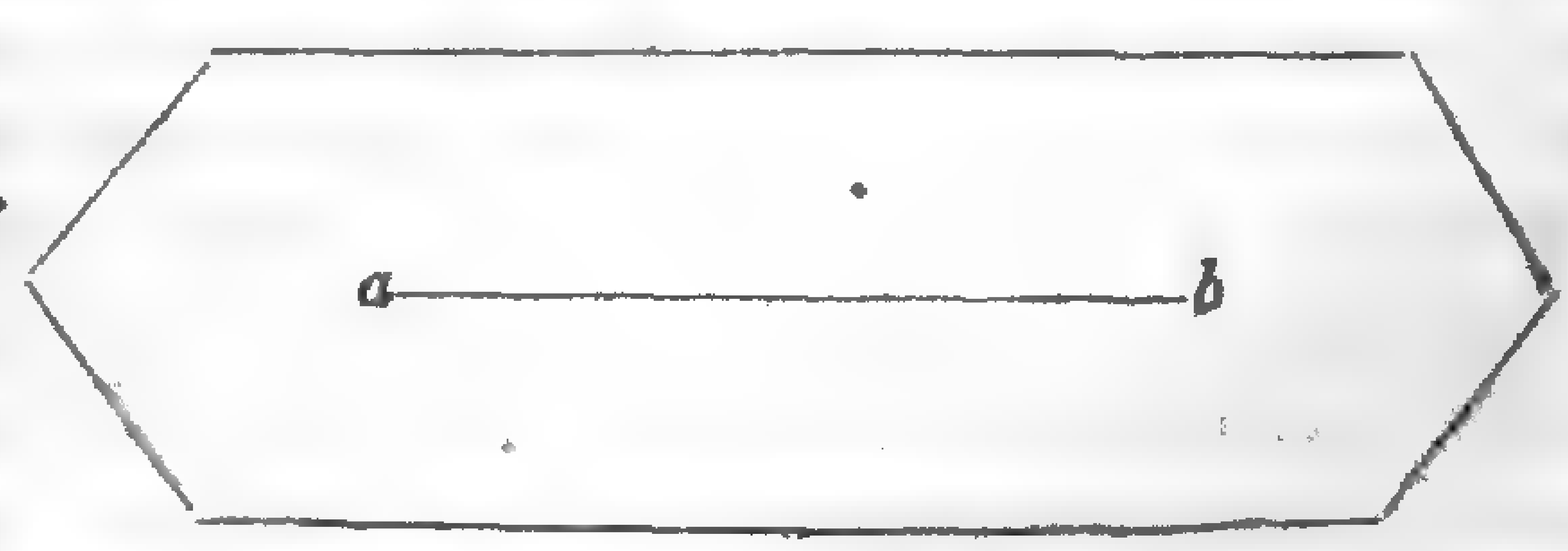
As in the determination of latitude so in that of time, a pair of stars equally distant from the zenith is always observed, each being pointed upon four times in each position of the circle, the eight pointings requiring twenty minutes or less. The stars are of course observed near the prime vertical.

[To be concluded.]

ART. XXVI.—*On Cryophyllite, a new mineral species of the Mica Family, with some associated minerals in the granite of Rockport, Massachusetts;* by JOSIAH P. COOKE, Jr.

IN a paper published in a recent number of this Journal* I described a new mineral species allied to Helvin, to which I gave the name of Danalite. Associated with Danalite in the granite ledges forming the extremity of Cape Ann, Massachusetts, are two remarkable micas, one of which is the new species to which on account of its easy fusibility and foliated structure I have given the name Cryophyllite.

Mineralogical Characters.—The mineralogical characters of cryophyllite are as follows. Like other varieties of mica it crystallizes in six-sided prisms, which are frequently of considerable size, from one to two inches in length and of proportionate diameter. The basal cleavage is highly perfect, yielding thin flexible and transparent laminæ, which when examined with a polarizing microscope give a biaxial image, the angle between the optical axes varying from 55° to 60°. The angles 55°, 57° 30′, and 60°, were all measured on different specimens. The dispersion of the axes, if any, is so slight that its character could not with certainty be determined, the color of the mineral tending to obscure any such effect. The perfect uniformity of the two systems of rings both as to form and to color indicates that the mica belongs to the trimetric system. Nevertheless, the angle between the prismatic planes measured with an application goniometer 120° as accurately as is possible with this instrument, and in one instance the planes of an hexagonal pyramid terminating the prism were distinctly seen. Considering, however, these crystals as belonging to the trimetric system, in accordance with the generally received opinion of mineralogists as to crystals of the mica family, all of which present essentially the same crystallographic characters, we must regard the six-sided prism of cryophyllite as formed by the union of the planes *I* of the rhombic prism with the brachydiagonal basal planes *iĭ*. The plane of the optical axes coincides with the shorter diagonal of the rhomb base, and the crystals are frequently much elongated in this direction, so that the form of the cleavage face was as shown in the accompanying figure, the line *a b* indicating the position of the plane of the optical axes. Furthermore, the crystals were frequently twinned together on the plane *iĭ*, and it was observed that in such cases the planes



* Vol. xlii, No. 124, July, 1866.

of cleavage of the two crystals were absolutely coincident, proving that the rhombic prisms are rectangular and not oblique, as De Senarmont has previously shown to be true of other crystals of the mica family.

The color of cryophyllite in axial directions is dull emerald green, not unlike glass colored with protoxyd of iron, and so deep that the laminæ are opaque unless quite thin, but like other colored micas it is dichrous and appears brownish-red in the direction of the lateral axes. The color of the streak is light gray with a tint of green. The luster is brilliant on the cleavage face inclining to resinous. The hardness is from 2 to 2·5 and the specific gravity 2·909.

Before the blowpipe cryophyllite very easily fuses with some intumescence to a greyish enamel bead, and it even fuses in flakes of considerable size in the flame of a candle, so that its fusibility is from 1·5 to 2 of von Kobell's scale. It imparts to the flame of a Bunsen's lamp a most brilliant lithia reaction, and by examining the colored flame with a spectroscope the presence of potassium, sodium and rubidium may also be readily discovered. The amount of sodium however must be exceedingly small as it does not sensibly modify the lithia flame as seen by the naked eye, and the same is true to a still greater degree of rubidium. The presence of rubidium is best recognized by mixing the pulverized mineral with pure pulverized sulphate of lime, exposing a small bead of this mixture supported by a loop of fine platinum wire to the flame of a gas blowpipe and examining the flame with a spectroscope. The characteristic double blue line of rubidium is then seen very distinctly for a few moments, but soon disappears. No trace of cæsium could be discovered, either by the mode of experimenting just described or by examining the platinum salt obtained in the course of the analysis, by the partial precipitation of the alkalies with chlorid of platinum.

Heated alone in a closed glass tube cryophyllite slightly changes color, but gives no sublimate, although when heated in the same with bisulphate of potash it gives a strong reaction of fluorine. When in fine powder, it is completely decomposed after some time even by the dilute mineral acids, the silica separating as a fine powder. From this description it is evident that in its mineralogical characters cryophyllite closely resembles other members of the mica family, especially the lepidolites, differing from these chiefly in the ease with which it is decomposed by acids and in a somewhat greater fusibility.

Method of Analysis.—In analyzing the mineral the fine powder was decomposed in a closed glass flask in the same way as described in my paper on Danalite, using dilute hydrochloric or sulphuric acids as the case required. Each complete analysis was made with three portions of the same powder. From the first portion, decomposed by hydrochloric acid, the silica, manganese, iron and aluminum were determined, the last two being precipitated as basic acetates and weighed together as oxyds, and the manganese subsequently precipitated from the filtrate by bromine. From the second portion, decomposed by dilute sulphuric acid, with perfect exclusion of air, the amounts of protoxyd and sesquioxyd of iron were determined by means of permanganate of potash, when by subtracting the total quantity of iron, calculated as sesquioxyd, from the sum of the alumina and sesquioxyd of iron already known, the amount of alumina was ascertained. From the third portion of the powder, decomposed by hydrochloric acid, the magnesia and the alkalies were determined. The alkalies were weighed as sulphates, and from the amount of sulphuric acid subsequently determined, the relative quantities of potash and lithia were calculated. From the fourth portion of the powder the quantity of fluorid of silicon was determined. In the first analyses of the mineral the fluorine was precipitated as fluorid of calcium according to the well known method of Berzelius as modified by Rose; but the process was found to be very tedious and the results not accordant. Subsequently the following method was devised, which may be found to be useful in other cases.

Determination of Fluorid of Silicon.—A weighed amount of finely pulverized mineral is first decomposed in a tared platinum dish with dilute sulphuric acid, and the greater part of the water having been removed on a steam bath and the excess of sulphuric acid having been driven off by gradual heating on a sand bath, the whole mass is ignited during at least an hour, the dish meanwhile being covered with a piece of platinum foil forming part of the tare. The dish with its contents having been weighed, the dried mass is next treated with hydrochloric acid and the residual silica determined in the usual way, and in the filtrate from the silica the sulphuric acid is determined and weighed as sulphate of baryta. We thus obtain four weights: A, the weight of the mineral employed in the analysis; B, the weight of the ignited residue; C, the weight of the residual silica; and D, the weight of the residual sulphuric acid. It is now evident that $A+D-B$ equals the weight of the fluorid of silicon, and that $B-C-D$ equals the weight of the sum of all the bases present. The iron is of course present in the residue as sesquioxyd, but in order to ensure its complete oxydation, it is important to add a few drops of nitric acid to the decomposed mineral, before expelling the excess of sulphuric acid. The sum of the weights of all the bases, which we find incidentally as one of the results of this method, not only furnishes an important control of the rest of our analysis, but also enables us to test the accuracy of our method. In the analysis given below it appears that the sum of the bases each separately determined as the mean of two analyses equals 45·03 per cent, while the sum of the bases weighed together in the method just described equals 45·18 per cent, as the mean of three determinations. A closer agreement than this could not possibly be expected. The process is comparatively short and presents no unusual difficulties. The chief liability to error is in the determination of the sulphuric acid, and it is necessary in washing the sulphate of baryta to take great care to remove the impurities, which this precipitate is apt to carry down; but the methods recommended by Rose and Fresenius were found to be generally sufficient for the purpose. Nevertheless, when the amount of fluorine is less than one per cent, the old process is to be preferred.

Results of Analysis.—Two very distinct varieties of cryophyllite were analyzed,—the one finely foliated and consisting of an aggregate of small crystals and the other in large distinct crystals imbedded in massive feldspar; but no other differences of character were observed, and they were found to have the same percentage composition. The purest material was selected for analysis and such as had evidently never undergone the slightest change. There is probably in all the analyses a small loss of silica, but the error, if any, is in that direction. The results are given in the following table. In columns 1 and 2, we have the complete analyses made as first described of the large crystals, while in columns 3, 4 and 5, we have the partial analysis made of the more finely foliated variety by the process last described in connection with the determination of fluorid of silicon.

Analysis of Cryophyllite from Rockport.

	1.	2.	3.	4.	5.	Mean.	Oxygen.
Silica,	51·53	51·54	51·65	51·37	51·36	51·49	27·46
Fluorid of silicon,			3·29	3·34	3·62	3·42	1·06=28·52
Alumina,	16·76	16·77				16·77	7·82
Sesquioxyd of manganese,	0·33	0·35				0·34	0·10
Sesquioxyd of iron,	2·00	1·94				1·97	0·59= 8·51
Protoxyd of iron,	8·00	7·96				7·98	1·76
Magnesia,	0·76		45·06	45·29	45·02	0·76	0·30
Potassa,	13·14	13·16				13·15	2·23
Lithia,	4·05	4·06				4·06	2·16= 6·45
Soda,	*trace.*					*trace.*	
Rubidia,	"					"	14·96
						99·94	

Oxygen ratio, 14·96 : 28·52

14·26 : 28·52=1 : 2.

General formula, RO, SiO_2. Probable rational formula, $(\tfrac{1}{3}\dot{R}^3 . \tfrac{1}{2}\ddot{\ddot{R}}), 3\dddot{Si})$.

The fluorine in the mineral is so firmly incorporated that, as stated above, it is not driven out even by a red heat, and there can be no doubt that it replaces a portion of the oxygen of the silica in the proportion of one equivalent of fluorine to every twenty-eight of oxygen. The ratio of the oxygen of the protoxyds to that of the sesquioxyds is as 13 to 17, but if we estimate all the iron as protoxyd, assuming with many mineralogists that a sesquioxyd base may under certain conditions replace a protoxyd base, we shall then have very nearly a ratio of equality and may then write our general symbol $(\frac{1}{2}\dot{R}^3 . \frac{1}{2}\ddot{\ddot{R}}), 3\ddot{S}i$.

As has already been stated, the physical characters of the new mineral do not differ essentially from those of other well known micas, and even its greater fusibility is shared with some varieties of lepidolite, resulting probably from the very large amount of alkali which the silicate contains. The ground on which this mica must be regarded as a new species is the definite oxygen ratio of 1 to 2, which has never before been observed among the micas. The five analyses given above of two distinct varieties, from different localities, differing markedly in appearance, leave no doubt in regard to the definiteness of this ratio, and no more specific character for a new species than this could be desired. When now we consider the very great want of definiteness in the micas as a class, their composition varying between $2RO, SiO_2$ in several varieties, and RO, SiO_2 in cryophyllite, it would appear that the new mica has a distinct typical character, forming as it were one boundary of this family of minerals. Moreover, it is at least a probable theory that the two formulæ just given represent the only two distinct types of micas, and that the variation of composition may result from an admixture of these two isomorphous species. The masterly investigations of De Senarmont on the optical relations of the micas tend to show that such an admixture exists, and at least prove that even a very large difference in the angle of the optical axes does not afford a safe ground for making a distinction in species. He supposed that this difference arises from a mixture of two micas crystallographically isomorphous but optically distinct, the one, and the more common class, having the optical axes in the plane of the longer diagonal, while in the other they fall in the plane of the shorter diagonal, as is the case with cryophyllite. Moreover, he was enabled, by crystallizing together certain isomorphous salts, to produce artificially the same result, which we have naturally in the micas. If then the variation of optical characters results from an isomorphous mixture of *optically* distinct species, it is at least probable that the variation of composition, so far as the oxygen ratio is concerned, may be caused by a similar mixture of *chemically* distinct species, and this view may serve to bring into some sort of order the almost hopeless confusion which the analyses of micas have hitherto presented. The magnesian micas phlogopite and biotite are sufficiently distinguished by the character of their bases, and conform very closely to the general formula $2RO, SiO_2$; but there does not seem to be any good ground for distinguishing between the two. The optical distinction, as we have seen, is not specific, and if sesquioxyds may replace protoxyds, any apparent difference in the relative proportions of these oxyds is equally of no value as a ground of separation. Even this last difference, however, is not constant, and biotite must be regarded as a phlogopite in which a certain amount of magnesia has been replaced by protoxyd or sesquioxyd of iron. Passing next to lepidomelane, we have a pure iron mica in which all the magnesia has been in like manner replaced. Lastly, the presence or absence of a small and very variable amount of lithia does not seem to make any good ground of distinction between lepidolite and muscovite, and the only essential difference between these species is the much greater fusibility of the former, arising probably from the large amount of alkali and fluorine entering into its composition, a quality which we have endeavored to express by the name cryophyllite, following the analogy of the name cryolite. In lepidolite the oxygen ratio varies very widely between the extreme limits already named, the variation resulting, according to our theory, from a mixture of two species, the first having the type ratio 1 : 1, which we may still call lepidolite, and the second having the ratio 1 : 2, which has been described in this paper and called cryophyllite. A similar admixture of an isomorphous species having the type ratio 1 : 2 may explain the equally wide variations in the oxygen ratio of the muscovite, although the infusible mica corresponding to cryophyllite has not yet been observed. It is manifest that the theory here advanced would be very greatly substantiated if it could be shown that cryophyllite is actually associated with a distinct but isomorphous mica having the type ratio 1 : 1, and that it does actually influence the composition of its associate in the way we have indicated. Such is the case, as we believe, at the Rockport locality.

Lepidomelane.—The mica which is associated with cryophyllite at Rockport (or as we should rather say, with which cryophyllite is associated, for cryophyllite is the subordinate species) is an iron mica of the species lepidomelane. This is the common mica of the great granite ledges which form the extremity of Cape Ann. In the granite itself, however, it occurs only in small flakes forming a very small proportion of the whole mass; but in the numerous veins which intersect the rock, lepidomelane is found in crystals of considerable size and sometimes in plates several inches in diameter. The vein, from which most of the best specimens have been taken, is an offshoot of one of the great trap dikes which cross the Cape from north to south nearly parallel to each other, and consists chiefly of massive quartz and feldspar almost completely segregated, the quartz lining the lower wall, while the feldspar lines the hanging wall of the vein. The best crystals, both of lepidomelane and of cryophyllite, are found in the massive feldspar, sometimes in direct contact and interpenetrating each other, while at other times they are comparatively isolated. The crystals of the two minerals resemble each other so closely in their external aspect that it requires some experience to distinguish them, without applying the distinctive test soon to be mentioned, and even an experienced mineralogist might readily mistake an aggregate of the two for a homogeneous mass. Like cryophyllite the lepidomelane crystallizes in hexagonal prisms with an angle of 120° between the prismatic planes, as was measured on several specimens with an application goniometer. Moreover the crystals have the same general habitus as those of the associated mica. They are frequently seen elongated in the direction of the brachydiagonal and twinned together on the plane *i*ǐ, and, in a word, the description of the crystals of cryophyllite already given applies equally well to those of lepidomelane; but unfortunately on account of the great opacity of lepidomelane I have not yet succeeded in determining its optical relations. There can be no doubt, therefore, that the two micas are perfectly isomorphous. But while the outward resemblance of these micas is so striking, the mineralogical characters of the two species are wholly distinct, as will be seen from the following description.

Mineralogical characters of Rockport Lepidomelane.—The cleavage is basal and perfect, but it is not so eminent as in most micas, and the foliæ are not at all or only slightly elastic. The color is black, and that of the streak dark green, differing wholly from the color of the streak of cryophyllite, which is light gray with only a faint tinge of green. The laminæ are opaque unless exceedingly thin. The luster is very brilliant, inclining to resinous on the cleavage face. The sp. gr. was found to be 3·169, and the hardness about that of calcite, or 3. Before the blowpipe it fuses to a black enamel bead, which is highly magnetic, and this affords another ready means of distinguishing it from cryophyllite. The fusibility is about that of iron-garnet, or between 3 and 4 of von Kobell's scale. With borax it forms a bottle-green glass. The powder when heated in a closed glass tube gives off water, and its green color changes to a pinchbeck-brown not unlike that of magnetic pyrites. Heated with bisulphate of potash it gives a slight reaction for fluorine. The powder is easily decomposed by the dilute mineral acids, the silica separating in fine scales. These characters agree very closely with those of the original lepidomelane from Wermland as described by Soltmann,* only the more perfect crystals from Rockport enable us to determine the crystalline form with more cer-

* Pogg. Annalen, l, 664, also Dana's System, 4th edition, vol. ii, page 297.

tainty than was possible with the minute scales from which the species was first established.

Analysis of Rockport Lepidomelane.—My analyses of this mica are given in the following table. In the analyses 2, 3, and 4, the same methods were followed which have already been described in connection with cryophyllite. In analysis 5, I employed, with some slight modification, the method first proposed by H. Saint Claire Deville,* and the close agreement of the figures obtained by such very different methods serves to confirm the general accuracy of the result. The determination of the water was the chief difficulty met with in the analyses. The water enters so intimately into the composition of the mineral that it is not expelled below a low red heat, and then only quite slowly. Moreover at this temperature the mineral is rapidly oxydized. But by igniting the mineral in a current of carbonic acid gas the oxydation was prevented and constant results were obtained. With this precaution portions of the same powder were ignited, first without and then with oxyd of lead with the following results:

	1.	2.	3.	Mean.
Loss on ignition without PbO,	1·54	1·52	1·52	1·53
" " with "	1·55	1·40		1·48

The difference is within the limit of probable error, and the results prove that the fluorine is not expelled at a low red heat. Moreover the mineral after ignition gave as strong a reaction for fluorine as before, and when heated to the highest temperature which could be obtained with a gas blast lamp, underwent no farther loss of weight. This is in accordance with what we found to be true of cryophyllite; but not in accordance with the comportment of hydrous minerals into which fluorine enters as an essential constituent. Compare analyses of Cookeite, this Journal, [2], xli, 246. These facts, taken in connection with the circumstance that fluorine was not found by Soltmann in the lepidomelane of Wermland, lead to the inference that the fluorine in the Rockport mineral is an accidental constituent, derived from the admixture of material foreign to the species itself. The amount of fluorid of silicon in analysis 2 was determined by the method of Berzelius; but the limit of error in this process is so wide that the result can only be regarded as approximate. The analyses which follow were all made on material dried at 100°, and selected to represent the different varieties of the mineral found at Rockport. Analyses 2 and 3 were made from portions of a mass of comparatively compact material. No. 4 from a perfect crystal imbedded in the massive feldspar of the vein already referred to, and the silica determination. No. 1 from scales picked out from the granite of Boylston Hall in Cambridge, which is built of stone from the Rockport quarries.

* Annales de Chimie et de Physique, [3], xxxviii, 5.

Analysis of Rockport Lepidomelane.

	1.	2.	3.	4.	5.	6.	7.	8.	Mean.	Oxygen.
Silica,	39·50	39·49	——	39·79	39·43	——	——	——	39·55	21·09
Fluorid of silicon,		0·62	——	——	——	——	——	——	0·62	0·19=21·28
Alumina,		16·72	16.41	16·90	16·87	——	——	——	16·73	7·81
Sesquiox. of manganese,		——	0·63	0·58	0·59	——	——	——	0·60	0·18
Sesquiox. of iron,		——	——	——	——	12·21	12·01	11·98	12·07	3·62
Protox. of iron,		——	——	——	——	17·57	17·47	17·41	17·48	3·88
Magnesia,		——	——	0·64	0·59	——	——	——	0·62	0·25
Potassa,		——	——	10·68	10·63	——	——	——	10·66	1·81
Lithia,		——	——	0·60	0·57	——	——	——	0·59	0·32
Soda,		——	——	——	——	——	——	——	*trace.*	——
Rubidia,		——	——	——	——	——	——	——	"	——
Water,		——	——	1·55	1·40	1·52	1·52	1·54	1·50	1·33=19·20
									100·42	

Oxygen ratio, 19·20 : 21·31,

After an examination of the results of the above analyses no one can doubt that the true oxygen ratio of the mineral is 1 : 1, and that the general formula is $2RO, SiO_2$ or $2(\frac{1}{3}\dot{R}^3 . \frac{1}{3}\bar{\bar{R}})3\dddot{Si}$. This is not only the nearest probable formula, but moreover it harmonizes with the well established formulæ of allied species and with the results of Soltmann's analysis of lepidomelane, a mineral which our Rockport mica resembles most closely in all its characters. Nevertheless the discrepancy between the actual and the probable ratio is very great, and cannot possibly be referred to impure material or imperfect processes. As has been already stated, the material used in the fourth analysis was a portion of a perfect crystal completely isolated in a mass of feldspar, and the results of this analysis agree almost precisely with those obtained in No. 5 by an entirely different process and with wholly different material. Here then are the same unsatisfactory results, which have been obtained again and again in the analyses of the micas, and have made it so difficult to reduce to order this important family of minerals. Fortunately we find at the Rockport locality what I believe to be the clue to the whole mystery. The common mica of the granite is there associated with a second mica containing twice as much silica, but still perfectly isomorphous with it in crystalline form. Now if two isomorphous salts crystallize together from the same solution, we obtain crystals which are mixtures of the two in definite proportions, the proportions depending chiefly on the relative quantity of each which may be present; but also at times on other conditions less accurately determined.* When the sedimentary rocks were undergoing the metamorphism which converted them into the granite ledges of Rockport, or when by any other means this granite was formed, the two isomorphous micas, described in this paper, did actually crystallize together, for so we find them; and it is reasonable to suppose that the same results followed in the one case as in the other, and that

* See Rammelsberg's important paper on this subject, Pogg. Ann., xci, 321.

the mica of the Rockport granite is an isomorphous mixture of these two distinct species. This conclusion, moreover, is favored by the fact that lepidomelane—the species to which this mica undoubtedly belongs—contains in other localities neither lithia nor fluorine; while on the other hand these same ingredients are strikingly characteristic of the lepidolite micas, to which cryophyllite is allied. Assuming then that the lithia and fluorine in the analyses belong to the cryophyllite and not to the lepidomelane, we have endeavored in the following table to eliminate this disturbing element from our results. Thus, in column 1 we have repeated the mean result of our analyses. In column 2 we have the amounts of the several ingredients of cryophyllite corresponding to 0·59 per cent of lithia, deduced from the analyses of this mineral given above. Subtracting these quantities from those in the first column we have the numbers in the third column. In column 4 we have reduced the same to a percentage composition, and these numbers, according to our theory, represent the true composition of the Rockport lepidomelane. In column 5 we have placed for comparison the analysis of lepidomelane by Soltmann.

Reduction of analyses of Lepidomelane.

	1.	2.	3.	4.	Oxygen.	5.	Oxygen.
Silica,	39·55	7·48	32·07	**37·39**	....=19·94	**37·40**	=19·94
Fluorid of silica,	0·62	0·50	....	....	....		
Alumina,	16·73	2·44	14·29	**16·66**	7·78	**11·60**	5·42
Sesquiox. of manganese,	0·60	0·05	0·55	**0·64**	0·19		
Sesquiox. of iron,	12·07	0·29	11·78	**13·74**	4·12	**27·66**	8·29
Protoxyd of iron,	17·48	1·16	16·32	**19·03**	4·23	**12·43**	2·76
Magnesia,	0·62	0·11	0·51	**0·59**	0·24	**0·26**	0·10
Potassa,	10·66	1·91	8·75	**10·20**	1·73	**9·20**	1·61
Lithia,	0·59	0·59	....	....	....		
Water,	1·50	....	1·50	**1·75**	1·56=19·85	**0·60**	0·53=18·71
				100·00		**99·15**	

Oxygen ratio, 19·85 : 19·94 = 1 : 1.

General formula 2RO, SiO_2. Probable rational formula, $2(\frac{1}{2}\dot{R}^3, \frac{1}{2}\ddot{\ddot{R}})3\dddot{Si}$.

The result of our calculation, as will be seen, is most satisfactory; for not only is the oxygen ratio thus obtained exact, but also the numbers agree very closely with those of Soltmann, the only apparent discrepancies disappearing when the sum of the alumina and the oxyds of iron and manganese are compared together in the two analyses, and the difference in the distribution of the iron between the two oxyds is unimportant if we assume as before that the oxyds may replace each other. We have estimated in both analyses the amount of water among the bases for the following reasons, which seemed to us conclusive: first, because the loss of water is attended by a very marked change in the color of the mineral—from green to brown—

proving that the water must be chemically, and not merely hygroscopically, combined; secondly, because while water of crystallization would be present in a definite number of equivalents —one or more—the quantity of water in this mineral obeys no such law, and only amounts to a small fraction of a single equivalent; lastly, because the water is only driven out at a high temperature, indicating that it is in a state of intimate combination. There does not appear to be any simple relation between the amounts of the protoxyd and sesquioxyd of bases in the Rockport lepidomelane; but the general formula of the mineral may readily be reduced to that of the magnesian micas by assuming that a portion of the protoxyd of iron has been replaced by the sesquioxyd.

The facts advanced in this paper seem to show quite conclusively that the variation in composition of the Rockport lepidomelane from the normal type is caused by the admixture of a second isomorphous mica with a higher oxygen ratio, which we have called cryophyllite, and this being the case we may expect to find that similar variations in the composition of other micas are due to a similar cause, and it will therefore be interesting to search for the disturbing element at the various localities. Such an examination will be likely to reveal either the presence of cryophyllite itself or else of some new species analogous to it; and if the Rockport locality is any guide, such minerals are more likely to be found in feldspathic veins or nodules of the granite rather than uniformly diffused through the rock itself. It is a fact worthy of notice, and which is quite evident from the above analyses, that the proportions in which cryophyllite is mixed with lepidomelane are quite constant throughout the Rockport locality; and this again is wholly in accordance with the well known facts which have been developed by Rammelsberg* and others in regard to the crystallization of isomorphous salts when mixed together in the same solution. It appears from these investigations that isomorphous salts do not necessarily crystallize together in every proportion, but that, in most cases at least, any two given salts have, so to speak, a definite capacity for each other, and that when the point of saturation is passed, pure crystals of the salt in excess may be deposited in direct contact with those which are mixtures of the two. Such experiments furnish an exact counterpart of the conditions which we actually realize in the Rockport granite.

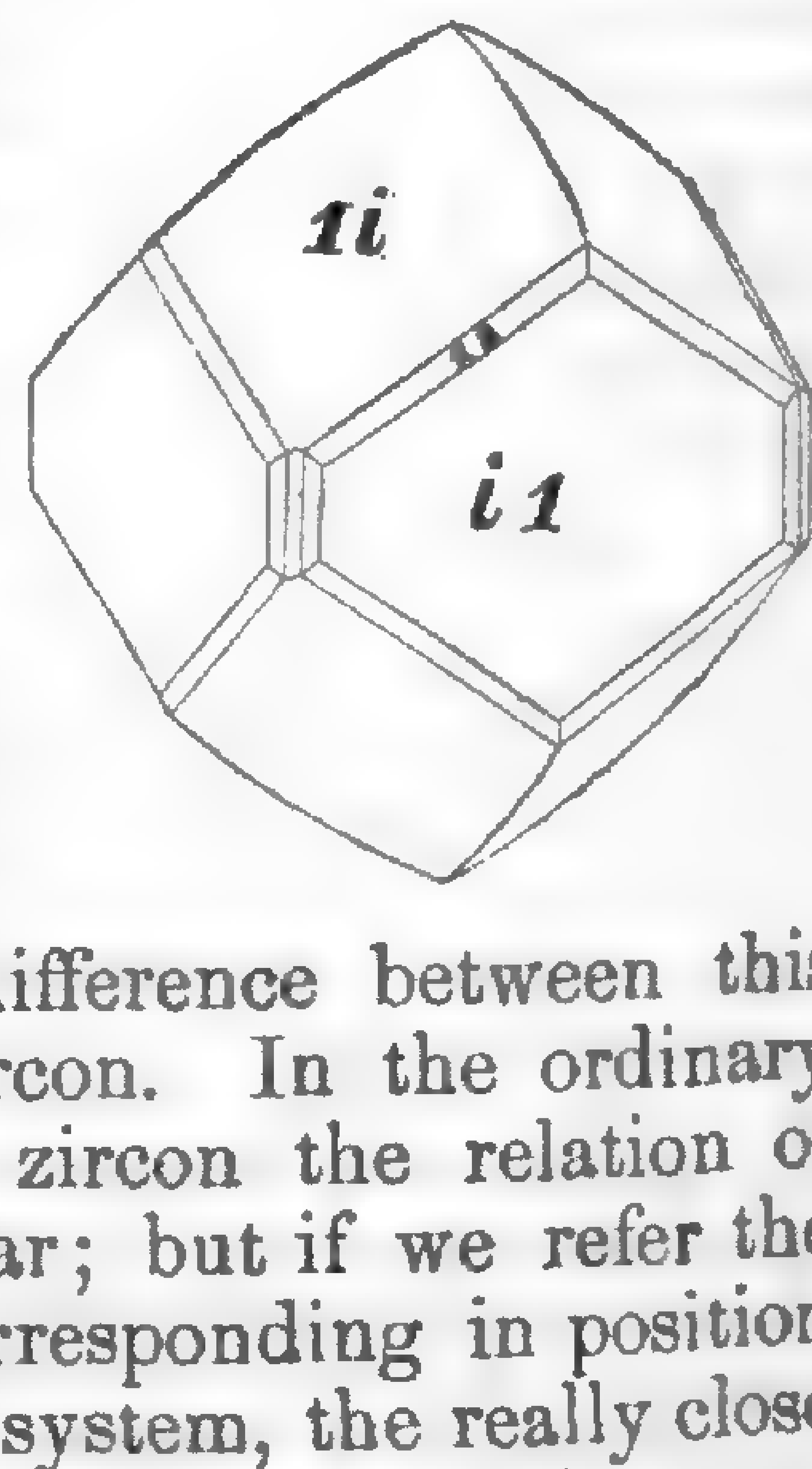
Albite.—The general nature of the vein in which the best crystals, both of cryophyllite and lepidomelane, have been found, has already been described in the earlier part of this paper. This vein consists chiefly of quartz and feldspar of the ortho-

* Pogg. Ann., vol. xci, p. 321.

clase variety. Very fine green colored crystals of the last have been obtained here, and good crystals of the usual color are abundant. Associated with the orthoclase I have frequently noticed a compact variety of albite distinguished by a peculiar luster and very marked striation on the plane of easy cleavage. It resembles somewhat, in outward aspect, oligoclase, but the mineral had the characteristic cleavages of a clinoclase feldspar, and the angle *O* on *ĭi* measured with an application goniometer 93°. Moreover it contains, if any, only the merest trace of lime. The albite is actually imbedded in the orthoclase, and the intimate association of these two heteromorphous species is worthy of notice.

Malacone.—The same vein contains also a peculiar variety of zircon, which is probably identical with the malacone of Scheerer, only somewhat more altered. The crystals have the general form represented in the figure, and resemble the crystals of zircon from Expailly in France. On account of the great predominance of the planes 1*i* and *i*1, they resemble the rhombic dodecahedron of the regular system, and can only be distinguished from this form by the distribution of the modifying planes; since on account of the strong curvature of the faces the limits of necessary uncertainty in the measurement of the angles cover the whole difference between this form and the corresponding form of zircon. In the ordinary method of representing the crystals of zircon the relation of the forms just referred to does not appear; but if we refer the planes of the zircon crystals to axes corresponding in position to those of the allied form of the regular system, the really close affinity of the two becomes evident. Thus the ratio of the axes, which in the regular system is unity, is in zircon $a:b=0{\cdot}906:1$, and the angle 1*i* on *i*1, which in the dodecahedron equals 120°, is in the zircon crystal equal to 123° 19′. In the figure here given the crystal has been drawn and the planes lettered with reference to the axes of the dodecahedron, and this must be borne in mind when comparing it with other figures of zircon. The most striking peculiarity of the crystals is the strong curvature of the terminal faces, which has been indicated in the figure, and which, as already intimated, renders accurate measurements impossible. Nevertheless, within the limits of necessary uncertainty the angles measured the same as those of zircon. The small planes not lettered on the crystal for want of space are *ii* and *i*3.

2.



The color both of the crystal and the powder is brownish-red, and this color is not altered by ignition. Luster more or less adamantine on different specimens, evidently varying with the degree of alteration, and becoming more brilliant after ignition. Fracture after ignition conchoidal and very brilliant, but varying on the natural crystals, like the luster, with the degree of alteration. There is no distinct cleavage. Hardness before ignition from 5 to 5·5; after ignition from 7 to 7·5. Specific gravity before ignition from 3·985 to 4·040, the extreme limits observed; after ignition 4·095. Before the blowpipe the mineral is infusible. In a closed tube it gives off water, which has at first an alkaline reaction, but becomes acid when the mineral is heated more intensely. With bisulphate of potash gives slight reaction for fluorine. The powder dissolves with some difficulty in melted borax, giving only the reaction for iron. In phosphorus salt it dissolves only with great difficulty and incompletely, giving in the reducing flame, even when treated with tin on charcoal, a colorless glass. The mineral is partially decomposed by hydrochloric acid; more perfectly by strong sulphuric acid, and completely by fusion with carbonate of soda. An imperfect analysis gave the following results:

Silica, - - - - - - - -	27·90
Zirconia, - - - - - - -	66·93
Sesquioxyd of iron with trace of manganese, -	2·57
Water, - - - - - - -	2·19
	99·59

These numbers must give very nearly the composition of the material analyzed; but the composition must vary with the degree of alteration, and probably no two specimens would give precisely the same result. The material used was the best I could command, but not so good as might be desired, and I am happy to learn that a more trustworthy analysis will soon be published. On comparing these numbers with Scheerer's analyses of malacone, it appears that the amount of silica is somewhat greater in the original specimens, but the difference is evidently the result of further alteration. The zirconia was examined for other earths and metallic oxyds, but without positive results. No distinct indications of titanium could be obtained with the blowpipe, although it is possible that in the presence of so large an amount of zirconia a small amount might have escaped notice. The zirconia separated from the mineral was converted into chlorid, and the solution when evaporated crystallized to the last drop, forming a large mass of white silky needles. A solution of this chlorid, still acid to litmus paper, turned turmeric paper orange-yellow. In a solution of the same chlorid, oxalic acid produced a voluminous precipitate, which, when the solution was cold, readily dissolved in an excess of the reagent, and the more readily the larger the quantity of free hydrochloric acid present. If the solution was heated to boiling during the precipitation, the precipitate was not easily redissolved; but by digesting it for several hours with a very large excess of oxalic acid complete solution was finally effected. In a similar solution of the chlorid, a strong solution of sulphate of potash produced a precipitate, which in the presence of free hydrochloric acid readily dissolved in an excess of the reagent if the solution was kept cold. But if the solution was heated during the precipitation, the precipitate did not thus redissolve; but it immediately disappeared on adding a small amount of dilute sulphuric acid. From a solution of the chlorid of zirconium, ammonia throws down a gelatinous precipitate, but this precipitation was entirely prevented by the addition of tartaric acid. The hydrate thus obtained, when heated before the blowpipe, became intensely luminous and changed into a hard granular powder insoluble in all dilute acids. After digesting it, however, for several hours in strong sulphuric acid, it was converted into a sulphate, which dissolved completely on diluting the acid with water. These reactions appear to indicate that the zirconia was quite, if not entirely, free from an admixture of other earths, and the manner in which its reactions are modified by the temperature is the probable explanation of the confusion on the subject which is found in many text-books. The two modifications of zirconia, distinguished by Berzelius, seem to be repeated in many of its compounds, and malacone stands in the same relation to ordinary zircon that the soluble oxalate and sulphate do to the insoluble varieties. The malacone at Rockport is unquestionably in process of alteration, but whether the original mineral was the ordinary zircon or what we may call the normal malacone, I have not yet been able to determine.

ART. XXVII.—*On a possible Geological Cause of Changes in the Position of the Axis of the Earth's Crust*; by JOHN EVANS, F.R.S.*

AT a time when the causes which have led to climatal changes in various parts of the globe are the subject of so much discussion, but little apology is needed for calling the attention of this Society to what possibly may have been one of these causes, though it has apparently hitherto escaped observation.

That great changes of climate have taken place, at all events in the northern hemisphere of the globe, is one of the best estab-

* Proceedings of the Royal Society, xv, p. 46.

lished facts of geology, and that corresponding changes have not been noticed to the same extent in the southern hemisphere may possibly be considered as due, rather to a more limited amount of geological observation, than to an absence of the phenomena indicative of such alterations in climatal conditions having occurred.

The evidence of the extreme refrigeration of this portion of the earth at the Glacial Period is constantly receiving fresh corroboration, and various theories have been proposed which account for this accession of cold in a more or less satisfactory manner.

Variations in the distribution of land and water, changes in the direction of the Gulf Stream, the greater or less eccentricity of the earth's orbit, the passage of the solar system through a cold region in space, fluctuations in the amount of heat radiated by the sun, alternations of heat and cold in the northern and southern hemispheres, as consequent upon the precession of the equinoxes, and even changes in the position of the center of gravity of the earth and consequent displacements of the polar axis, have all been adduced as causes calculated to produce the effects observed; and the reasoning founded on each of these data is no doubt familiar to all.

The possibility of any material change in the axis of rotation of the earth has been so distinctly denied by Laplace* and all succeeding astronomers, that any theory involving such a change, however tempting as affording a solution of certain difficulties, has been rejected by nearly all geologists as untenable.

Sir Henry James,† however, writing to the 'Athenæum' newspaper in 1860, stated that he had long since arrived at the conclusion that there was no possible explanation of some of the geological phenomena testifying to the climate at certain spots having greatly varied at different periods, without the supposition of constant changes in the position of the axis of the earth's rotation. He then, assuming as an admitted fact that the earth is at present a fluid mass with a hardened crust, showed that slaty cleavage, dislocations, and undulations in the various strata are results which might be expected from the crust of the earth having to assume a new external form, if caused to revolve on a new axis, and advanced the theory that the elevation of mountain-chains of larger extent than at present known produced these changes in the position of the poles.

The subject was discussed in further letters from Sir Henry James, the Astronómer Royal, Professors Beete Jukes and Hennessy, and others, but throughout the discussion the principal question at issue seems to have been whether any elevation of a

* Méc. Cél., vol. v, p. 14. † Athenæum, Aug. 25, 1860, &c.

mountain-mass could sensibly affect the position of the axis of rotation of the globe as a whole, and the general verdict was in the negative.

At an earlier period (1848) the late Sir John Lubbock, in a short but conclusive paper in the 'Quarterly Journal of the Geological Society'* pointed out what would have been the effect had the axis of rotation of the earth not originally corresponded with the axis of figure, and also mentioned some considerations which appear to have been absent from Laplace's calculations.

Sir John Lubbock, however, in common with other astronomers, appears to have regarded the earth as consisting of a solid nucleus with a body of water distributed over a portion of its surface; and there can be but little doubt that, on this assumption of the solidity of the earth, the usually received doctrines as to the general persistence of the direction of the poles are almost unassailable.

Directly, however, that we argue from the contrary assumption that the solid portion of the globe consists of a comparatively thin, but to some extent rigid crust with a fluid nucleus of incandescent mineral matter within, and that this crust, from various causes, is liable to changes disturbing its equilibrium, it becomes apparent that such disturbances may lead, if not to a change in the position of the general axis of the globe, yet at all events to a change in the relative positions of the solid crust and the fluid nucleus, and in consequence to a change in the axis of rotation, so far as the former is concerned.

The existence in the center of the globe of a mass of matter fluid by heat, though accepted as a fact by many, if not most geologists, has no doubt been called in question by some, and among them a few of great eminence. The gradual increase of temperature, however, which is found to take place as we descend beneath the surface of the earth, and which has been observed in mines and deep borings all over the world, the existence of hot springs, some of the temperature of boiling water, and the traces of volcanic action, either extinct or still in operation, which occur in all parts of the globe, afford strong arguments in favor of the hypothesis of central heat.

And though we are at present unacquainted with the exact law of the increment of heat at different depths, and though, no doubt, under enormous pressure the temperature of the fusing-point of all substances may be considerably raised, yet the fact of the heat increasing with the depth from the surface seems so well established that it is highly probable that at a certain depth such a degree of heat must be attained as would reduce all min-

* Vol. v, p. 5.

eral matter with which we are acquainted into a state of fusion. When once this point was attained, it seems probable that there would be no very great variation in the temperature of the internal mass; but whether the whole is in one uniform state of fluidity, or whether there is a mass of solid matter in the center of the fluid nucleus, are questions which do not affect the hypothesis about to be considered.

Those who are inclined to regard the earth as a solid or nearly solid mass throughout, consider that many volcanic phenomena may be accounted for on the chemical theory, which has received the support, among others, of Sir Charles Lyell. But apart from the consideration that such chemical action must of necessity be limited in its duration, the existence of local seas of fluid matter, resulting from the heat generated by intense chemical action, would hardly account for the increase of heat at great depths in places remote from volcanic centers; and the rapid transmission of shocks of earthquakes and the enormous amount of upheaval and subsidence as evidenced by the thickness of the sedimentary strata, seem inconsistent either with the general solidity of the globe or any very great thickness of its crust.

The supposition that the gradual oscillations of the surface of the earth, of which we have evidence all over the world as having taken place ever since the formation of the earliest known strata up to the present time, are due to the alternate inflation by gas and the subsequent depletion of certain vast bladdery cavities in the crust of the earth, can hardly be generally accepted.

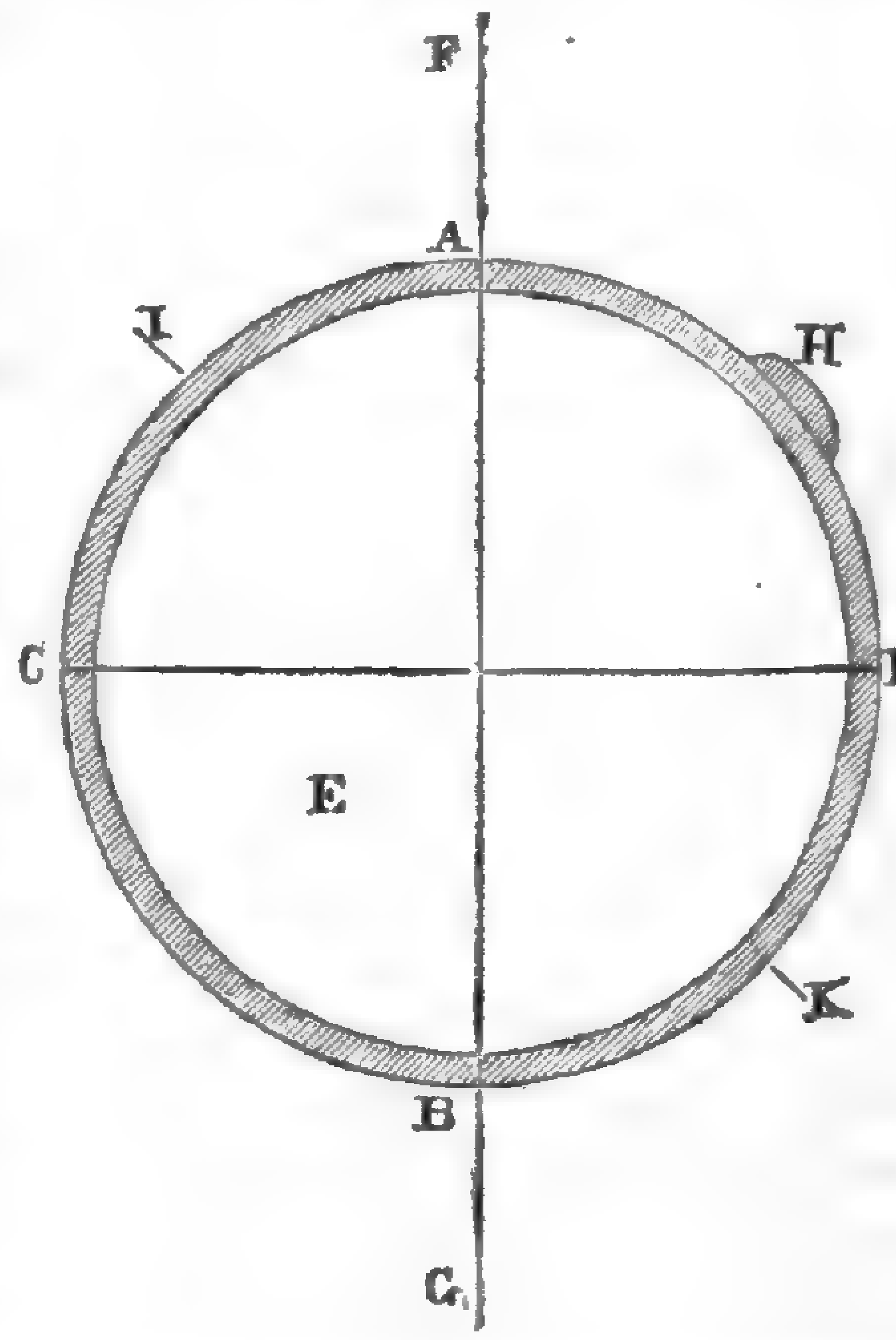
Those who wish to see the arguments for and against the theory of there being a fluid nucleus within the earth's crust, will find them well and fairly stated in Naumann's 'Lehrbuch der Geognosie.'* My object is, not to discuss that question, but to point out what, assuming the theory to be true, would be some of the effects resulting from such a condition of things, more especially as affecting climatal changes. The agreement or disagreement between these hypothetical results and observed facts may ultimately assist in testing the truth of the assumption.

The simplest form in which we can conceive of the relations to each other of a solid crust and a fluid nucleus in rotation together is that of a sphere.

Let A C B D be a hollow sphere composed of solid materials and of perfectly uniform thickness and density, and let it be filled with the fluid matter E, over which the solid shell can freely move, and let the whole be in uniform rotation about an

* 2nd edit., 1858, vol. i, p. 36.

axis F G, the line C D representing the equator. It is evident that in such a case, the hollow sphere being in perfect equilibrium, its axis and that of its fluid contents would perpetually coincide. If, however, the equilibrium of the shell or crust be destroyed, as, for instance, by the addition of a mass of extraneous matter at H, midway between the pole and the equator, not only would the position of the axis of rotation be slightly affected by the alteration in the position of the center of gravity of the now irregular sphere, but the centrifugal force of the excess of matter at H would gradually draw over the shell toward D until, by sliding over the nucleus, it attained its greatest possible distance from the center of revolution by arriving at the equator. The resultant effect would be that though the whole sphere continued to revolve around an axis as nearly as possible in the line F G, yet the position of the pole of the hollow shell would have been changed by 45°, as by the passage of H to the equator the points I and K would have been brought to the poles by spirals constantly decreasing in diameter, while A and B, by spirals constantly increasing, would have at last come to describe circles midway between the poles and the equator.



The axis of rotation of the hollow sphere and that of its fluid contents would now again coincide, and would continue to do so perpetually unless some fresh disturbance in the equilibrium of the shell took place.

If instead of the addition of fresh matter at H we had supposed an excavation or removal of some portion of the shell, a movement in the axis of rotation of the shell would also have ensued, since from the diminished centrifugal force of that portion of the hollow sphere where the excavation had taken place, it would no longer equipoise the corresponding portion on the opposite side at I, and the excavated spot would eventually find its way to the pole.

In order more clearly to exhibit these effects, I have prepared a model in accordance with a suggestion of Mr. Francis Galton, F.R.S., in which a wheel representing a section of a hollow sphere has its axis, upon which it can freely turn, fixed in a frame, which is itself made to revolve in such a manner that the axis of its rotation passes through one of the diameters of the wheel, and coincides with what would be the axis of the sphere of which the wheel is a section.

In the periphery of the wheel are a number of adjustable screws with heavy heads, so that, by screwing any of them in or out, the addition of matter or its abstraction at any part of the sphere may be represented.

If by adjusting these screws the wheel could be brought into perfect equilibrium, its position upon its own axis would remain unchanged in whatever position it was originally placed, notwithstanding any amount of rotation being given to the frame in which it is hung; but practically it is found that with a certain given position of the screws a certain part of the wheel coincides with the axis of the frame, or becomes the pole around which the sphere revolves. The rim of the wheel is graduated so as to show the position of the poles in all cases, and generally speaking the wheel always settles down after rotation with the pole within three or four degrees of the same spot, if no alteration has been made in the adjustment of the screws, though of course what was the uppermost pole may become the lower one; and in some cases the wheel may be *in æquilibrio* with a projecting screw either above or below the equator, in which case there may be four readings on the circle at the index-point, according as the one pole or the other is uppermost, and the projecting screw is above or below the equator.

With the screws on the wheel evenly balanced, a slight alteration in the adjustment of any of them immediately tells upon the position of what, for convenience sake, may be called the poles, except, indeed, in such cases, as screwing outward those already at the equator, or making similar alterations in the adjustment of two screws at equal distances on either side of one of the poles. If a screw be turned outward so as notably to project at any spot, no matter how near to the pole, it will be found, after the machine has been a short time in revolution, in the region of the equator. Or again, if one or, better still, two opposite screws at the equator be turned inward, they will be found after a short period of revolution at the poles.

Now let us assume for a moment that, though the crust was partially covered by water, the earth, instead of being a spheroid, was a perfect sphere, consisting of a hardened crust of moderate thickness supported on a fluid nucleus over which the crust could travel freely in any direction, but both impressed with the same original rotatory motion, so that without some disturbing cause they would continue to revolve forever upon the same axis, and as if they were one homogeneous body. Let us assume, moreover, that this crust, though in perfect equilibrium on its center of rotation, was not evenly spherical externally, but had certain projecting portions, such as would be represented in nature by continents and islands rising above the level of the sea.

It is evident that so long as those continents and islands remained unaltered in their condition and extent, the relative position of the crust to the enclosed fluid nucleus would remain unaltered also. But supposing those projecting masses were either further upheaved from some internal cause, or worn down and ground away by the sea or by subaërial agency and deposited elsewhere, it seems impossible but that the same effects must ensue as we see resulting upon the model from the elevation and depression of certain screws, and that the axis of rotation of the crust of the sphere would be changed in consequence of its having assumed a fresh position on its fluid nucleus, though the axis of the whole sphere might have retained its original direction, or have altered from it only in the slightest degree.

An irregular accumulation of ice at one or both of the poles, such as supposed by M. Adhémar, would act in the same manner as an elevation of the land; and even assuming that the whole land had disappeared from above the surface of the sea, yet if by marine currents the shallower parts of the universal ocean were deepened and the deeper parts filled up, there would, owing to the different specific gravity of the transported soil and the displaced water, be a disturbance in the equilibrium of the crust, and a consequent change in the position of its axis of rotation.

Now if all this be true of a sphere, it will also, subject to certain modifications, be true of a spheroid so slightly oblate as our globe.

The main difference in the two cases is, that in a sphere the crust may assume any position upon the nucleus without any alteration in its structure, while in the case of the movement of a spheroidal crust over a similar spheroidal nucleus, every portion of its internal structure must be more or less disturbed as the curvature at each point will be slightly altered.

The extent of the resistance to an alteration of position arising from this cause will depend upon the oblateness of the spheroid and the thickness and rigidity of the crust; while the thicker the latter is, the less also will be the proportionate effect of such elevations, subsidences, and denudations as those with which we are acquainted. The question of friction upon the nucleus is also one that would have to be considered, as the internal matter though fluid might be viscous.

It will of course be borne in mind that the elevations and depressions of the surface of the globe are not, on the theory now under consideration, regarded according to the proportion they bear to the earth's radius, but according to their relation to the thickness of the earth's crust; and that, even assuming Mr. Hopkins's extreme estimate to be true, yet elevations or depressions, such as we know to have taken place, of 8,000 or 10,000 feet, bear an appreciable ratio to the 800 or 1,000 miles which he assigns as the thickness of the earth's crust.

It is, however, to be remarked that the extremely ingenious speculations of Mr. Hopkins are based on the phenomena of precession and nutation, and that if once the possibility of a change in the position of the axis of rotation of the earth's crust be admitted, it is not improbable that the value of some of the data upon which the calculations of these movements are founded may be affected.

The supposition of the thickness of the crust being so great seems also not only entirely at variance with observed facts as to the increase of heat on descending beneath the surface of the earth, but to have been felt by Mr. Hopkins himself to offer such obstacles to any communication between the surface of the globe and its interior, that he has had recourse to an hypothesis of large spaces in the crust at no great depth from the surface, and filled with easily-fusible materials, in order to account for volcanic and other phenomena.

But though it may be possible to account for volcanoes upon such an assumption, yet, as already observed, the phenomena of elevation and depression, such as we find to have taken place, and more especially the existence of vast geological faults, cannot without enormous difficulty be reconciled with such a theory.

Taking the increment of heat as 1° Fahrenheit for every 55 or 60 feet* in descent, a temperature of 2400° Fahr. would be reached at about 25 miles, sufficient to keep in fusion such rocks as basalt, greenstone, and porphyry; and such a thickness appears much more consistent with the fluctuations in level, and the internal contortions and fractures of the crust which are everywhere to be observed. Sir William Armstrong, on the assumption of the temperature of subterranean fusion being 3000° Fahr., considers that the thickness of the film which separates us from the fiery ocean beneath would be about 34 miles.

Even assuming a thickness of 50 miles, so as to make still greater allowance for the increased difficulty of fusion under heavy pressure, the thickness of the crust would only form one-eightieth part of the radius of the earth; or if we represent the earth by a globe 13 feet in diameter, the crust would be one inch in thickness, while the difference between the polar and equatorial diameters would be half an inch.

In such a case, the elevation or wearing away of continents such as are at present in existence, rising, as some of them do, nearly a quarter of a mile on an average above the mean sea-

* Page, 'Advanced Text-book of Geology,' p. 30.

level, would cause a great disturbance in the equilibrium of the crust, sufficient to overcome considerable resistance in its attempts to regain a state of equilibrium by a movement over its fluid nucleus.

Whether the thickness of the earth's crust was not in early geological times less than at present, so as to render it more susceptible of alterations in position—whether the spheroid of the fluid mineral nucleus corresponds in form with the spheroid of water which gives the general contour of the globe—whether or no there are elevations and depressions upon the nucleus corresponding to some extent with the configuration of the outer crust, and whether the motion of the crust upon it, besides effecting climatal changes, might not also lead to some elevations and depressions of the land, and produce some of the other phenomena mentioned by Sir Henry James, are questions which I will leave for others to discuss.

My object is simply to call attention to what appears to me the fact, that if, as there seems reason to suppose, our globe consists of a solid crust of no great thickness resting on a fluid nucleus, either with or without a solid central core, and if this crust, as there is abundant evidence to prove, is liable to great disturbances in its equilibrium, then it of necessity follows that changes take place in the position of the crust with regard to the nucleus, and an alteration in the position of the axis of rotation, so far as the surface of the earth is concerned, ensues.

Without in the slightest degree undervaluing other causes which may lead to climatal changes, I think that possibly we may have here a *vera causa* such as would account for extreme variations from a tropical to an arctic temperature at the same spot, in a simpler and more satisfactory manner than any other hypothesis.

The former existence of cold in what are now warm latitudes might, and probably did in part, arise from other causes than a change in the axis of rotation, but no other hypothesis can well account for the existence of traces of an almost tropical vegetation within the arctic circle.

Of the former existence of such a vegetation, the evidence, though strong, is not conclusive. But if the fossil plants of Melville Island, in lat. 75° N.,* which appear to agree generically with those from the English coal-measures, really grew upon the spot where they were now discovered, they seem to afford conclusive evidence of a change in the position of the pole since the period at which they grew, as such vegetation must be considered impossible in so high a latitude.

The corals and Orthoceratites from Griffiths Island and Cornwallis Island, and the Liassic Ammonites from Point Wilkie,

* Lyell, 'Principles of Geology,' 1853, p. 88.

Prince Patrick's Island, tell the same story of the former existence of something like a subtropical climate at places at present well within the arctic circle.

To use the words of the Rev. Samuel Haughton,* in describing the fossils collected by Sir F. L. McClintock, "The discovery of such fossils *in situ*, in 76° N. latitude, is calculated to throw considerable doubt upon the theories of climate, which would account for all past changes of temperature by changes in the relative position of land and water on the earth's surface;" and I think that all geologists will agree with this remark, and feel that if the possibility of a change in the position of the axis of rotation of the crust of the earth were once admitted, it would smooth over many difficulties they now encounter.

That some such change is indeed taking place at the present moment may not unreasonably be inferred from the observations of the Astronomer Royal, who, in his Report to the Board of Visitors for 1861, makes use of the following language, though "only for the sake of embodying his description of the observed facts," as he refers the discrepancies noticed to "some peculiarity of the instrument. . . . . The transit circle and collimators still present those appearances of agreement between themselves and of change with respect to the stars which seem explicable only on one of two suppositions—that the ground itself shifts with respect to the general earth, or that the axis of rotation changes its position."

Art. XXVIII.—*On Fluorescence;* by J. Eneu Loughlin, Philadelphia.

In the year 1845, Sir J. Herschel published two papers in the 'Philosophical Transactions,' on what he termed the epipolic dispersion of light. His researches were made upon sulphate of quinia and other organic substances, from which researches he deduced the conclusion that the colors came from the surface of the liquid at which the light entered, and that a ray of light having once passed through such a stratum has lost the power of reproducing the same effect. Sir D. Brewster, in 1846, in a paper read before the Royal Society of Edinburgh, drew attention to a similar phenomenon in a solution of the green principle of leaves, and disproved the ideas of Sir J. Herschel, by showing that the light was dispersed not merely at the surface, but for a long distance within the fluid. In 1852, the subject was taken up by Mr. Stokes of Cambridge, and by him ably discussed. He examined many organic substances and arrived at

* Journal of the Royal Dublin Society, vol. i, p. 244.

several valuable conclusions. He was the first to examine the fluorescent nature of glass colored by oxyd of uranium.

In June of the present year, I commenced a series of experiments upon the tinctures and infusions of the leaves, barks, and roots of various plants. A beam of sunlight was the agent employed for illumination. The apparatus, that of Prof. Stokes. Of the specimens examined, those worthy of note, with their results, are given in the following table:

Tinct. of	Quassia root,	light green.
"	Veratrum viride leaves,	greenish-yellow.
"	Aconite root,	orange-yellow.
"	Opium,	greenish-yellow.
"	Belladonna leaves,	yellowish-green.
"	Stramonium leaves,	light green.
"	Nux vomica root,	yellow.

The tinctures were then deprived of color by being filtered through animal charcoal, the object being to remove the coloring matter, as several of them gave reactions which were due to the presence of chlorophyll. On an examination they gave the following results:

Tinct. of	Quassia,	light green.
"	Veratrum viride,	yellowish-green.
"	Aconite,	yellowish-green.
"	Opium,	deep yellow tint.
"	Belladonna,	yellowish-green.
"	Stramonium,	light green.
"	Nux vomica,	light green.

Tinct. of Nux vomica deserves more than passing notice; when deprived of color it gave a faint green tint in place of the original yellow tint. All the alkaloids of the above that could be obtained were examined, viz:

Quassia,	distinct light green.	Codeia,	faint green passing to orange.
Veratria,	yellowish-green.	Atropia,	yellowish green.
Aconitia,	yellowish-green.	Strychnia,	faint green passing to orange.
Morphia,	yellow.		
Narcotina,	yellow.		

The next step was the examination of the fluorescence shown on the pouring of infusions of different substances into water contained in a tall jar, also the fluorescence shown by paper saturated with different infusions. The flame of burning sulphur served as the illuminating agent. The intensity of color varied as is shown in the table.

		Paper.	Liquid.
Infusion of	Esculin,	distinct,	distinct.
"	Cinchona,	pale,	distinct.
"	Quassia,	pale,	distinct.

	Paper.	Liquid.
Infusion of Stramonium,	pale,	distinct.
" Aconite,	indistinct,	pale.
" Veratria,	indistinct,	pale.
" Galls,	distinct,	distinct.

For the light of sulphur was then substituted that of the following illuminating agents, alcohol flame colored by different substances being used, with the accompanying results.

Red by nitrate of strontia,	no action.
Green by nitrate of baryta,	indistinct.
Yellow by chlorid of sodium,	no action.
Violet by chlorid of potassium,	similar to sulphur.
Red by carbonate of lithia,	indistinct.
Blue by blue fire,	very distinct.
Potassium,	distinct.
Magnesium,	no action.

The infusions of the above were spread upon paper and made to receive the solar spectrum. Those that produced elongation of the violet portion were—

Infusion of Cinchona,	very decided.
" Esculin,	very decided.
" Quassia,	very distinct.

Philadelphia, Dec. 8th, 1866.

ART. XXIX.—*Note on Dr. Andrews' paper on the Glacial Drift*;* by E. W. HILGARD, Prof. of Chemistry, University of Mississippi.

DR. ANDREWS' interesting paper on the Drift of Illinois, in the January number of this Journal, defines in a precise manner a point which I have heretofore failed to find distinctly elucidated, viz: the exact stratigraphical relations of the great stratified deposits of sand and gravel in the Northwest to such as exhibit unquestionable evidences of *glacier* action, and not only those which, so far as their character was concerned, might equally as well be referred to that of stranded floes, or shore-ice. It seemed strange, indeed, that the former should be absent, where so much of glacial transporting agency was apparent.

The occurrence of glacier-scored rocks is likely, in general, to be confined to a moderate distance from the parent glacier. Apart from the terminal moraine, we find them frozen into the bottom or sides of the glacier, and of course into the corresponding surfaces of the iceberg detached from it. They are therefore liberated by thawing long before those unscored an-

* This Jour., Jan. 1867, p. 75.

gular blocks, which, by falling into crevasses, become enclosed in the mass of the glacier without penetrating to the bottom. It is only when two thick glaciers unite into one at a very acute angle, that scored rocks may become imbedded in the interior of the combined mass, and afterward be conveyed to considerable distances in an iceberg.

Stratification, therefore, must always be the criterion between the moraine and the deposits formed of the ballast dropped by floating ice, though, from the mode of formation, distinct or continuous stratification could not be expected even in the latter.

Dr. Andrews specially mentions the stratification of the drift penetrated in the Chicago tunnel, and that by great care it can be observed in the greater part of the formation. The latter is therefore clearly not of the moraine character—it is the result of the combined action of water and floating ice, as required by the hypothesis advanced in the paper referred to by him. Nor does the occurrence of the true "glacial drift" beneath the stratified beds in any way detract from the importance of the latter, and the necessity of assigning the origin of their "thick masses" to a cause more powerful in degree and more widely active, than is implied in the sentence quoted from Dana's Manual.

While angular blocks do occur in the stratified drift of middle Illinois and Missouri, they, nevertheless, manifestly decrease in proportion to those of rounded form, as we advance southward; and the lithological composition of the "Orange Sand" of the Southwest is precisely such as we should expect to result from the modification, in proportion to distance and lower latitude, of the agencies to which the stratified drift of the Northwest seems to owe its conformation.

University of Mississippi, Feb. 2, 1867.

Art. XXX.—*On Naphtha and Illuminating Oil from Heavy California Tar (Maltha)*; by B. Silliman.

Having lately had an opportunity to examine a specimen of "surface oil," so called, from Santa Barbara county, in California, I present the following experimental results in the hope that they may not be without interest, as an addition to our knowledge of one extreme of that class of hydrocarbons which occur in nature in the fluid form, and of every density, from those which are but little lighter than water down to the lightest naphtha found in a natural state.

It is proper to state that the chemical examination of this sample had chiefly a technical object, to prove whether or not illuminating oil of good quality could be obtained from the distillation of so dense a body. The experiments were conducted on quantities of from five to ten gallons each. The crude oil was very dark, almost black, transmitting yellow brown light in thin films. At ordinary temperatures (60° F.) it is a thick, viscid liquid, resembling coal tar, but with only a very slight odor.

Its density at 60° F. is 0·980 or 13° Baumé. It retains, mechanically entangled, a considerable quantity of water, which is neutral in its reaction. The odor of sulphydric acid, which is very decided in this product, as I have noted in its locality, had entirely disappeared in the specimen under consideration.

The tar froths at the commencement of distillation, from escape of watery vapor. It yields by a primary distillation no product having a less density than 0·844, or 37° B. at 52° F.

Distillation to dryness produced in two trials an average result as follows:

Oil having a density of ·890 to 0·900, - -	69·82
Coke, water, and loss, - - - - -	30·18
	100·00

In one of these trials the product was divided as follows:

Oil, of density 29° B. at 52° (·885 sp. gr.), -	50·0
" " 24·75 " 53° (·908 "), -	17·5
Coke, water, loss, &c., - - - - -	32·5
	100·0

The coke is very large in quantity, strong, and is a good fuel, resembling gas-house coke. The odor of ammonia is given off toward the close of the distillation.

It is well known to distillers of petroleum that by the process called "cracking," heavy oils unfit for illumination are broken up into bodies of less density, from light naphtha to the heavier illuminating and lubricating oils. This process is simply the application of a carefully regulated heat producing a slow distillation. By this treatment the molecules apparently rearrange themselves into groups of different density, which by a subsequent distillation are divided into fractions (or "heaps" as Mr. Warren calls them) of tolerably constant boiling points.

The first distillate, having a density of about ·890 at 60° F., treated in this manner, yielded a product having a density of about ·885 at 60°, or only 1° Baumé lower than before distillation. After treatment with sulphuric acid and soda and redistilling from soda, it had a density of ·880 at 60° F. Upon redistilling, 100 measures of this last distillate yielded—

Light oil having a density of about ·834 at 60° F.,	21·58
Heavy " " " " ·880 " 66° F.,	37·41
" " " " " ·916 " 64° F.,	34·53
Coke, &c., - - - - - - - - -	6·48
	100·00

In another experiment undertaken with a view to "cracking," &c., treating and redistilling with soda, the products were as follows, stated in percentages of the whole quantity operated on, the several steps being as before.

Naphtha,* sp. gr. about ·760 at 60° F., - -	11·33
Oil,† " " ·836 " " - -	66·22
" " " ·893 " " - -	12·67
" " " ·921, - - -	3·56
Loss, - - - - - - - -	6·22
	100·00

The illuminating oil from both these experiments, after treatment with sulphuric acid and soda in the usual manner, acquired an agreeable odor, a light straw-yellow color, and burned as well in a lamp as good commercial oil.

With a view to test the effect of heat aided by pressure in breaking up the heavy hydrocarbons—a method of treating heavy hydrocarbon oils patented in 1866 by Mr. James Young of Glasgow—a portion of the first distillate from the crude oil was subjected during distillation to a pressure of ten to fifteen pounds to the square inch, in an apparatus adapted to the purpose, the distillate thus obtained being about the same density as in the first named experiment, ·890 at 60° F.

From this distillate were obtained, after the ordinary treatment with sulphuric acid and soda, the following products:

Light oil, sp. gr. ·825 at 60° F., - -	19·2 p. c.
Heavy " " ·885 " " - -	25·86 "
" " " ·918 " " - -	38·14 "
Coke, loss, &c., - - - - -	16·80 "
	100·00

The illuminating oil from the last experiment flashed at 80° F. and lighted on the surface at 85° F., showing the presence of naphtha or some very light body, the quantity of which cannot be very considerable. The light oil could with care be taken off in practice without materially diminishing the yield of illuminating oil. It would be rash to conclude that there may not be an important economical advantage in employing in the large way Mr. Young's method of treatment under pressure, over that of "cracking" by a regulated heat alone. It is highly probable that there would be found an important saving of time, as under a regulated pressure and a corresponding increase of temperature, the transformation of the heavy oils into a mixture of those of less density, will occur more speedily. The experiments herein mentioned gave nearly the same result whether

* This naphtha caught fire from a match at an atmospheric temperature of 56° F.
† This oil flashed at 113° F. and ignited at 124° F.

pressure was used or not; a certain loss, all falling upon the lighter portions, was found to result from leakage of the apparatus under pressure, which in the larger way of operating commercially could be avoided.

No paraffine could be detected by refrigerating the heavy oils obtained in these distillations in a mixture of salt and ice. It is no doubt the absence of this body from the series of products obtained from the California oils generally, that accounts for the illuminating oil burning well at a density considerably below the commercial standard for oil obtained from Pennsylvania petroleum—a difference enhanced also by the absence of any considerable quantity of light naphtha. The lubricating oils of this series, likewise free from paraffine, retain on this account their fluidity at low temperatures.

The light oils obtained in this series of experiments correspond respectively to 12·96, 14·56 and 18·96 per centum of the crude oil. The total commercial products are about 60 per cent of the crude body, which likewise yields sufficient coke to supply the fuel required in the distillations.

In the large way, by returning the lightest oils to the heavier portions in the successive distillations and employing Mr. Young's method by pressure, it is probable the product of light or illuminating oils may be raised in these very heavy natural products to 30 per cent.

It is evident from these experiments that heavy hydrocarbon oils containing no naphtha are convertible into oils of the naphtha series under the action of heat by molecular transformations, the excess of carbon being left behind as coke; each successive distillation eliminating a new but always a diminished portion of carbon.

I am indebted to Mr. A. J. Corning, formerly assistant to Mr. Warren, for conducting this research under my direction; and to Messrs. Downer and Merrill, of the kerosene works in South Boston, I am under many obligations for the permission to employ their operative laboratory in conducting this research. As before stated, the research had chiefly a technical object, the points of scientific interest being subordinate in a great degree. For the crude material operated on I am indebted to the California Petroleum Company, from whose estate it was derived.

Note.—In the number of this Journal for May, 1865, I published the analyses of a sample of crude petroleum, believed by me to be from a well-known spring, called the "Pico Spring," in Santa Barbara county, California. This sample, as well as a subsequent one in larger quantity, came to me under seal from responsible parties and no question of its authenticity, until a very recent period, ever reached me. It is now confidently asserted, by certain parties, that the samples in question were sophisticated by the addition of refined commercial petroleum. An inquiry instituted privately by me has elicited from the parties immediately concerned in its transmission only an emphatic denial of the charge of falsification, and if any such fraud has been perpetrated I am well persuaded that the responsibility falls elsewhere. My investigations in this direction are unrelaxed, and the truth cannot remain long concealed.

New Haven, January 14th, 1867.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the influence of the absorption of heat upon the formation of dew.*—The long pending controversy between Magnus and Tyndall in relation to the absorptive power of aqueous vapor, appears to have been brought to a conclusion by an experiment of Magnus based upon the principle of the equality of the radiating and absorbing powers of bodies. The apparatus employed consisted of a horizontal brass tube, which could be heated red hot by means of a row of burners, and served to conduct the gases and vapors to be examined. One end of this tube was turned up vertically so as to form the radiating jet of gas or vapor; the other was connected with a bellows, while by means of interposed branched tubes and other apparatus the air driven through could be previously dried or passed through water at a known temperature: finally, pure aqueous vapor could be employed to form a jet without admixture of air. A thermometer was suspended over the jet so that its temperature could be determined with sufficient accuracy. The heat radiated from the jet of gas or vapor was allowed to fall upon one surface of a thermo-pile provided with conical reflectors and placed within a double chest of card-board. The effect produced by the radiation of heat from other sources than the jet of gas or vapor was compensated by placing a second and precisely equal source of heat upon the other side of the thermo-pile. With this arrangement a jet of dry air produced by radiation a deviation of the galvanometer which amounted to only three divisions of the scale. When the air was passed through water the deviation remained almost the same. When dry carbonic acid gas was passed through the hot brass tube the deviation amounted to 100–120 divisions, and common illuminating gas gave nearly the same deviation. When air was passed through water heated to 60°–80° C. the deviation rose to 20, but very gradually, while the deviations produced by carbonic acid and illuminating gas were sudden, and rapidly rose to their maxima. When the water boiled so as to produce clouds in the jet of air the deviation exceeded 100 scale divisions, and the same result took place when no jet of air was forced through but the steam alone formed vesicular vapor. When no vesicular vapor was present the galvanometer gave no greater deviation than 20, no matter how much steam might be present.

The greater deviation invariably accompanied the formation of vesicular vapor. From these experiments Magnus concludes that transparent or proper aqueous vapor has a radiating and absorbing power but little greater than that of air, and consequently that the absorptive power of air which contains transparent vapor differs but little from that of dry air. In conclusion the author brings forward an argument based upon the formation of dew. If aqueous vapor were as good an absorbent of heat as Tyndall supposes, dew could never be formed at all, since the vapor necessary for its formation would form a covering over the surface of the earth and prevent radiation. In the tropics, where the atmosphere is loaded with moisture, the dew is very heavy. If the vapor of water possessed as high an absorptive power as Tyndall attributes to it, only a small portion of the heat radiated from the earth could reach the clouds, and the effect of clouds in preventing the formation of dew could not be explained. The conclusions of Frankland in regard to the ice period, and of Tyndall for certain climatic phenomena, based upon the absorptive power of aqueous vapor, remain unchanged if we substitute vesicular vapor. The author further cites the experiments of Cooke and Secchi in regard to the absorption of light by aqueous vapor as shown by the spectroscope, a few dark lines being produced which scarcely diminish the total intensity of the light.—*Pogg. Ann.*, cxxvii, 613.

W. G.

2. *On some new forms of electrical apparatus.*—Töpler and Holtz have described independently, but at about the same time, new forms of electrical machines which may be regarded most simply as rotating electrophori. Töpler's machine, which is the simpler of the two, consists essentially of a circular plate or disc of thin vulcanized rubber, gutta percha or glass, mounted upon a vertical axis and caused to rotate rapidly by means of a band and wheel. The disc is coated upon each side with two segments of tin foil, a free space being left between the segments, while the coatings are connected over the edge of the disc by strips of foil. A piece of hard rubber forming a segment of a circle is then excited by friction and placed near and parallel to the lower coated surfaces of the revolving disc. This lower surface becomes electrical by induction, the opposite electricity being driven over the edge to the upper surface of the plate. As the plate revolves, one under segment of tin foil is removed from the inductive action of the excited surface, and the second becomes parallel to it, when the free electricity is decomposed as before. Two isolated conductors are placed above and parallel to the disc, and each carries at one end a light spring or strip of tin foil which rests upon the upper surface of the disc. The two strips are so arranged that as the disc revolves one strip is just leaving a segment of tin foil as the other is brought into contact with it. In this manner the electricity driven to the upper surface is first carried off by one conductor, while the electricity retained upon the lower surface at first, as the plate revolves, passes to the upper surface and is drawn off by the second conductor. The same process then takes place with the second coating, and so on alternately. It will be seen that so far the apparatus is exactly equivalent to an electrophorus, and that the action, though powerful at first, must diminish rapidly as the inductor loses electricity. To remedy this

difficulty a second but smaller disc of glass is placed on the same axis, coated with tin foil in the same manner and provided with a similar inductor and similar conductors. This second inductor is connected with one pole or conductor of the upper and larger plate. Of the two similar conductors belonging to the lower plate, one is connected with the earth while the other is connected with the inductor of the upper plate. In this manner, as the discs rotate, the earth furnishes a constant supply of electricity, and the action of the machine is remarkably powerful. Holtz's machine depends upon similar principles, but could hardly be made intelligible without figures. Several of them have already arrived in this country. A simpler form of apparatus of the same kind has since been described by Bertzch. All these instruments appear to be very much more powerful than plate electrical machines of the same size, and they have the advantage of working with but a small application of force.—*Pogg. Ann.*, cxxv, 469; also Holtz in *Pogg. Ann.*, cxxvii, 320; Bertzch in *Cosmos*, No. 7, 1866. W. G.

3. *On nitrites of cobalt and nickel.*—O. L. Erdmann has described a series of double nitrites which, while not wanting in interest from a theoretical point of view, are of some importance in analytical chemistry. Nickel gives, with potash and nitrous acid, a soluble double salt, crystallizing in brownish-red octahedrons and having the formula $2KO,NO_3+NiO.NO_3$, as already found by Lang and Rammelsberg. When a solution of this salt is mixed with one of chlorid of calcium, or when nitrite of potash is added to a solution containing both nickel and calcium, a yellow crystalline precipitate is formed which is very slightly soluble in cold but much more soluble in hot water. The solution is green, but the salt is always more or less decomposed. When the salt is formed slowly it crystallizes in well-defined regular octahedrons. Its constitution is represented by the formula

$$CaO,NO_3+NiO.NO_3+KO,NO_3 \text{ or } \left.\begin{matrix}NiO\\CaO\\KO\end{matrix}\right\} 3NO_3.$$

The corresponding barium salt has been described by Lang. It is also very slightly soluble in water, and crystallizes in microscopic cubes with octahedral faces. The strontium salt forms reddish-yellow crusts consisting of microscopic cubes. Cobalt forms precisely analogous compounds. The triple nitrite of cobalt, potash and lime, forms a black-green crystalline precipitate. The salts of cobalt with barium and strontium, have a still more beautiful green color, but like the calcium salt are decomposed by washing. The ammonia nitrite of nickel, which Erdmann terms nitrite of diamin-nickel, forms small cherry-red brilliant crystals having the formula $2NH_3.NiO,NO_3$, and easily decomposed. Fischer's nitrite of cobalt and potash, which according to Stromeyer has the formula $Co_2O_3.2NO_3+3KO,NO_3$, is, according to Erdmann, a mixture of two different salts, one of which is formed in an acid and the other in a neutral solution. The salt formed in a neutral solution has the formula $\left.\begin{matrix}3CoO\\3KO\end{matrix}\right\} 6NO_3+HO$. It is a yellow crystalline powder composed of microscopic cubes. The author has satisfied himself that no absorption of oxygen takes place during the formation of this salt, and consequently that the cobalt is present as protoxyd, and not as sesquioxyd as Stromeyer supposed. The salt is insoluble in cold water, but dissolves in boiling water with a red color. When a solution of chlorid of cobalt is acidulated with acetic acid and then a solution of nitrite of potash added, a yellow precipitate of a brighter color than that of the last mentioned salt is formed. If the quantity of acetic acid is small the solution gradually becomes less acid and finally weakly alkaline. The first mentioned salt is then deposited, so that in analyses the substance weighed is usually a mixture of the two salts. The salt precipitated from an acid solution has the formula $\left.\begin{matrix}2CoO\\3KO\end{matrix}\right\}6NO_3+3HO$, which may perhaps be written more correctly $\left.\begin{matrix}2CoO\\3KO\\HO\end{matrix}\right\}6NO_3+2\text{ aq}$. The corresponding ammonia salt has the formula $\left.\begin{matrix}2CoO\\3NH_4O\\HO\end{matrix}\right\}6NO_3+2aq$, and consists of microscopic cubes slightly soluble in cold water with a yellow color. When a solution of chlorid of cobalt is heated with much sal-ammoniac, and then with a solution of nitrite of potash, a yellow precipitate is formed in brilliant micaceous scales, while the liquid becomes strongly acid and evolves nitrous acid. The mother liquor afterward deposits brown crystals. The yellow salt appears not to have a constant composition, but the brown compound is easily purified by recrystallization; it has the formula $2NH_3.Co_2O_3,3NO_3+KO,NO_3$. With nitrate of silver this salt gives a yellow or orange precipitate which has the formula, $2NH_3.Co_2O_3,3NO_3+AgO,NO_3$. The author describes a corresponding ammonium salt isomorphous with the potassium compound. When a solution of chlorid of cobalt is heated with an excess of a mixture of ammonia and nitrite of potash, the solution absorbs oxygen on standing and becomes darker, depositing finally bright brownish-yellow leaf-like crystals which are with difficulty soluble in cold water but dissolve pretty easily in hot water, and crystallize from the solution in the form of brilliant deep yellow flat needles or leaves. This compound has the formula $3NH_3.Co_2O_3,3NO_3$, and appears to be the nitrite of the base $3NH_3.Co_2O_3$, the sulphite of which was described by Künzel.—*Journal für prakt. Chemie*, xcvii, 385. W. G.

4. *On the synthesis of alcohols by means of chlorinated ethers.*—Lieben has studied the action of zinc-ethyl upon the chlorinated ethers, and has obtained results of great interest closely connected with those of Frankland on the structure of the organic acids. By the action of zinc-ethyl upon bichlor-ether, $\left.\begin{matrix}C_2H_3Cl_2\\C_2H_5\end{matrix}\right\}O$, Lieben and Bauer had already obtained ethylo-chlor-ether, $\left.\begin{matrix}C_2H_3.Cl.C_2H_5\\C_2H_5\end{matrix}\right\}O$. By the action of concentrated iodhydric acid upon this body the chlorine is in a great measure replaced by hydrogen, iodine is set free and a heavy oil is formed containing iodid of ethyl, ethylated chlor-ethyl, and ethylated iodid of ethyl. Ethylated iodid of ethyl has the constitution and boiling point of Wurtz's iodid of butyl. With acetate of silver it yields ethylated

acetate of ethyl and butylene. Ethylated acetate of ethyl, by boiling with concentrated caustic potash yields ethylated alcohol, which has the properties of the butyl-alcohol obtained by Wurtz from the fusel oil of beet sugar. Lieben thinks it probable, however, that this body is only isomeric with butyl-alcohol and is identical with butylene-hydrate. By the action of iodhydric acid upon biethylated ether, $\left.\begin{matrix} C_2H_3 . C_2H_5 . C_2H_5 \\ C_2H_5 \end{matrix}\right\} \Theta$, Lieben has obtained biethylated iodid of ethyl, from which it is probable that biethylated ethyl-alcohol will be obtained. This would be a secondary or tertiary alcohol isomeric with normal butyl alcohol. The author promises a continuation of these researches which can hardly fail to result in the formation of a great number of new alcohols with their corresponding acids.—*Sitzungsber. der Wiener Acad.*, liv, 225, quoted in *Chem. Centralblatt*, No. 1, 1867. W. G.

5. *Graphitoidal Boron, a compound of aluminum.*—St. Claire Deville communicated to the French Academy at its session on the 21st of January the fact that in connection with Wöhler he had recently ascertained that the variety of boron called graphitoidal, originally described by them, was not pure boron, but a definite compound of boron with aluminum. It is formed in the preparation of crystallized boron by means of aluminum, especially when the temperature is not sufficiently high. This aluminic borid crystallizes in very fine hexagonal plates, of the color of pale copper, is perfectly opaque and possesses a metallic luster. According to W. H. Miller these plates belong to the monoclinic system. Heated in the air, it does not burn, but is blued like steel. In chlorine it burns forming aluminic and boric chlorids. It is slowly soluble in hot concentrated chlorhydric acid, and in a hot solution of sodic hydrate, evolving hydrogen. In very strong nitric acid it dissolves easily. The addition of ammonic carbonate to this solution precipitates a basic aluminic borate. In the analysis the boric acid was expelled from this precipitate by fluohydric acid, and then the fluorine by sulphuric acid. Two analyses gave 54·02 and 54·91 per cent respectively of aluminum, corresponding to the formula AlB_2.—*L'Institute*, 1867, p. 27.

6. *Tests for glucose.*—Braun uses a solution of picric acid in 250 parts of water. The glucose solution, containing a little caustic soda, is heated to 90°, a few drops of the picric solution are added, and the whole raised to ebullition; the presence of glucose is indicated by a blood-red coloration due to the production of picramic acid. Cane sugar does not produce this change.—*J. pr. Ch.*, xcvi, 411.

Franqui and deVyvere modify Böttger's test by using an alkaline solution of the bismuthic oxyd. It is prepared by precipitating bismuthic nitrate by a large excess of potash, and adding gradually to the mixture, moderately heated, a solution of tartaric acid; the precipitate dissolves completely, even before the liquid becomes neutral. If a few drops of this reagent be added to diabetic urine, and the whole be boiled, the liquid speedily becomes black and throws down a deposit of metallic bismuth.—*Jour. Med. Brux.*, 1865, 359.

7. *Hydrocarbons from animal fats.*—Warren and Storer have examined the products resulting from the destructive distillation of a lime soap, produced by the saponification of "menhaden oil," from the *Alosa*

menhaden. The crude hydrocarbons thus obtained were distilled in a current of steam, the distillate treated with sulphuric acid and soda, and again distilled. The rectified product "so closely resembled refined coal oil and petroleum in odor, color, and illuminating properties, that it could hardly be distinguished from these." Their special investigation, however, was confined to the naphtha obtained from the crude product by Warren's process of fractional condensation; indicating by this name, all those hydrocarbons which passed the hot condenser at 220° C. By repeated distillations of this sort, occupying nearly a year, sixteen bodies of constant boiling point were obtained, belonging to several series. To the hydrid series (C_nH_{2n+2}) the hydrids of amyl, caproyl, œnanthyl and capryl; to ethylene series (C_nH_{2n}) amylene, caproylene, œnanthylene, caprylene, pelargonene, rutylene, margarylene, laurylene; and to the benzole series (C_nH_{2n-6}) benzole, toluole, xylole, isocumole. 23·5 per cent consisted of isocumole and rutylene; 13·3 per cent of xylole; 12·5 per cent of caprylene and hydrid of capryl; and 10·2 per cent of margarylene. The importance of this research in relation to the geological production of petroleum is at once evident.—*Mem. Am. Acad.*, new series, ix, 177.

8. *Naphtha from Rangoon petroleum.*—Warren and Storer communicate also the result of the examination, by fractional condensation, of the naphtha from Rangoon petroleum. Owing to the limited supply of material in their hands, they regard their results as only partially complete. Of the hydrid series they assume the presence in this naphtha of the hydrids of œnanthyl, capryl, and pelargonyl; of the ethylene series, they obtained rutylene, margarylene, laurylene, cocinylene, and probably pelargonene; and of the benzole series they regard the presence of xylole and isocumole as probable.—*Mem. Am. Acad.*, new series, ix, 208.

9. *Synthesis of petroleum.*—Berthelot has recently raised the question whether the hydrocarbons found so abundantly in many places may not be of inorganic origin. How otherwise can their presence in volcanic vapors and even in meteorites be accounted for? Without presuming to decide the matter, he thinks it of interest to show, from his recent researches, how such compounds could be formed from purely inorganic materials. If we admit that the alkaline metals may exist in the earth's interior, a hypothesis by no means improbable, the production of these hydrocarbons necessarily follows. For by the action of these alkaline metals upon carbonates, Berthelot has shown that acetylids result; as for example from calcic carbonate, is produced calcic acetylid (C_2Ca). By the action of water upon these compounds free acetylene is evolved; thus $C_2Ca+(H_2O)_2=C_2H_2+CaH_2O_2$: but under the conditions of pressure and temperature there existing, the acetylene would at once be condensed, forming the benzole series; $(C_2H_2)_3=C_6H_6$ or benzole. But from the action of steam upon the alkaline metals, hydrogen would be evolved; and this hydrogen, being condensed with the acetylene, would produce the ethylene series ($C_2H_2+H_2=C_2H_4$); or even the hydrid series ($C_2H_2+H_4=C_2H_6$ ethylic hydrid), all of which series occur in natural hydrocarbons. "We can thus conceive the production by a purely mineral method of all the natural hydrocarbons. The intervention of heat, water, and alkaline metals,—lastly the tendency of the carbides to unite together so as to form matters more condensed, suffice

to account for the formation of these curious compounds. This formation can also be effected in a continuous manner since the reactions which produce it are incessantly renewed."—*Ann. Ch. Phys.*, December, 1866.

10. *Silvering upon glass.*—Having occasion recently to silver some thin microscopic glass, several processes were tried with indifferent success, until finally I hit upon Bothe's method as modified by Böttger (J. pr. Ch., xcii, 494) which afforded most excellent results. Its simplicity, economy, and satisfactory performance induce me to reproduce it here.

7·8 grams of argentic nitrate are dissolved in 60 cc. of water and the solution is divided into two equal portions. A solution of 3·11 grams potassio-sodic tartrate (Rochelle salt) in 1420 cc. of water being brought to *active ebullition*, one of the above portions of the silver solution is gradually added, the boiling is continued 8 or 10 minutes, the whole is allowed to cool and is then filtered. This is the reducing solution.

To the second portion of the silver solution, caustic ammonia is added till the precipitate is *almost* redissolved, care being taken to avoid an excess, and then 355 cc. of water being added, the whole is filtered.

To silver the glass, equal portions of these two fluids, thoroughly mixed and perfectly clear, are poured upon it. After the lapse of about *ten minutes*, a most brilliant layer of metallic silver is deposited, which may be thickened to any desired extent by repeating the process. The film is protected by a layer of varnish. G. F. B.

11. *Nodal figures in organ pipes;* by Dr. AUGUST KUNDT.—In continuing his acoustic researches (see this Journal, Sept., 1866,) Dr. Kundt has made some farther very interesting discoveries, which are of great theoretical importance and very useful in the lecture room. First he substitutes fine ground or precipitated silicic acid in the place of lycopodium: the silica can be freed from all moisture by ignition, is not acted upon by gases, is equally light, etc. Repeating the experiment reported in the September number of this Journal, he discovered that the *silica forms very thin vertical partitions often across the whole section of the tube while vibrating*, dropping down at the close of the motion, thus forming the transverse ripplings there spoken of.

Taking now an organ pipe—say the mouth-piece of a common tin whistle to which a clean dry glass tube is attached by means of a rubber tube—and intonating any of the higher tones of the pipe, and, if necessary, aiding the silica evenly distributed in the horizontal tube by a few light taps to follow the undulations of the air,—we see a nodal figure of great beauty and distinctness appear, most readily in a closed, but also in an open, pipe. The whole pipe is divided into oval nodal spaces, distant half a wave-length from one another, and between them we see fine, parallel and very distinct, nearly equidistant transverse ripplings, resulting from the transverse walls raised in the tube during the vibration. The experiment is so easily repeated (blowing by means of a bellows or even the mouth) and the nodal figures so exceeding beautiful both during and after the intonation, and the same may so easily be preserved thereafter, that every reader ought to repeat the experiment. Measuring the distance of any two nodal areas gives with great accuracy the half-wave-length of the tone; the same pipe may in quick succession—after merely shaking up the silica in the pipe—be made to give different tones, the pitch of which is easily ascertained by the ear, and the length of whose waves is found to coincide admirably with the calculation based upon the first determination and the interval—or the velocity of sound and the number of vibrations. The known methods of Hopkins, König, and others, for representing the vibrations of the air in organ pipes are very deficient: Kundt's method is as complete as it is simple.

But it shows more than anticipated. If repeated by means of a vertical pipe, with a *gas-flame* in place of the silica, this flame shows a corresponding stratification in dark and bright layers—the luminous strata evidently due to an accumulation of carbon particles. The mutual distance of these luminous strata is nearly proportional to the length of the tube. From this and other facts Dr. Kundt concludes that the rippling of the silica and the stratification of the flame probably are due to the higher or *secondary tones* (obertöne of Helmholtz) coëxisting with the one produced, and whose wave-length is measured by twice the distance between two consecutive nodal areas.

For farther detail, and many other interesting results, we must refer to the paper of Kundt in Poggendorff's Annalen, 1866, cxxviii, 337–355 and 496. In the same volume, page 610–613, the same investigator gives an interesting method for the observation of the vibratory forms of plates by means of reflection. G. H.

12. *Influence of the interior friction of the air on the transmission of sound;* STEFAN (Acad. Vienna, April, 1866).—The analytical results are:

(1.) The velocity is greater for the tones of higher pitch; for the highest tones it only is one-thousandth of a millimeter [so that dispersion of sound is practically impossible?].

(2.) The amplitudes of plane progressive waves decrease in a geometrical progression, the ratio of which is proportional to the square of the number of vibrations. The amplitude is reduced to one-ninth in 1000 meters for 10,000 vibrations, or in 100 meters for 30,000 vibrations per second.

(3.) In stable vibrations the wave-length cannot be greater than four times the mean excursion of a molecule of the air (as assumed in Krönig's theory of the construction of gases).

(4.) The amplitudes in stable waves decrease in geometrical progression of the time, the ratio being proportional to the square of the number of vibrations. Thus the amplitudes of tones of 1000, 10,000, and 30,000 vibrations will in 100, 1, and $\frac{1}{10}$ second be reduced to one-half their original amount.—*L'Institut,* 1866, p. 271. G. H.

13. *Interferential tones.*—In May, 1866, STEFAN communicated to the Academy of Vienna some interesting experiments, giving for tones, the vibratory motion of which cannot be contested, a transformation perfectly analogous to the theoretical decomposition of light-waves traversing a quartz crystal in the direction of the axes and producing the rotation of the plane of polarization.

A square plate exhibiting two nodal lines at right angles will produce a more intense tone if the two opposite sectors (having the *same* motion) are covered with a card of their own figure and size: for then the parts of the plate adjacent to these will alone move the air with concordant impulses. If now the card (or the plate) be rotated n' times a second, the intensity will show n' periods per second; if the amplitude of the original vibration of the plate be a, the amplitude corresponding to the rotation of the card be a', and the pitch of the tone of the plate n, we have $a=a'\sin 2n'\pi t$, and hence the original tone $A=a\sin 2n\pi t$ becomes

$$A=a'\sin 2n'\pi t\sin 2n\pi t=\frac{a'}{2}\cos 2(n-n')\pi t-\frac{a}{2}\cos 2(n+n')\pi t,$$

that is *two tones of pitch* $n-n'$ *and* $n+n'$ (or a *graver* and a *higher* tone) *will be heard instead of the primary tone of pitch* n.

Thus Stefan found that a plate giving the tone fis_2, which according to Quincke's table (this Journal, Nov. 1866, p. 417) corresponds to $185=n$ vibrations, produces, when $n'=10$ rotations per second, the tones $f_2=174{\cdot}6$ and $g_2=196$, which are very nearly 185 ± 10. L'Institut gives fis_1, etc., no doubt by a mistake in translating Stefan's German notation.—*L'Institut*, 1866, No. 1710, p. 327; *Cosmos*, 1866, vol. iv, pp. 458, 459. G. H.

14. *Foucault's silvered objectives for observations of the sun.*—A very ingenious method for close observation of the solar disc was communicated by Foucault in September, 1866. Having noticed that no heat and very little light is transmitted through the thin bright silvering of his glasses, he coated the outer surface of the objective of a refracting telescope with such silvering, and found, as he expected, that all heat-rays were reflected, as also the greater part of the light, so as to permit only a pale bluish-violet to pass through. LeVerrier reported, October, 1866, most favorably as to the results obtained by a 9-inch refractor (equatorial). No heat could be felt in the very focus of the objective directed toward the sun—thus freeing all solar observations of a very great cause of error. Furthermore only the ultra-red rays are really absorbed; all others are, as the prismatic spectrum shows, only diminished in intensity so as to give a steady (calme) and pure image of the sun, showing all detail of outline and color with excellent definition, and permitting a magnifying power of 300.—*L'Institut*, 1866, pp. 281, 313; *Cosmos*, 1866, iv, 387, 430. G. H.

15. *Lead-thallium glass* has greater density and refracting power than common lead-flint glass; 300 pure sand, 200 minium, and 335 carbonate of thallium (instead of the usual 100 carbonate of potassa), give a glass of density 4·235, index of refraction 1·71, and only very slight yellowish tint. It has been made in England.—*L'Institut*, 1866, p. 320. G. H.

16. *Expansion of water and mercury*; A. MATTHIESSEN.—The results of this very elaborate investigation are—the volume of water at any temperature $t°$ C. is $V=a-bt+ct^2-dt^3$, the volume at 4° C. being 1 and the coëfficients

	for $4°<t<32$	for $32<t°<100°$
a	1·00013845328	0·999695
b	0·00000579896	0·000000
c	0·00000752824	0·0000054724
d	0·00000007173	0·000000011260

The coëfficient of expansion for a volume of mercury he finds from five series of determinations (per degree C.)

0·0001812

Regnault found 0·0001815.

—*Poggendorff's Annalen*, 1866, cxxviii, 512–540. G. H.

17. *On the expansion of crystals.*—Fizeau has invented a method for the exact determination of the coëfficient of expansion of small solids (only a few millimeters thick), and obtained important results thereby (Cosmos, 1865, xxvi, 641). The following is the substance of a later and more elaborate research of Fizeau.

Let the coëfficient of expansion in the direction of the three axes of elasticity of any crystal be represented by α, α', α'', then the expansion D in any direction determined by the three angles δ, δ', δ'', will be

$$D = \alpha \cos^2 \delta + \alpha' \cos^2 \delta' + \alpha'' \cos^2 \delta'',$$

and the cubical expansion is

$$c = \alpha + \alpha' + \alpha'',$$

which is the same as D for $\delta = \delta' = \delta'' = 54° \, 41'$, or in a direction at right angles to the surface of a regular octahedron whose axes coincide with the directions of α, α', α''.

Fizeau determines α for three temperatures (viz., 20°, 40° and 60° C.) from which he deduces the value for α at any temperature ϑ, and also the variation of α for each degree, that is $\frac{\Delta\alpha}{\Delta\vartheta}$, which is a constant quantity.

He puts the crystal with one side on a platinum support, and places a polished glass plate above the upper surface so as to leave a small interval; by means of a telescope he counts the number of fringes passing beyond certain fixed points of the support, these Newtonian rings being produced by an alcohol flame with salt, and changed by heating the whole apparatus. For the detail of this method we must refer to the original paper—we can here only give a tabular view of the results obtained thereby. At 40° C. the coëfficient of linear expansion in the direction of the axis is α, at right angles to the same α', cubical expansion $c = \alpha + 2\alpha'$, Δ the variation for each degree; t is the temperature at which the body has a *maximum of density*. The unit of α, α', c and Δ is 0·00000001, or *one hundred millionth* of the unit of length or volume.

	α	Δ	α'	Δ	c	Δ	t° C.
Platinum with 0·1 iridium,	883·847	0·7588	....	....	....	....	......
Mirror-glass, ...		.....	....	....	2331	4·74	......
Diamond, ...		.....	....	....	354	4·32	−42°·3
Cuprite, ...		.. ..	....	....	279	6·30	− 4°·3
Beryl, ...	106	1·14	137	1·33	380	3·80	− 4°·2
Quartz, ...	781	1·77	1419	2·38	3619	6·53	......
Rutile, ...	919	2·25	714	1·10	2374	4·45	......
Cassiterite, ...	392	1·19	321	0·76	1034	2·71	......
Periclase (artificial), ...		.....	. ..	....	3129	8·01	......
Spartalite (ZnO), ...	316	1·86	539	1·23	1394	4·32	......
Corundum, ...	619	2·05	533	2·25	1705	6·55	......
Hematite, ...	829	1·19	836	2·62	2501	6·43	......

	c	Δ	t° C.
Senarmontite,	5889	1·71	......
Arsenious acid (artificial),	12378	20·37	......
Spinel (regular system, hence $\alpha = \alpha' = \alpha''$),			......
1. Ruby from Ceylon,	1787	7·29	......
2. Pleonast from Warwick,	1805	5·34	......
3. Gahnite from Fahlun,	1766	5·19	......
4. Kreittonite from Silberberg,	1750	5·31	......

It is evident that t is found by $c - \Delta t = 0$; it thus appears that the maximum of density instead of being an exception may be the rule! Fizeau has cut a needle of beryl wherewith he proposes to verify it.—*Poggendorff's Annalen*, 1866, cxxviii, 564–589. G. H.

18. *Expansion of a conductor due to the galvanic current;* by Er. Edlund (Swedish Academy, January, 1866).—When a current passes through a conductor, the latter is heated to a certain temperature, t, above its surroundings and consequently expanded; but it may be questioned whether this expansion is due to the temperature of the conductor, or *whether it is greater*, so that the galvanic current itself produces a peculiar expansion of the conductor through which it flows. That this last is the case has been experimentally demonstrated by Edlund. This expansion might perhaps be called *galvanic;* the usual, *caloric expansion.*

He very carefully measured the actual expansion, E, of the conductor (platinum, iron and brass were used) and the corresponding resistance R. Next he determined the expansion produced by heat alone in the same wire, so that he accurately can determine the temperature, T_1, of the conductor from E, considering this expansion due to the temperature alone. Finally, he carefully determines the influence of temperature on the conducting power of the very same wire; so that he can calculate the temperature T_2, which would correspond to the above resistance R—that is, he determines the actual temperature of the conductor while the current circulates by the resistance it offers.

Edlund found T_2 invariably from 1° to 10° *lower* than T_1,—or the actual expansion, E, of the conductor is greater than would be produced by the actual heating, T_2, of the same, this being calculated from the measured resistance, R, of the same conductor. The expansion was not due to a change in elasticity, for the tension of the wire varying from 2½ to 3½ pounds did not change the result. *This galvanic expansion increases rapidly with the intensity of the current*—but according to what law is still unknown.—*Poggendorff's Annalen*, 1866, cxxix, 15–44.

G. H.

II. MINERALOGY AND GEOLOGY.

1. *Note on the use of the name Hudson-river group:* by F. B. Meek.—In the Introduction to the Illinois Paleontology, just published, Mr. Worthen and the writer have some remarks on the impropriety of transferring the name *Hudson-river group*, from the older series of contorted slates and argillaceous sandstones to which it was originally applied (existing in great force along that stream above the Highlands), to the more modern group composed of the *Lorraine shales, Frankfort slates*, &c., with which the true Hudson-river rocks were subsequently confounded.

Since these remarks were in print, I observe we were in error in supposing that late investigations had brought to light facts casting doubt upon the occurrence of the later types of fossils along *any* part of the Hudson river, in other than the little isolated masses alluded to as occupying synclinal axes in the older rocks, or entangled amongst their contorted strata. The fact, however, that the more modern types of fossils are not known to occur under other circumstances than those mentioned, along the part of that stream regarded as the *typical localities* of the *Hudson-river group* and lying mainly between the Highlands and the region of Albany, while the name, as originally used by Conrad and Mather, was expressly applied by them to this older series, which they regarded as belonging to the Cambrian of Sedgwick, is believed to be a sufficient reason for objecting to the transfer of the name to the later group. Hence if retained at all, it is believed this name should be applied exclusively to the group of rocks for which it was originally intended, and to which it must always carry the minds of those who may look into its origin and history. As it, however, subsequently became very generally also associated with the more recent series already alluded to, it probably could not now be restricted without much inconvenience, to the rocks to which it properly belongs. Consequently the surest, if not the only, way to avoid confusion, will be to strike it entirely from our nomenclature. The name applied to the more recent rocks, in Mr. Worthen's Report on Illinois, is the *Cincinnati* group, from the great development and highly fossiliferous character of these beds at the well-known city of that name in Ohio.*

2. *Note on Bellinurus Danæ, from the Illinois Coal-measures;* by F. B. Meek.—In the Proceedings of the Academy of Natural Sciences of Philadelphia for March, 1865, and again in the Illinois Paleontological Report, Mr. Worthen and the writer have described a new species of crustacean under the name *Bellinurus Danæ.* In both of these publications it is stated that we had not seen the original description published by the founder of the genus *Bellinurus*, nor a full description of it by any other author; but that our species, although closely allied to the forms figured by Prestwich and usually referred to this genus, differs from the characters assigned it by Portlock, Owen and some others, in having its body segments anchylosed, as well as in the position of the eyes.

In the Quarterly Journal of the Geological Society of London, Nov. 1865, p. 490, I observe Mr. Henry Woodward, in speaking of the genus *Bellinurus*, says, "the segments of the abdomen, if not anchylosed in all, are so in most" of the species.

In "The Reader" of Dec. 1866, containing an abstract of the Proceedings of the London Geological Society, it is stated that in a paper read by Mr. H. Woodward, Nov. 1866, "On some points in the structure of the *Xiphosura*," he remarked that this group is "divisible into three genera; 1st. *Bellinurus*, having 5 freely articulated thoracic segments, three anchylosed abdominal ones, and a telson; 2nd. *Prestwichia*, a new

* It has been suggested that Prof. Safford's name, Nashville group, should be retained for this formation. To this I do not seriously object: the only reason for not using it is, that Prof. S. applied it to a group including along with the so-called Hudson river rocks, the upper part of the Trenton. Hence it cannot be conveniently used when we wish to speak with precision of the later so-called Hudson river rocks, as a distinct formation from the Trenton.

genus, having the thoracic and abdominal segments anchylosed together; 3d. *Limulus*, Müller, having a head composed of 7 cephalic and one thoracic segments, followed by 5 coalesced thoracic somites bearing branchiæ, and one or more coalesced abdominal somites, to which is articulated the telson."

From this I infer, that Mr. Woodward proposes to separate as a new genus under the name *Prestwichia*, those species formerly referred to *Bellinurus*, in which the body segments are anchylosed together. If so, our Illinois species would fall into the latter group, under the name *Prestwichia Danæ*.*

3. *Section of the Rocks of Illinois, from Worthen's Geological Report*, vol. II, p. viii.

	Feet.
POST-TERTIARY.	
Drift, Loess, etc.—Clay, sand, pebbles, boulders, etc........	150
TERTIARY.	
Eocene period? Clays and greenish sand,..............................	150
CARBONIFEROUS SYSTEM.	
Carboniferous period. Coal-measures and Millstone grit.—Coal, shale, clay, limestones, sandstones and conglomerate,......................	1200
Mountain Limestone or Subcarboniferous period. Chester group.—Limestone, sandstone and shale, ...	800
St. Louis beds.—Limestone and shale, ...	200
Keokuk group.—Limestone and shale, ...	150
Burlington group.—Coarse, subcrystalline limestone, ...	200
Kinderhook group.—Shales, limestone, sandstone, etc.	150
DEVONIAN SYSTEM.	
Hamilton period. Genesee division.—"Black slate" and grayish shale,.....	100
Hamilton beds.—Dark grayish fetid and lighter, more pure limestones,	120
Upper Helderberg period. Corniferous and Onondaga beds.—Gray, more or less sandy limestone,....................................	25
Oriskany period. Oriskany—upper bed.—Quartzose sandstone, ...	40
Oriskany—lower beds, or Clear-creek group.—Highly siliceous, very cherty magnesian limestone, usually in thin layers, ...	200
UPPER SILURIAN.	
Lower Helderberg period. Lower Helderberg group, (D. shaly limestone of N. Y. geologists).—More or less magnesian and argillaceous limestone, in thin layers, including flinty concretions, ...	200
Niagara period. Niagara group.—Magnesian and argillaceous limestones,...	200
LOWER SILURIAN.	
Cincinnati period. Cincinnati group.—Limestones, shales and sandstone,...	140
Trenton period. Galena and Trenton beds.—Magnesian and more or less pure limestones, ...	300
Potsdam or Primordial period. St. Peter's division.—Pure quartzose sandst.,	150
Calciferous division.—Magnesian limestones and sandstones,.........	120 seen.

* Since the publication of the Illinois Report, I observe Quenstedt figures, on tab. 21, fig. 7, of his Handb. der Petref., under the name *Gampsonyx fimbriatus*, a little Crustacean from the Coal-measures of Germany, almost certainly congeneric with an imperfect specimen referred by us, provisionally, to our *Palæocaris typus*. (See Ill. Rep., ii, pl. XXXII, fig. 5*a*.) If Jordan's original figure, however, of the type of the genus *Gampsonyx*, as reproduced by Pictet, and that given by Bronn, are even nearly accurate, the typical specimen of our genus *Palæocaris* must be very distinct from *Gampsonyx*.

4. *Geological Survey of Canada.—Catalogue of the Silurian Fossils of the Isle of Anticosti, with descriptions of some new genera and species;* by E. Billings, Paleontologist, F.G.S. 93 pp., 8vo, with 42 wood-cuts. Montreal, Nov., 1866.—The whole number of species enumerated and described in this valuable memoir is about 330, of which some 130 are here for the first time made known to Science. Altogether they represent over 70 genera of *Protozoa, Radiata, Mollusca,* and *Articulata.* Of these genera, the following are new, viz., *Ischyrinia,*—a genus of bivalves apparently allied to the *Trigoniidæ; Streptoceras,* a Cephalopod like *Ormoceras* but with a trilobate aperture like *Phragmoceras,*—and *Særichnites,* supposed to be the tracks or trails of a Mollusk. In enumerating the species previously described, full references are given to the works in which the descriptions were originally published; while the larger portion of the new species are illustrated by good wood-cuts, printed in the text.

In regard to his genus *Pasceolus,* published some time back, the author says he thinks the evidence upon which it has been referred by others to the *Cystidea,* not conclusive; and he denies that he had, as some have thought, regarded it as presenting Ascidian affinities. He also doubts its identity with *Cyclocrinus* of Eichwald.

On pages 75 to 82, he has some highly interesting and instructive remarks on the paleozoic rocks and fossils of Anticosti and New Brunswick, and their relations to those of Canada, New York and Great Britain. It would be impossible to give here, even an intelligible abstract of the whole of these remarks; but it is worthy of note that he places the *St. John's group* of New Brunswick, consisting of about 3000 feet of Black slates and Sandstones (conformably underlaid by a series of rocks very like the Cambrian) *beneath the Potsdam sandstone,* and on a parallel with the Lower Lingula flags of Wales. He mentions seeing, from the St. John's group, species of *Orthis? Paradoxides, Conocephalites, Arionchlus, Microdiscus* and *Agnostus.*

The Potsdam sandstone he considers divisible into lower and upper, the first or lower division being represented by the sandstones and limestones of the north shore of the Straits of Belle-isle, and the rocks, which in Vermont are called the *Georgia slates,* and Red sandstone characterized by *Olenus Vermontana, O. Thompsoni, Conocephalites Adamsi,* &c., also probably including the St. John's slates (of Jukes) Newfoundland, and the Paradoxides beds near Boston.

The upper Potsdam he views as being composed of the Minnesota and Wisconsin trilobite beds, and probably the upper part of the Potsdam sandstone of Canada and New York.

The Calciferous he likewise divides into lower and upper, the first being the original typical Calciferous beds, and the latter (not known in Canada or New York) occurring in Newfoundland, where it is over 1000 feet in thickness.

Above the latter he places the Lévis formation, and next the Silery. Between the Lévis and the Calciferous formations, there is a great paleontological break, as there is also between the Lévis and the Chazy above, many of the *Trilobites* in the Lévis being closely allied to those of the Upper Lingula flags and Tremadoc slates.

This work will be indispensable to those wishing to study the rocks and fossils of Anticosti, as well as highly interesting, from the general bearing of some of the author's views, to all engaged in investigating the Silurian rocks everywhere.

5. *Tertiary of North and South Carolina;* by T. A. Conrad. (From a letter to one of the editors, dated Philadelphia, Jan. 31, 1867.)—The Tertiary strata of North and South Carolina are well worthy of a more thorough study than they have yet received. Prof. Tuomey has described some disturbed Eocene strata in South Carolina, in which he finds many specimens of the following Cretaceous forms: *Ammonites placenta, Terebratula Harlani, Gryphæa mutabilis,* and *Spondylus gregalis.* He remarks that the beds containing these fossils are of the same age as the conglomerate at Wilmington, N. C. That this mixture of Cretaceous and Eocene species is accidental is clearly proved by their never having been found in the undisturbed strata of older Eocene in Alabama and Mississippi, and especially by the occasional presence of Cretaceous fossils in the Miocene of Cape Fear river, N. C. No one would believe that they lived through the Eocene period and escaped alive into that of the Miocene. Prof. Emmons remarks that *Belemnitella mucronata, Exogyra costata,* and *Cucullæa vulgaris* (cast) are all found in the Miocene, and he regards their presence as accidental.

The *Ostrea Georgiana,* according to Tuomey, is associated, near Aiken, S. C., with *O. Alabamiensis,* which is a species of the siliceous sand stratum of Claiborne. The buhrstone of South Carolina and Georgia, by their fauna, would appear to be synchronous with the above-mentioned sand group of Alabama. The *O. Georgiana* may be of this age, or immediately succeeding it, but does not occur in the older Eocene, though it might be inferred from some accounts of Shell Bluff that were associated. Mr. Ruffin has published a diagram of Shell Bluff, but unfortunately he does not mention in what stratum he found *O. sellæformis,* but he remarks that *O. Georgiana* "is seen in the upper part of the perpendicular face of the cliff, above the marl of the great Carolina bed" (to which *O. sellæformis* belongs) "and there separated from it by a body of from four to ten feet in thickness. . . . This complete separation should forbid the belief that the deposit of gigantic oyster shells belongs to the same geological formation as the great Carolinian bed below."

Whatever position in the Eocene may be assigned to *Ostrea Georgiana,* it can have but one horizon throughout its vastly remote localities, and appears everywhere to have been suddenly introduced into the Eocene fauna, and to have had a short existence compared with *O. sellæformis,* as a deposit of six feet is the greatest thickness recorded.

6. *On Human remains in Belgium;* by Mr. Dupont. (Continuation of the account on pages 121, 122, of this volume.)—Mr. Dupont has very recently explored three other caverns in the valley of the Lesse; bringing up to twenty-two the number of those which he has examined in the vicinity of Dinant, since the commencement of his researches, undertaken at the expense of the State upon the recommendation of the Academy. These three new caverns bear the names of Cave of Praule, Cave of the Germans, Cave of the Nutons of Gendron. If they have furnished few new facts in regard to the study of the quaternary period,

they have presented facts important for the understanding of the relations between the human race which inhabited the country at the period of the reindeer and that which succeeded it. We will say a few words concerning the results obtained in these new explorations.

The Cave of Praule is situated five hundred meters above Furfooz, on the left bank of the Lesse, about thirty meters above the river. Breadth of the cavern, six meters; length, three and one-half meters in the middle; mean height, two meters. On the sides are two narrow galleries having a depth of four and of eight meters respectively. The quaternary sediments there were of small thickness; they showed at the bottom, immediately above the limestone floor, a thin layer of the sandy-argillaceous stratified deposit with rolled pebbles and gravel arranged in seams not continuous; in a word, the most decided characters of the lehm or middle period of the quaternary formation of the province. That deposit contained a humerus and a canine of a great bear. The layers superimposed upon the preceding are, as ordinarily, yellow pebbly clay; they are less than a meter in thickness; they contained, especially at the bottom, bones and some worked flints. The bones indicate the following species: bear, wolf, fox, horse, reindeer, goat. The flints, all worked in the knife form, are few, and are derived from the cretaceous deposits. These facts confirm the placing of the remains of the reindeer period in the pebbly clay, and the priority of that age to the deposition of that immense layer of clay. The small number of bones and of worked flints indicates a brief residence of man in that cavern, which seems nevertheless to have been perfectly adapted for habitation, being easy of access, spacious, well lighted, and very dry at that period, as is shown by the absence of stalagmites between the lehm which then covered the floor of the cavern, and the pebbly clay which is of a date subsequent to man's residence there.

The cave of the Germans is not so much a cavern as a simple shelter furnished by a dolomitic rock (stratum III. of the Carboniferous limestone), which overhangs, and under which the gypsies still establish themselves during their journeyings; whence the name which has remained to it, the gypsies being called Germans in that district. Shelters of this nature are quite numerous on the Lesse, and they are all known under the name of caves of the Germans. The following is the section of the one in question, which is situated near the road from Hulsonniaux to Celles: 5, at the level of the Lesse, rolled pebbles, transported from Ardennes, consolidated with gravel; 4, above, yellow clay with dolomitic pebbles; 3, Loess; 2, recent alluvium, formed of little seams alternately sandy and argillaceous like the lehm; 1, the same, modified and mixed with vegetable remains; in this last bed, which forms the present floor of the cavern, are found some flints of the knife form and a small hatchet of sandstone, polished and irregular in surface.

The third cavern, called the cave of the Nutons of Gendron, is situated two thousand five hundred meters (in a straight line) above the caverns of Furfooz, on the left bank of the Lesse; but as the river describes numerous curves between the two localities, the real distance is more than eight kilometers. This cavern is at an elevation of about seventy meters from the river, near the village of Gendron: it is excavated in the *psammite* formation of Le Condroz. That is a schistose formation with some calcareous beds alternating. The limestone has produced in this cavern stalactites, which have cemented the schistose beds together, and have preserved it from the caving-in which is very frequent in caverns of this sort. Width of the cavern at the entrance two and one-half meters; length, fourteen meters; it terminates in the form of a wedge. When Mr. Dupont visited it for the first time, he was able to penetrate only to a distance of eight meters; at that point the passage was obstructed by little columns of stalactite and cones of stalagmite. The soil is formed of a sort of mold apparently derived from the decomposition of leaves, and resembling the detritus known under the name of heath-mold (terre de bruyère). It rested on a layer of yellow clay with pebbles of schist, without ornaments or remains of industry, itself resting upon the rock. The soil covered the clay only from a point eight meters from the entrance, and was itself covered by stalagmite, which attained, in some places, a thickness of six decimeters.

In examining this soil, a great number of human bones were found, which were recognized as belonging to seventeen skeletons. Although the bones were all broken, the laborers were able to observe that the remains of the head, then those of the arms and trunk, then those of the legs, were discovered successively over a length of less than two meters. They discovered afterward, in the same order, a second, a third, then a fourth row of imperfect skeletons. Afterward a little skeleton was discovered laid transversely. Then the longitudinal arrangement of the bones again presented itself; the remains of the head toward the entrance, those of the limbs toward the inmost part of the cave. Another little skeleton was found, also placed transversely, and finally two others extended, like those of the preceding rows, parallel to the axis of the cavern. Among the human bones were found bones of foxes, badgers, hens, &c. At the entrance of the cavern was found a very small fragment of cretaceous flint in the form of a plate, with three fragments of coarse pottery. Upon the slope of the escarpment, immediately under the opening of the cave, lay two large plates of schist differing from that of the cave and of the surrounding country: one of these plates measured 1·50 meters in length by 85 centimeters in breadth; the other 1·05 meters by 1·65.

After the comparative examination which was made by Mr. Bruner-Bey of the human remains found in this cavern, one may say, in general, that none of the bones differs notably from the type of the reindeer period. As during that age, there are two forms of the lower jaw, one with horizontal branches very low and stout, the other with branches more elevated and more slender. Nevertheless, the genian eminence, triangular in the external aspect, and the bifid genian eminences in the interior are here well marked, although the chin, always rounded, is yet nearly vertical. As in the jaws of the reindeer period found at Furfooz, the angle of the chin, in the pieces where it exists, is rounded, turned inward, and very much inclined; the condyle and the glenoid cavity have the same characters in the series from Furfooz and from Gendron. The molars found have generally the normal size, and the wearing of the crown is circular in all. In one jaw with very high horizontal branches, the two first molars are of equal size: that is a fact which is observed also in the jaws of the reindeer period of Furfooz. The molars have likewise only four tubercles. Finally, in two pieces there exists also a strongly marked symphyscal prognathism. One jaw of an old man presents, besides this considerable prognathism, genian eminences much blunted, but the chin is prominent. The most perfect fragment of the upper jaw is orthognathous. Except the middle incisors, the teeth are small. Among the separate teeth is noticed a very stout canine. Two temporal bones belonging to individuals not of the same age, also exhibit perfectly the peculiarities of the type of the reindeer period; the mastoid processes are short and rounded; the glenoid fossæ are narrow and deep; the post-mastoideal part is very thick, and the depressions of the inferior cerebral lobes on the inner surface are deep. This last peculiarity is noticed likewise on a fragment of a frontal bone of the ordinary thickness; it bears all the characters of the ancient race: external orbital process and root of the nose very broad; superciliary arches very prominent; glabella triangular and depressed. A femur, scarcely epiphysized, is forty-two centimeters in length; its circumference below the trochanter minor is eleven centimeters; the length of the neck is twenty-two millimeters; the circumference is one hundred and two millimeters; it exhibits, moreover, the double curvature peculiar to the race of Furfooz, the very large trochanter minor; the rough line is very prominent, although flattened.

From what has been said above, it is seen that the Cave of the Nutons of Gendron was a sepulchral cavern. But when did it serve that purpose? This is what Mr. Dupont says on that point.

The bones and the earth which encloses them are above the yellow pebbly clay. Now, in the province of Namur, the remains of the reindeer period are always found beneath the yellow pebbly clay. This rule is confirmed by each new exploration, without having offered as yet a single exception. The superposition of the ossiferous soil above the pebbly clay demonstrates then that the skeletons in question are of date subsequent to the reindeer period. It remains to endeavor to refer them to a definite time within the period limited on the one side by the deposit of pebbly clay, and on the other by the present time. The mode of burial indicates great antiquity; it can scarcely be met with except in the dolmens.

We have said that three fragments of coarse pottery were found at the entrance of the cavern. Mr. de Mortillet, who has examined them, describes them as follows:

"Two of the fragments evidently formed a part of the same vessel, and traces are seen of the bourrelet which formed the opening; the other is red on one side, black on the other. This pottery was made by hand, without any use of the wheel. It is very poorly baked, and consequently has not passed through the oven. Powdered calcite was mixed with the clay, to give it consistency, and prevent it from cracking while drying and especially on the approach of fire, the baking being done probably before the vessels were perfectly dry. The outer surface of the fragments shows a polishing which has left numerous little striæ, as if it had been done with a bunch of grass or straw dipped in a barbotte (fine clay suspended in a large quantity of water). These three fragments offer then all the characters of very ancient pottery. In material, in composition, they seem to belong to the plastic art of the dolmens; but the border which surrounds the opening on two of them and the application of a barbotte would perhaps prove them to be a little more recent. It seems then more natural to refer them to the period of transition between the stone and the bronze. We are thus brought, says Mr. Dupont, to consider this race as the same that constructed those fortresses with cyclopean walls of which numerous examples are found in the province, and as belonging to the same age with the celebrated remains collected at Chauvaux by Mr. Spring."

In regard to the origin of the humus or soil which covered the skeletons, it is quite difficult to explain. It is certain that the existence of the humus, and consequently the introduction of the leaves which formed it, is more ancient than the layer of stalagmite which covers it, a layer which attains, in certain places, a thickness of six decimeters. It is certain also that, since the formation of the layer of stalagmite, no more humus has been formed, for the stalagmite contains none and is covered by none. It follows from this that a long space of time must have passed since the introduction of the leaves, for the rock in which the cavern is found is formed of schist, in which the limestone appears only in rare beds fifteen or twenty centimeters in thickness. This last remark agrees then with the preceding in attributing to the burials a very remote antiquity. If now one recalls the discovery, at the entrance of the cavern, of large plates of schist, not derived from the walls of the cavern, nor from the surrounding country, and consequently evidently brought from elsewhere, one would be tempted to see in these plates the fragments of a flag-stone which had closed artificially the entrance of the cavern, and had been subsequently removed and broken. If such was the case, the presence of the soil or rather of the decomposed leaves under the stalagmite would be explained with difficulty by a natural introduction. Perhaps it might be better explained by supposing, for burials of that remote period, a custom still used by the Peaux-Rouges of Brazil and the New-Caledonians, a custom which consists in wrapping corpses in a layer of leaves, and placing them thus enveloped in caves, in dolmens, and hanging them upon trees. Admitting this supposition, we should understand why dolmens are so rare in the province of Namur, numerous caves presenting themselves in many places to the men of that age to serve exactly the purpose of dolmens, and exempting them from erecting monuments whose construction must then have required great labor. We are thus led to consider sepulchral caverns as natural dolmens, which were used in the period of the reindeer or in the period of polished stone.

7. *Volcanic eruptions in Hawaii*; by Rev. T. Coan. (From a letter to J. D. Dana, dated Hilo, Hawaii, Aug. 31, 1866.)—I wrote you Feb. 27th of an eruption in Mokuaweoweo on the summit of Mauna Loa. This was first noticed at Hilo about the last of Dec. 1865, and we continued to see the light and smoke until the last of April, or four months. I am told by Mr. Richardson, who keeps a good hotel at Kilauea, that from his place he occasionally saw steam rising from that crater during all

May. It now seems quite extinct, and though the action for two months was vigorous and the light vivid, the lavas never overflowed the rim of the great crater or burst out laterally. Like most of the eruptions in Kilauea, the action was confined within the walls of the old crater.

In May, June, and July, the action in Kilauea was greatly increased. It was often intense and vehement. The old south lake (Halemaumau) overflowed several times, and a chain of lakes, three, four, and sometimes five or six, opened on a curved line from N.W. to N. and N.E. from the old lake. The action in this chain of lakes was often violent. Jets of lava were thrown 50, 100 and 200 feet high; the lakes overflowed, and fiery rivers seethed along the northern and eastern walls of the crater, sweeping around beyond the eastern sulphur banks. This curved line of action is about four miles long, and the igneous stream was in some places half a mile wide. The new deposits lie in strata of 50 to 100 feet in thickness. Cones and domes of lava were also raised, and yawning fissures opened, interrupting the traveller in crossing the bottom of the crater. At different times, and sometimes for many days, the fiery flood swept up to the path by which visitors go into the crater and cut off all ingress by the usual route. Many parties were obliged to view the surging waves from above, without being able to enter the crater. Occasional earthquakes shook down avalanches of rocks from the walls of the crater, and frightened the spectators.

During all this action, extending more than half round the crater, the central area, an elevated plateau, remained undisturbed, unless it may have been raised quietly, which is probable, by the forces below. This central table has been, for years, 200 feet higher than the surrounding area between this and the outer walls. For a few weeks past the action in Kilauea has been feebler, but we have no assurance that it will not increase at any time.

There has been a vast filling up and an upraising in Kilauea since 1840. Should you now visit it, you would recognize nothing except the outer walls and the surrounding regions. Internally *all* is changed and all is new. The lavas now stand higher in the crater than before the great eruption of 1840. Whether the walls will sustain the pressure until the vast pit fills and overflows the outer rim, or whether they will be rent and give lateral vent to the fusion, as in 1840, remains to be seen. And whether the cessation of action on Mt. Loa, about the last of April, had any influence on the increased action in Kilauea in May, June and July, we leave for the geologist to determine.

8. *Notice of a Human Skull, recently taken from a Shaft near Angel's, Calaveras County;* by J. D. Whitney.—This skull was taken from a shaft sunk on a mining claim at Altaville, near Angel's, in Calaveras county, by Mr. James Matson. By him it was given to Mr. Scribner, of Angel's, and by Mr. Scribner to Dr. Jones. Mr. Matson states that the skull was found at a depth of about one hundred and thirty feet, in a bed of gravel five feet in thickness, above which are four beds of consolidated volcanic ash, locally known as "lava;" these volcanic beds are separated from each other by layers of gravel, and Mr. Matson gives the following as the section of the various deposits passed through in sinking the shaft, which is one hundred and fifty-three feet deep, to the bed rock:

1.	Black lava,	40 feet.
2.	Gravel,	3 "
3.	Light lava,	30 "
4.	Gravel,	5 "
5.	Light lava,	15 "
6.	Gravel,	25 "
7.	Dark brown lava,	9 "
8.	Gravel,	5 "
9.	Red lava,	4 "
10.	Red gravel,	17 "
		153 feet.

The skull was found, according to Mr. Matson, in bed No. 8, just above the lowest stratum of lava. With the skull were found fragments of silicified wood, the whole being covered and partly incrusted with stony matter, so that the fact of its being a skull was not recognized until after it had passed into Mr. Scribner's hands, by whom it was cleaned and presented to Dr. Jones.

The skull is said by Mr. Matson to have been taken from the shaft February 25th, 1866, and it came into my hands in the July following, when I immediately proceeded to the locality, but found the shaft temporarily abandoned and partly filled with water, so that it was impossible at that time to make any farther search in the bed from which the skull was procured. A careful inquiry into all the circumstances of the alleged discovery, and an interview with all the persons who had been in any way connected with it, impressed upon my mind the conviction that the facts were as stated above, and that there was every reason to believe that the skull really came from the position assigned to it by Mr. Matson. Still, as it is evidently highly desirable that as large an amount of evidence as possible should be accumulated in regard to a discovery of so much importance, I made arrangements that I should be notified whenever the shaft was reopened and the water taken out, and hope at a future meeting to be able to lay before the Academy the results of a personal examination of this interesting locality, and of further excavations in the bed from which the skull was taken.

Assuming the correctness of Mr. Matson's statements, this relic of human antiquity is easily seen to be an object of the greatest interest to the ethnologist as well as the geologist. The previous investigations of the Geological Survey have clearly demonstrated the fact that man was contemporaneous with the mastodon and elephant, since the works of his hands have been repeatedly found in such connection with the bones of these animals that it would be impossible to account for the facts observed on any other theory. (See Geology of California, vol. i, p. 252.) But in the case of the skull now laid before the Academy, the geological position to which it must be assigned is, apparently, still lower than that of the mastodon, since the remains of this animal, as well as the elephant, which are so abundantly scattered over this State, are always (so far as our observations yet extend) limited in their position to the superficial deposits, and have never been found at any considerable depth below the surface. There is every reason to believe that these great proboscidians lived at a very recent date (geologically speaking), and posterior to the epoch of the existence of glaciers in the Sierra Nevada, and also after the close of the period of activity of the now extinct volcanoes of that great chain. In fact, they belong to the present epoch. The bed, on the other hand, in which this skull was found, must have been deposited at a time when the volcanoes of the Sierras were still in vigorous action, and, as seems to us highly probable from a careful consideration of the geological structure of the region, previous to the glacial epoch of the Sierra, and also previous to the erosion of the cañons of the present rivers. No pains will be spared, however, to investigate all the conditions of the occurrence of this skull, and they will be fully reported on at a future time.

The portions of the skull which are preserved are, the frontal bone, the nasal bone, the superior maxillary bone of the right side, the malar bones, a part of the temporal bone of the left side, with the mastoid process and the zygomatic process, and the whole of the orbits of both eyes. The base of the skull is imbedded in a mass of bone breccia and small pebbles of volcanic rock, incrusted with a thin layer of carbonate of lime, which appears once to have extended over the whole surface of the skull and of which a considerable portion still remains, the rest having been removed apparently in the process of cleaning. Under the malar bone of the left side, a snail shell is lodged, and partly concealed by the breccia of bone wedged in the cavity. This shell is the *Helix Mormonum*, according to Dr. Cooper, a species now living in the region where the skull was obtained. Although not competent to express a decided opinion on the subject of the ethnological relations of this skull, I should suppose that it belonged to the type of the Indians now inhabiting the foot-hills of the Sierra. It is certain that the facial angle is not one indicating a low order of intellect. The skull, however, seems to have been very thick and solid. It will be placed in the hands of competent craniologists for examination and description, as soon as reliable information has been obtained with regard to its occurrence, or whenever all has been ascertained that can be.—*Proc. California Acad. Nat. Sci.*, iii, 277.

9. *Notice of the occurrence of the Silurian Series in Nevada ;* by J. D. Whitney.—At a meeting of the Academy in May last, I gave some account of the geology of the state of Nevada, with particular reference to the age of the stratified deposits occurring there, as determined from the collections of fossils brought from that region to the office of the Geological Survey, by J. E. Clayton, and various members of our corps. In that communication I spoke of the probable future discovery of rocks older than the Carboniferous or Devonian, in the mountain ranges near Austin. This expectation has been realized, and we are now in possession of a very interesting collection of fossils, obtained by Mr. A. Blatchley, in the vicinity of the Hot Creek Mining District, about one hundred miles southeast of Austin. This collection enables us to state positively that both Upper and Lower Silurian rocks occur in that district, and that they are well filled with fossils; not less so, indeed, to judge from the specimens received, than the strata of the same age in New York, Ohio, Iowa, and Wisconsin, which they resemble in a most marked degree, both lithologically and paleontologically.

The fossils from the Hot Creek district are mostly weathered out on the surfaces of thin slabs of bluish-gray argillaceous limestones, and are crowded together in the same profusion with which they have often been noticed by myself and others as occurring in the Lower Silurian shales and limestones of the Wisconsin lead region, around Big Bay des Noquets, and in many other localities in the country bordering on the great lakes.

Both the upper and lower divisions of the Silurian appear to be represented by the fossils of the Hot Creek District; but the Lower Silurian seems to be much the most prolific in fossils, as is the case in Wisconsin and Iowa. The particular period to which these Lower Silurian forms may be referred is the Trenton, including the Chazy, Birdseye, Black river and Trenton limestones of the New York geologists, and the Buff and Blue limestones of the western surveys. Nearly all the prevailing types of the eastern rocks of this age are represented in the Hot Creek collection, namely, Brachiopods, Gasteropods, Cephalopods, Crinoids, Trilobites, and Corals; and there are among them several of the most widely-distributed and most characteristic species of the Lower Silurian. The following have been identified: *Maclurea magna*, a characteristic Chazy species, and *Pleurotoma lenticularis*, *Orthis testudinaria* and *Chætetes lycoperdon*, all of which are abundant in the Trenton limestone of New York, and the rocks of the same age farther west. Among the fragments of Trilobites, two or three different genera may be recognized, especially *Asaphus*, which is represented by a species apparently new. There are also fragments of Crinoids or Cystids closely resembling the species figured by Hall, in the Paleontology of New York, vol. i, as *Echino-encrinites anatiformis*.

The rocks containing the above-mentioned fossils crop out in the sides of a deep cañon; and overlying them, at a perpendicular distance of about a thousand feet, is a series of beds containing numerous fragments of corals and crinoids, silicified and weathered out from the surface of a bluish-gray limestone, which I refer without much doubt to the age of the Niagara limestone of New York. Among the corals, *Heliolites spinipora* and *Syringopora* are recognizable; and among the crinoidal fragments are stems of what appears to be *Caryocrinus ornatus*.

With the exception of the Potsdam sandstone fossils, described by Meek and Hayden as occurring at the base of the fossiliferous series, in the Black Hills, no recognizable Silurian forms have been observed by geologists, in the Rocky mountains, or anywhere to the west of them, unless possibly in New Mexico. The Silurian series, with the possible exception of the Potsdam sandstone, seems to be entirely wanting in the Rocky mountains proper, the Black Hills being a sort of outlier of the main ranges, and lying as far east as the one hundred and third to the one hundred and fifth meridian. Dr. Hayden says, in his paper, on the Geology and Natural History of the Upper Missouri, published in 1862, that "hitherto no indications of the existence of any other member (than the Potsdam sandstone) of the Silurian period have been discovered along the eastern slope of the Rocky mountains within the boundary of the United States." He considers it probable that the Potsdam sandstone is represented in the Rocky mountains, although no fossils of that member of the series have been as yet discovered anywhere to the west of the Black Hills.

On the Mexican Boundary Survey, a few fragments of fossils were found in the superficial detritus, near El Paso (longitude 106°), which indicated the existence of Silurian rocks in that vicinity; but none appear to have been found in place. Professor Hall remarks that "the specimens referable to strata of this age (Devonian and Silurian) are few, and they are in such condition as to give little satisfactory information regarding the rocks in place." The specimens obtained are figured in the Mexican Boundary Report, but not described, nor is their locality accurately stated.

Dr. Newberry, in his Report on the Geology of the Colorado river region, refers the lower portion of the strata exposed in the grand cañons of that river to the Devonian and Silurian series; but as no recognizable fossils were discovered by the Ives expedition from any rocks lower than the Carboniferous, this reference can only be taken as expressing a conviction based on lithological characters and stratigraphical considerations.

In view of the facts above cited, it will be seen at once how interesting this discovery is of undoubted Silurian rocks west of the Rocky mountains; and the more so, since we have in this remote region a recurrence of conditions and forms of animal life so closely allied to those with which we are familiar in the states east of the Mississippi. It is a very remarkable fact that these rocks have not been discovered in the Rocky mountains; and should farther explorations fail to reveal their presence, it will throw a new light on the history of the physical development of the central and western portions of this continent. Taking into view what has now been communicated, and what was stated in my previous paper in regard to the existence of the older stratified rocks in the Silver Peak District, it will appear that Dr. Newberry's generalizations were, in all probability, correct, and that we may expect to find in southern and southwestern Nevada the outcropping fossiliferous edges of the strata underlying the Carboniferous of the great Arizona or Colorado plateau, and that they will be proved to occupy an extensive area, and to yield a profusion of organic remains.

Among the specimens collected by Mr. Blatchley, as also by Mr. Clayton, Mr. Melville Attwood, and Dr. C. L. Anderson, and now at our office, there is a considerable number which demonstrate the existence of an extensive freshwater Tertiary deposit in Nevada. This formation, which belongs to a very late Tertiary epoch, evidently occupies a considerable area, as our specimens come from localities hundreds of miles distant from each other. The existence of any marine formation more recent than the Jurassic, in Nevada, has not yet been proved; but, as Mr. Gabb obtained evidence, in 1864, of the occurrence of rocks of Cretaceous age on Crooked river, in Oregon, east of the Cascade Range, it is possible that this member of the series may yet be discovered in Nevada.

All the fossils referred to in this and my previous communication on the geology of Nevada, will receive, in due time, thorough investigation at the hands of Messrs. Meek and Gabb, or other competent paleontologists; and we expect that our collections from that state will be largely increased during the present year.—*Proc. California Acad. Nat. Sci.*, iii, 307.

10. *Eozoön.*—At a meeting of the Natural History Society of Montreal in January last, Dr. Dawson exhibited a photograph of a remarkable specimen of *Eozoön Canadense*, found the past summer in the Laurentian limestone of Tudor, Canada West, by Mr. Vennor, of the Canadian Geological Survey, and which had been examined and described for Sir W. E. Logan by Dr. Dawson. The rocks at Tudor and its vicinity, which, according to the observations of Mr. Vennor are Lower Laurentian, have experienced less metamorphism than is usual in formations of that age, and this peculiarity gives especial interest to the present specimen, which is contained in a rock scarcely altered and in a condition not essentially different from that of ordinary Silurian fossils.

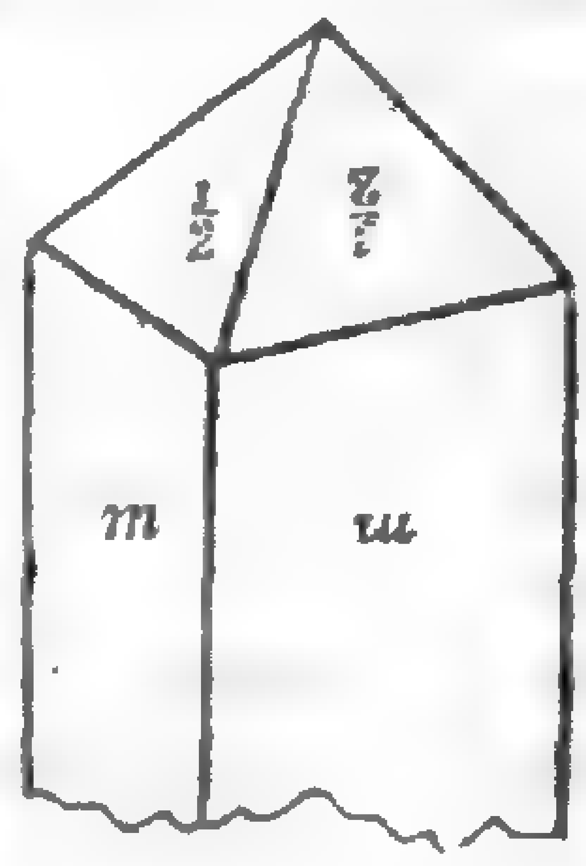
The matrix is a coarse laminated limestone of a dark color, and containing much sand and finely comminuted carbonaceous matter. The fossil itself is of a flattened clavate form, about six and a half inches in length, and with the septa of its chambers perfectly preserved, exhibiting on one side a well defined marginal wall produced by coalescence of the septa, and apparently traversed by small orifices. Under the microscope the minute structures of *Eozoön Canadense* can be detected, though less distinctly perceived than in some of the specimens mineralized by serpentine. In some of the chambers there are small amorphous bodies containing pointed siliceous spicules, which seem to be the remains of sponges that have established themselves in the cells after the animal matter of *Eozoön* had disappeared.

The importance of this specimen was pointed out as establishing the conclusions previously arrived at from the study of the remains of *Eozoön* included in the serpentinous limestones, and as overthrowing the objections raised in some quarters to the organic origin of *Eozoön*. The specimen will be taken to England by Sir W. E. Logan, and full details of its characters will be communicated to the Geological Society, along with some other recent discoveries tending to the establishment of a second species of *Eozoön.—Montreal Gazette*, Jan. 29, 1867.

11. *On Fossils in the Auriferous rocks of California;* by W. P. Blake, (from a notice of the meeting of the California Academy, Aug. 20, 1866.)—Prof. Blake read a paper upon a "New Locality of Fossils in the Gold-bearing Rocks of California," and exhibited specimens of Ammonites from a cut on the line of the Central Pacific Railroad, near Colfax. Although the specimen exhibited was quite perfect, it was not sufficiently so to enable the septæ to be seen. Prof. Blake remarked that these fossils were undoubtedly of the secondary period, and that they were apparently specifically identical with those from the American river, in the same vicinity, of which he had sent photographs to Mr. Meek, in 1863, and afterwards noticed the same at a meeting of the Academy in September, 1864; he also thought them identical with the species found at Bear Valley, Mariposa county. Prof. Blake also exhibited the tooth of an extinct elephant, a *molar*, found in the auriferous gravel near Michigan Bluffs; also, shark's teeth and other marine remains from Tulare valley; these remains were found by him at an elevation of at least twelve hundred feet above the sea, and probably belong to the Post-pliocene period.

Prof. Blake alluded to a "Quarry of Gold-bearing rock" in Placer county, known as the Banker or Whisky Hill mine, where no regular quartz vein exists, and the rock of the hill is profitably worked; some forty tons per diem are crushed, yielding from two to twenty dollars per ton—averaging from five to six dollars per ton.

12. *On the Crystalline form of Pachnolite;* by A. DesCloizeaux. (From a letter to J. D. Dana, dated Dec. 6, 1866.)—Pachnolite is not quadratic as has been stated. Its crystals are much less simple. They belong to the monometric system, and appear to me to be always macled, in the same manner as are those of amphibole. As only a single summit is visible, the crystals being retained in the gangue by the opposite one, it seems as if we were dealing with a right rhombic prism. The four faces of the terminal octahedron are actually of the same kind, and belong to a positive hemi-octahedron, $b\frac{1}{2}$. The crystals therefore appear as in the annexed figure, the axis of revolution being normal to the plane bisecting the acute angle of the fundamental prism. We may admit as a mean—



		Calculated.	Observed.	
m on m in front,	=	98° 34′	98° 40′	
m on u lateral,	=	81 26	81 43	macle.
$b\frac{1}{2}$ on $b\frac{1}{2}$ (planes $\frac{1}{2}$ in figure) adjacent,	=	108 15	108 15	
$b\frac{1}{2}$ on $\frac{z}{i}q$ adjacent,	=	94 13	94 13	macle.
m on $b\frac{1}{2}$ adjacent,	=	153 37	153 46	
$\frac{z}{i}q$ on $b\frac{1}{2}$ opposite,	=	52 46	52 46	

Edges $\frac{b\frac{1}{2}}{b\frac{1}{2}} : \frac{m}{m}$ adjacent,	=	146° 45′
Base $p : m$,	=	90 20
Plane angle of the base,		98 33 54″
Plane angle of the lateral faces,		90 16 48

The plane of the optic axes is perpendicular to the plane of symmetry, and makes an angle of about 10° to 15° with a normal to the edge $\frac{m}{m}$, and an angle of about 23° 15′ to 18° 15′ with a normal to the edge $\frac{b\frac{1}{2}}{b\frac{1}{2}}$. One of the bisectrices is normal to the plane of symmetry; the other makes with the edges $\frac{m}{m}$ and $\frac{b\frac{1}{2}}{b\frac{1}{2}}$ the same angles as the plane of the axes: but I have not yet been able to ascertain which of these is the bisectrix of the *acute* angle of the axes. The former is *negative.* As it has been impossible to cut a single thin plate normal to the bisectrices, it has not been possible to study the dispersion of the optic axes. The crystals rest upon small, translucent, crystalline laminæ, which appear to possess different optical properties. Is this mineral arksutite? These laminæ appear to make a transition stage between cryolite and pachnolite,

III. BOTANY.

1. *Salices Europææ;* recensuit et descripsit Dr. FRIDERICUS WIMMER. Breslau, 1866. pp. 286, 8vo.—While awaiting the appearance of the general elaboration of the order, contributed by Dr. Andersson to the Prodromus, and of the *Icones Salicum* he has also prepared, we receive this beautiful volume, in which Dr. Wimmer, restricting his attention to the European Willows, has revised these with much detail and evidently with very great care. The work is written throughout in Latin. There is a full account of the literature of the subject, of the structure and morphology, and of the various systematic arrangements of the species which different authors have proposed. Dr. Wimmer himself arranges the Willows of Europe under eleven tersely characterized tribes, each comprising from one to six species. He admits only 31 to the rank of genuine species, reducing a great number to mere synonyms, and having well characterized these in the first half of his volume, he devotes the rest to *Salices hybridæ.* These hybrids, 57 in number, and chiefly named according to their parentage, are disposed under fourteen sections, and their synonymy is fully indicated. The whole work gives the impression of being thoroughly reliable and excellent. A. G.

2. *Le Specie dei Cotoni descritte da* FILIPPO PARLATORE. Florence, 1866.—Professor Parlatore's essay upon the long-vexed question of the species of Cotton was called forth by a Royal Italian Commission, and is dedicated to its President, Devincenzi. The letter-press, of 64 pages, 4to, is divided into a general history of cotton-plants, in Italian; and the description of the species, with the characters and full synonymy, are in Latin, but the farther details in Italian. He describes seven species (besides referring to as many doubtful ones): *G. arboreum*, or Tree Cotton; *G. herbaceum*, the common herbaceous Cotton; *G. Barbadense*, or Sea-Island Cotton; *G. religiosum*, or Peruvian Cotton; *G. hirsutum*, or Siamese Cotton; *G. Taitense*, as a new species, from Tahiti, which had been long variously confounded with others; and *G. Sandvicense*, also as a new species from the Sandwich Islands; but this has already been published by Dr. Seemann, under Nuttall's name of *G. tomentosum.* These species are all illustrated in a separate atlas of six plates, in elephant folio, beautifully exhibiting them in specimens of the natural size, in good lithography, all but the last two printed in colors. Our copy of this fine work is presented by the President of the Royal Commission, through the author.

Coniferæ, &c.—It is well known that Prof. Parlatore has elaborated the *Coniferæ* for the Prodromus. We have from him his study of the organography of the flower and fruit of this order, a memoir, contributed to the Annals of the Museum of Natural History at Florence, written in Italian; in quarto, with three folio plates, filled with structural details. Botanists are aware that he does not adopt the view that they are gymnospermous. We may soon expect, in the Prodromus, the full presentation of this view.

A separate little sheet contains characters, given in advance, of a few new *Coniferæ:* among them a Larch of N.W. America, *Larix Lyallii*, remarkable for a cobwebby woolliness of the young shoots and leaf-buds, the scales of the latter with a fringed margin. We have from the same author his

Considérations sur le Méthode Naturelle en Botanique. 8vo pamph. Florence, 1863.—A good historical view of the development of the natural method, with some pertinent illustrations of the obvious importance in all the divisions, from highest to lowest, of looking to *types* and the *ensemble* of characters rather than resting upon single points,—in other words, of carrying the spirit of the natural rather than of artificial systems throughout the whole domain of botany. A. G.

3. *Tree-labels for the Arboretum.*—Mr. J. H. Creighton, of Chilicothe, Ohio, who is forming, with rare and thoughtful generosity, an extensive arboretum for a college in Ohio, has contrived a plan of permanent label for the trees, which is worthy of general adoption in public grounds and parks. The label is of cast iron; and it exhibits in capital letters, in bold relief, the scientific and the popular name of the tree. Having the pattern and a stock of letters prepared for his own use, Mr. Creighton offers to cast, at a low rate, any number of labels, with any desired name. A. G.

4. *Ozone produced by Plants.*—Professor Daubeny of Oxford has contributed to the Journal of the Chemical Society, for January last, an interesting article, giving the details of a series of careful experiments, which go to prove that green foliage, in assimilating carbonic acid, water, &c., liberates a part of the oxygen in the form of ozone. After his experiments were made, Dr. Daubeny found that Kosmann of Strasburg had reached the same conclusion, but through less refined experiments. Referring to the first paper he ever communicated to a scientific society, that published in the Philosophical Transactions for 1834, on the evolution of oxygen gas by plants in the day-time, Dr. Daubeny concludes: "Should I now have established to the satisfaction of the scientific world, that these same green parts of plants, at the very time they are emitting oxygen, convert a portion of it into ozone, I might hope that these researches of my later years will serve appropriately to wind up those undertaken in my younger ones, by showing that vegetable life acts as the appointed instrument for counteracting the injurious effects of the animal creation upon the air we breathe, not merely by restoring to it the oxygen which the latter had consumed, but also by removing, through the agency of the ozone it generates, those noxious effluvia which are engendered by the various processes of putrefaction and decay,"—engendered, we may add, as much by decaying vegetable as by animal matter. A. G.

5. *Morphology of Stamens, and use of Abortive Organs.*—In a recent number of the *Gardeners' Chronicle*, the editor, in giving a full account of *Dombeya angulata*,—a rare plant, which has just flowered at Kew,—describes as follows the morphology of the stamens, and the remarkable assistance which the *staminodia*, or barren stamens, seem to render as *go-betweens*, carrying pollen from the efficient stamens to the stigmas.

"The stamens in this plant, as in all the Malvales, may be looked upon as compound: while the ordinary stamen corresponds to a simple leaf, the groups of stamens in the Mallows and allied orders may be regarded as the equivalents of compound leaves, united together at their bases.

Some of the lobes or leaflets of these compound leaves bear anthers, while others are destitute of anthers, and constitute the barren stamens or staminodes. Some light is thrown on the uses of these barren stamens by an examination of the plant now under consideration. In the fully expanded flower, the inner surface of the upper angle or point of each petal is about on a level with the stigma and with the tip of the barren stamen, the outer flat surface of which latter, as well as the adjacent portion of the petal, are often dusted over with pollen, the true stamens nevertheless being at a considerable distance beneath these organs. In less fully developed flowers the barren stamens may be seen curving downwards and outwards so as to come in contact with the shorter fertile stamens, whose anthers open outwardly, and thus allow their contents to adhere to the barren stamens. These latter, provided with their freight of pollen, uncoil themselves, assume more or less of an erect position, and thus bring their points on a level with the stigma, whose curling lobes twist round them and receive the pollen from them. The use, then, of the long staminodes seems to be to convey pollen from the short fertile stamens to the stigma, which, but for their intervention, could not be influenced by it. The presence of pollen on the upper and inner corner of the petals is readily explained by the fact that owing to their position and peculiar form they all come in contact with the ends of the staminodes and the stigmas, and hence they too get dusted with pollen.

"These arrangements would therefore seem to favor self-fertilization; and they show how an organ spoken of sometimes somewhat contemptuously, as barren, rudimentary, imperfect, or the like, may yet play an important part, both in the architectural plan of the flower, and in its life-history."

We venture to suggest that, although this curious arrangement may serve to ensure a certain amount of self-fertilization, yet it must likewise be studied in relation to the action of insects which probably visit these flowers, and, we fancy, may have something to do either in the deposition or in the removal of this pollen, so bringing about cross-fertilization.

In regard to the stamineal structure, briefly sketched in the beginning of the above extract, we would remark that, if we mistake not, Duchartre should have the credit of having brought to view this structure of the malvaceous andrœcium more than twenty years ago; that the inferences from organogeny soon after found a striking illustration in this country in the genus *Sidalcea;* and, finally, we are gratified to perceive that a theoretical view which has in this country been set forth as a part of elementary botany for many years (see Bot. Text Book, third edition, 1850, p. 249–252), is now making its way in England. It is evident that the name (*deduplication*), and the fanciful or *un*-morphological conceptions, with which this sort of multiplication of organs (in which a pair or a group occupy the place of one) was originally associated, have prejudiced British botanists against the *thing;* and it was on this account that we preferred the unobjectionable name of chorisis,—defining it in the terms of the above parenthesis, and illustrating it, in the class of cases in question, by the comparison of such compound stamen with a compound leaf. In another class of cases, anteposed parts are likened to intrafoliaceous stipules. A. G.

6. *Remarkable union of two trees;* by PAYSON W. LYMAN.—Near the village of North Chester, in Hampden Co., Mass., there stands a remarkable elm tree (*Ulmus Americana*), of which the annexed sketch will give a tolerably accurate idea. It stands near the summit of a range of hills, on the eastern bank of a branch of the Westfield River, in a narrow ravine, on either side of which wooded hills rise abruptly. It is considerably exposed to the light, being near the edge of the woodland.

The two parts of the tree, which rise from the ground and support the arch, are 30 feet apart, the one on the left of the sketch being as much as 2½ feet in diameter, and rising to a height of nearly or quite 100 feet, while that on the right is 1¾ feet in diameter, and not so high. The arch springs from the tree on the left at the height of 14 feet, and connects with that on the right at the height of 4 feet. Its diameter, near its junction with the former, is fully 1½ feet, gradually diminishing in size toward its junction with the latter, where its diameter is about 6 inches.

Its union is equally perfect at either end, though its connection seems to be more natural and regular at its larger extremity; which would lead one to suppose that, in some way, a branch of the tree on the left had been bent over and become engrafted into that on the right. The probability of this supposition is enhanced by the statement of the gentleman who owned the land forty years ago, that the tree then stood on the line of a fence, and that he, noticing the arch, supposed that it had been bent over to form part of the fence. He further states that, if he remembers correctly, the branch now forming the arch then extended beyond the tree with which it has united.

The arch runs lengthwise of the ravine, and, together with the trunks which rise from it, derives its nourishment from both sets of roots. Of these three intermediate trunks, that on the left is 14 inches in diameter, and attains an altitude equal to that of the main trunk on the left of it. The diameter of the second is 11 inches, and of the third 6 inches, the two rising to a height proportioned to their size. By a rough estimate it would appear that the horizontal branch supports a weight in addition to its own of about 4400 pounds. About midway between the two original trees, there rises a beech tree (*Fagus ferruginea*), which divides before reaching the arch, which it includes within its branches, but does not in any place come in contact with or support it.

A person desiring to see this remarkable tree would need to go about a half-mile north of the village of North Chester, to a saw-mill, where he would cross to the east side of the stream, traverse the fields, and climb the hill, following a little ravine for a distance of forty or fifty rods to the edge of the woodland, where he would readily discover the tree.

It is somewhat difficult of access, but would repay any one interested in objects of this kind for the trouble required to reach it. It has been known more or less to individuals in its vicinity for forty years at least, but has never attracted very wide attention.

Amherst College, Jan. 15th, 1867.

IV. ASTRONOMY AND METEOROLOGY.

1. *November meteors in* 1866.—Accounts of the grand meteoric shower on the morning of the 13th–14th of November continue to reach us. We compile the following summary.

(*a.*) *In the Sandwich Islands* (W. long. 158°, N. lat. 21° 15′).—Mr. J. P. Cooke, with seven others, saw 317 meteors in five hours on the night of Nov. 13th–14th, 1866.

From 10^h to 11^h P.M.,	22 meteors.	Sky clear.
" 11 " 12 "	44 "	Cloudy in N.E.
" 12 " 1 A.M.,	47 "	Sky half covered.
" 1 " 2 "	63 "	Clear.
" 2 " 3 "	141 "	Clear.
Total in five hours,	317 "	

There was no special radiation from Leo. A few brilliant meteors were observed between 3^h and 4^h A.M., but they were not as numerous as between 2 and 3 o'clock. No count of them was kept however.

These observations serve as a continuation of those in the United States, and show that there was no revival of the shower directly after our dawn.

(*b.*) *Asia Minor.*—Rev. A. T. Pratt, M.D., in a letter from Marash, Turkey, gives the following account of the shower as seen at that place.

"After midnight, we did not look out till 2^h 45^m A.M., when they were decidedly frequent. Miss Spencer, who is living with us, being called, we went out and took our station to count them, with result as follows:

	N.W.	S.W.	Total.
From 3^h 0^m to 3^h 15^m,	200	298	498
" 3 15 " 3 30	300	566	866
" 3 30 " 3 45	486	662	1,148

"They were so numerous after this as to make it impossible to count them; falling by dozens and scores at a time till about 4^h 30^m, when from 4^h 30^m to 4^h 40^m, in the southwest, were counted 200,—the number having sensibly decreased,—when we were compelled to leave the field.

"All the meteors radiated from the same *space* in the heavens (hardly the same point), i. e., that between γ and ε Leonis, and passed thence in every direction, only two or three being observed which did not conform to this law."

(*c.*) *In India.*—Rev. Wm. Wood, in a letter to his son from Ahmednuggur (N. lat. 19° 5′, E. long. 74° 55′), says that he watched all the night of the 13th–14th, and that a good many meteors fell before midnight, and so on till three o'clock, but that from that time till light there was a shower of them. At one time he counted 100 in five minutes.*

* It is not certain, however, whether these were seen by one or by five persons.

One meteor left a train which moved *westward*, being visible for five minutes.

(*d.*) *In India.*—Rev. Edward Chester, writing from Dindigul (N. lat. 10° 25′, E. lon. 78°), says: "For a few moments I began to count the meteors, but they came so thick and so many at a time that I had to give it up. I saw thousands. I saw nothing else from 4 o'clock until daybreak, and even saw some within fifteen minutes of sunrise."

(*e.*) *In the N. Atlantic.*—Mr. E. Guillemin,* at sea 45 miles N.E. of Flores, saw the meteors cross the sky from E. to W., with long trains. A narrow cloud 10° high lay along the horizon. From behind it, from a point N. 59° E., luminous trains shot across the sky. The parallel paths were projected into the meridians of a sphere, the point of divergence being the pole. Those which were near the horizon were shorter and more like the ordinary shooting stars. Toward the zenith, however, they were much more brilliant, and their time of flight longer. Those which crossed the zenith rose perpendicularly from the eastern horizon, and leaving behind an immense phosphorescent arc, disappeared low in the west. From 10^h to 11^h the stars appeared either isolated or in groups of two and three, at intervals of from four to twenty seconds. They moved with uniform velocity, and had a mean duration of flight of seven or eight seconds. After 11 o'clock the display gradually diminished, and ended about half past three in the morning.

(*f.*) *At Cape of Good Hope.*—Mr. G. W. H. Maclear reports (Astron. Monthly Notices) between 10^h P.M. and 13^h A.M. 33 meteors seen at the Cape of Good Hope. Between $13^h\ 3^m$ and $16^h\ 21^m$ A.M. they saw 2742. Of these there were 1774 between $13^h\ 51^m$ and $14^h\ 36^m\ 45^s$, that is, in about three-fourths of an hour. The number of observers is not stated.

(*g.*) *Eastern Asia.*—There appears to have been no remarkable display at Shanghai, and at Yokuhama in Japan a watch kept that night detected nothing unusual.

(*h.*) *At Athens.*—Dr. J. F. J. Schmidt deduces hourly numbers for one observer for the twelve hours from 6^h P.M. to 6^h A.M. from observations made at Athens. There were different persons actually counting during the separate hours, but allowances are made for personal peculiarities. During the two critical hours, 2^h to 4^h A.M., no direct count was kept up. The following are the numbers:

6	6	133	785 (?)
6	7	980	405
6	50	1055 (?)	125

Total in the 12 hours, 3564 meteors.

(*j.*) Throughout the continent of Europe the shower was observed, and it maintained everywhere the same general character, no differences being noted that may not be due to personal peculiarities or to the weather. In Paris and Rome the weather was unfavorable.

Mr. A. Quetelet, at Brussels, locates the radiant at R.A. 148°, N. Dec. 24°. The time of the maximum was, he thinks, about a quarter past one o'clock.

(*k.*) *In Great Britain.*—At Edinburgh one observer saw the following numbers in successive minutes from $12^h\ 58^m$ to $1^h\ 38^m$ (G. m. time),

* Comptes Rendus, lxiii, 961. Compare this vol., p. 86, No. 25.

another person keeping the record. The sums of the columns give the numbers for each five minutes.

28	30	38	40	44	33
30	36	29	35	31	30
32	34	30	35	30	23
60	64	40	52	29	23
60	38	41	50	29	23
210	202	178	212	163	132

During the next half hour were seen 395, making a total of 1492 for one observer in the hour. Similar records of numbers by other observers are given in the Astr. Soc. Notices.*

Sir John Herschel located the radiant at long. 142° 20′, lat. 10° 15′ N. Since this point is very nearly—perhaps exactly—90° from the sun, he concludes that the orbit of the meteors is very nearly circular and the motion retrograde. He adds (Astr. Soc. Notices, xxvii, 21), "How far this conclusion of a retrograde motion of the meteorites' revolution round the sun—a conclusion already, I believe, arrived at by Mr. Newton—is compatible with the truth of the 'nebular hypothesis,' we may leave it to the advocates of that hypothesis to consider."

A train observed by him remained visible six minutes, drifting slowly *southwards* over a space 8° or 9°, and at the same time changing its direction so that at its disappearance it was at right angles to its original position.

Mr. A. S. Herschel gives (Astron. Soc. Notices) the following determinations of the radiant. Most of them are from paths recorded by different observers upon charts of the British Association.

Long.	N. Lat.	Long.	N. Lat.	Long.	N. Lat.
141° 6′	10° 5′	144° 45′	10° 4′	145° 40′	11° 52′
142 41	10 58	141 37	11 19	143 41	9 54·5
143 7	9 16	143 31	9 28	143 12	10 3
142 10	10 15	141 36	9 27	142 58	9 9
142 28	9 49	146 41	10 20	142 51	10 42

The magnets at Greenwich were remarkably quiet during the night. Prof. Challis remarked an unusual glow in the atmosphere during the display.

(*l.*) *Observations with the spectroscope.*—Mr. A. S. Herschel and Mr. John Browning were provided with spectroscopes arranged for direct vision. Mr. Browning says (Astron. Soc. Notices, 1867, p. 77):

"After catching a few spectra in different directions, I at length decided on keeping the direct-vision prism pointed a little to the west of Leo Major, with the axis of the prism parallel to the horizon. The spectra which I saw were those of meteors which started from the radiant point and passed through the belt of Orion. Of course the number of meteors which came into my field was comparatively limited, but the whole of them travelled in a direction parallel to the axis of the prism, a condition essential in the observation of the spectra.

"From the rapid flight of the meteors rendering the spectra very difficult to catch, I cannot pretend to speak with confidence of the appear-

* There is an important misprint in the 25th line, p. 87 of the last number of the Journal, in Dr. Gould's letter. For 12h 39m 0s, read 12h 59m 0s.

ance of the spectra shown by the prism, but I saw a great difference between the spectra. I believe that I saw spectra of the following kinds:

"A. Continuous spectra, or those in which the whole of the colors of the solar spectrum were visible, excepting the violet rays.

"B. Spectra in which the yellow greatly preponderated; but which in every other respect resembled those above described.

"C. Spectra of almost purely homogeneous yellow light, but with a faint continuous spectrum, that is, a faint trace of red on one side and green on the opposite side of the yellow portion of the spectrum.

"D. Spectra of purely homogeneous green light; of this kind I only saw two.

"I observed through the prism spectra of several trains. The light which was mostly blue, *green*, or steel gray, generally appeared homogeneous; but this may have arisen from the light having been too faint to produce a visible spectrum. Stars below the second or third magnitude, although visible through the prism, fail from this cause to give spectra in which blue and red are perceptible."

As was indicated in the last number of the Journal (p. 88), the eastern limit of the shower must have been in Central Asia. It was a little east, however, of the line there given.

Several papers concerning the theory of the meteors by Schiaparelli, Faye, LeVerrier, Peters, &c., of which we had intended to give here an abstract, must be deferred to the next number of the Journal. H. A. N.

2. *New minor planet, Antiope,* (90).—Dr. Luther discovered a minor planet on the 1st of October, to which the name Antiope has been given.

3. *New minor planet,* (91).—The ninety-first minor planet was discovered by Mr. Stephan at Marseilles on the 4th of November.

4. *Comet.*—Mr. Stephan discovered a telescopic comet on the night of the 22d of January, in R.A. $2^h\ 34^m$, and N.P.D. 74° 26′.

5. *Aurora Borealis at Highland, Illinois;* by A. F. Bandelier. (From a letter to the editors, dated Highland, Madison Co., Ill., Nov. 11, 1866.) —I find in No. 119, 2d series of this Journal, (Sept. 1865,) observations on the aurora of Aug. 3, 1865, at your city, among which I notice some remarks on the change of color of auroral streamers, from white and yellow into a rosy hue; which the observer attributes to the effect of "*sunlight* striking the tops of those streamers at the height of several hundred miles—as it must have been at that hour—above the earth's surface." The learned author of the said communication calling the attention of auroral observers to this fact, I venture to transmit to him, through your kind intermediary, some extracts from my auroral note-book (kept since 1860, and containing new observations of 47 displays), bearing on the points alluded to by him.

1860, Aug. 12, 9·4 P. M.—A group of splendid streamers appeared N. 15° W., white at first, but turning into purple above.

1860, Sept. 6, 8·33 P. M.—A bluish glow, N. 30° W., issuing a cluster of red streamers; they shifted slowly toward Ursa Major, color turning from purple into an intensive bloody red.

10·5.—The entire upper border of the dark segment dissolved into a smoky cumulated mass, out of which a perfect sea of streamers is seen to issue. The streamers are white below, purple above, the most vivid red being always toward the middle of the streamer.

10·25.—E. and W. the streamers incline toward the horizon, and assume the deepest red hue, while in the N. the color is much paler.

1861, March 9, 8·20 P. M.—The dark segment has completely vanished and a semicircle of streamers has taken its place. They reach as high as the pole-star, and assume a red hue above an altitude of 25°. The most beautiful color is at both the eastern and western extremities.

Observation made on Durham Terrace, Quebec, Aug. 7, 1862, in bright moonlight. Yellow streamers rose from N.E. to N.W., their base being at an altitude of 25°–28° and the tops reaching the zenith. . . . . These streamers appeared stationary, but the intensity of the light moved regularly through their feet from E. to W. and backward, also flowing upward along the streamer. (Same observation at 8·10 P. M. of Aug. 8, on St. Lawrence river, near Trois-Rivières, moon shining very brightly. Streamers of yellow hue.)

1862, Oct. 3.—Full moonlight and display rather indistinct on account of it. I noticed the sky to turn purple in the E. at a low altitude, and at the beginning of the aurora.

Feb. 20.—Near the moon there was a patch of pale carmine, of alternately increasing and decreasing intensity.

In general, I have never seen a single streamer that was not originally *white*, but turned sometimes into purple or bloody-red *upon reaching a certain altitude.* At the moment of issuing, the beam is white and brightest at its base; as it increases in size, it generally attains a motion along the horizon to the west, and also the intensity decreases below and appears greatest in the middle of the beam. When the beam has reached its most westerly position, then the base vanishes and the top appears brightest, the streamer appears as an isolated cloud of more or less brilliant light of varying intensity, until it begins to vanish.

When several arches or layers of auroral matter succeed each other and the tops of the streamers of one arch (still below our horizon) appear at their vanishing points behind the arch immediately preceding, we may sometimes notice the sky under an auroral arch in sight to turn purple also.

I have also noticed that the condition of the atmosphere has great influence on the color of auroral light. By hazy weather streamers appear red, nearer the horizon than by a clear transparent sky.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Analysis of a Meteoric Iron from Colorado;* by Dr. C. T. JACKSON. (From a letter to one of the editors, dated Boston, Nov. 10, 1866.)—I received last Tuesday, Nov. 6th, a piece of meteoric iron from Rev. Mr. Thompson, who brought it from Colorado and who had negotiated for the large mass with the intention of presenting it to the Boston Society of Natural History. I have just learned that Prof. Shepard through the agency of a friend in Denver City has secured the original mass, said to be two feet in diameter, for his cabinet. It appears from Mr. Shepard's letter to me that it is the same mass that is mentioned in the last (Sept.) No. of your Journal, page 250. I made the chemical analysis of it before being aware it was the same meteorite described, and since no previ-

ous analysis of it has been made, I offer mine to you for the Journal, Prof. Shepard expressing a desire that it should be published.

The piece of meteoric iron given me by Mr. Thompson, who brought it from Colorado, weighs four ounces. It has been heated in a forge fire in order to cut it more easily; but still the Widmannstättian figures come out, when dilute nitric acid is applied to the polished surface, as distinctly as possible and consist of a series of small nearly equilateral triangles with the lines well defined and quite elevated. On one side of the specimen was a crust about one-eighth of an inch thick, consisting of sulphid of iron. This probably in the unaltered meteorite is a bisulphid of iron mixed with oxyd of iron.

A portion of the clean metal sawed off from the mass has the sp. gr.= 7·692.

On chemical analysis by the most approved method, separating the iron from the nickel by succinate of ammonia and determining the nickel as oxyd of nickel and then analyzing this oxyd for cobalt and copper—a separate portion of the meteorite being employed in analysis for the tin which was twice determined, and the nitric solution being tested for phosphoric acid and sulphuric acid, &c.—the results per cent of my analysis are as follows:

Metallic iron, - - - - -	90·650
" nickel, - - - -	7·867
" cobalt, - - - -	0·010
" tin, - - - -	0·020
Insoluble matter consisting of a little silica, schreibersite and chrome as proved by blowpipe investigation, - - - -	0·950
	99·497

2. *Hailstones in China;* by S. W. Williams.—On Tuesday at 6 P. M. on June 5, 1866, a thunder storm came from the northeast, and broke over Peking with great violence. The hailstones soon followed the first dash of rain, and increased in size and quantity till the rain almost seemed to cease. The shower lasted forty minutes, leaving the yards white with hailstones, but as the wind was light no damage was done. The very largest stones were 4 to 4½ inches in circumference; the prevailing shape was conical, and almost all the stones exhibited a kernel of clear ice enclosed in frozen snow, with a covering of ice outside. The strata of air through which they passed in their descent must have been of very different degrees of temperature to produce such distinct layers of ice and snow in the stones. Such hailstorms are not frequent in the North of China, and the people say that this one is the most remarkable since July, 1838, when the stones were like oranges and apples and melons for size, and did great damage to dwellings and trees.

3. *U. S. Coast Survey.*—The eminent mathematician, Prof. Pierce of Harvard, has been appointed to the office of Superintendent of the Coast Survey, left vacant by the death of Prof. Bache.

4. *Chicago Museum of Natural History.*—The late Major Kennicutt at the time of his death was Director of the Chicago Museum of Natural History, an institution of which he was essentially the founder. This office has recently been filled by the appointment of Mr. William Stimpson, one of the best zoologists of the country.

OBITUARY.

Prof. BACHE.—The death of Professor ALEXANDER DALLAS BACHE, just announced, will awaken profound regret throughout a very large circle of scientific friends. For the last thirty years he has been intimately connected with the progress of American Science. In some important departments he, more than any other man, may be regarded as the leader.

He was graduated at the Military Academy at West Point, in 1825, holding the first rank in his class. He was immediately appointed Assistant Professor of Engineering in the Academy, and occupied the position for one year. After serving as an officer in the Corps of Engineers for three years, he resigned to accept the professorship of Natural Philosophy and Chemistry in the University of Pennsylvania, to which he was elected in 1827. After filling this place with distinguished success, for a number of years, he was called, in 1836, to the presidency of the Girard College, then recently established in Philadelphia by the princely bequest of Stephen Girard. Six years later he received and accepted the appointment of Superintendent of the United States Coast Survey, a post made vacant by the death of Professor Hassler. He entered upon this office in November, 1843. Since that time, a period of twenty-three years, the results of his labors have been public property. It would be out of place in this brief notice to speak of the magnitude or the importance of that great national work, the Coast Survey. It is proper to say, however, that few men could have carried to it such ample scientific preparation, so much practical wisdom, and such signal, almost unrivalled, administrative talents. His annual reports to Congress, growing in fulness and extent as the work advanced, form an invaluable series of scientific papers. They have justly won for him not only an American but a European reputation. It is well known that eminent scientists in Europe, engaged in the vast labors of geodesy undertaken by the different governments, have sought with eagerness for the Reports of the American Coast Survey, and have placed them, as regards accuracy and exhaustive thoroughness, in the first rank of works upon that subject.

He has contributed many memoirs to our scientific journals, and many to the American Association for the Advancement of Science, of which he was twice president, and always a leading member. These memoirs, often very elaborate, have generally been devoted to the discussion of original researches in the more progressive branches of physical inquiry, and are well worthy of attention not only as substantial contributions to science, but as models of research.

During his presidency of Girard College from 1836 to 1841, he spent a year abroad under the direction of the Board of Trustees, to examine and report upon the state of education in Europe. The results of this examination, executed with great care and minuteness of detail, were given to the public in a full and very instructive octavo volume in 1839.

On the establishment of the National Academy of Sciences, by the Act of Congress, in 1863, the members of that body, intended to represent and direct the highest science of the country, unanimously elected him their first president for a period of six years. Unhappily for the interests of science that period has been cut short. The disease which has now terminated fatally, induced perhaps by over mental action, has for many months been making inroads upon his fine physical constitution, and impairing the vigor of his large and well-balanced powers of mind. His friends have watched its progress with alternate hopes and fears, and have only recently yielded to the sad conviction that his allotted work was done.

In the administration of his office as Superintendent of the Coast Survey, Prof. Bache was always kind and considerate to his subordinates —but never blind to any remissness in duty. He was himself a great worker and he expected every body under him to follow his example.

In society he was eminently genial. No one knew better than he, how to throw off the care of business when a task was done, and give himself up to the mirth and merriment of the hour. To his friends he was most generous and obliging, and very many of them will feel his death as a sorrowful, personal bereavement. He leaves a devoted wife, who has been many years literally the sharer of his labors, to mourn her irreparable loss and bear the burden of solitude in the midst of society. A. C.

J. Burkhardt.—Mr. Burkhardt, long associated with Prof. Agassiz as his artist, died on the 20th of February last, from the effects of a disease consequent on exposure in the course of the late Brazilian expedition.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *First Annual Report on the Geology of Kansas;* by B. F. Mudge, A.M., Prof. of Geology and Nat. Hist. in the Kansas State Agricult. College, and State Geologist for 1864. Lawrence, 1866. 56 pp., 8vo.

Preliminary Report of the Geological Survey of Kansas; by G. C. Swallow, State Geologist. Lawrence, 1866. 198 pp., 8vo.

The first of these Reports gives the results of a reconnoissance made in 1864. It contains some facts of general interest to the people of Kansas, —especially in regard to the saline springs, and the manufacture of salt, but nothing new to science.

The second Report is a more important work. It contains the results of an examination of Eastern and Central Kansas, made in 1865, and includes the separate Reports of Dr. C. A. Logan on the sanitary relations of the State, that of Dr. T. Sinks on its Climatology, and the Report of the Assistant Geologist, Major F. Hawn.

A detailed section of the rocks of Eastern Kansas is first given, in which the classification of the Permian proposed by Swallow and Hawn is essentially retained. This makes the formation in that region about 700 feet in thickness, or nearly three times that admitted by Meek and Hayden (this Journal, [2], xxvii, 424). These geologists regarded the intermediate strata, which contain both Permian and Coal-measure fossils, as part of the Upper Coal-measures, resting conformably upon those below. In this Report these strata are considered as Permian; and it is claimed by Prof. Swallow that a want of conformability may be detected between them and the true Coal-measures, by comparing sections made at different localities. This question of conformability in the series is a very important one, and deserves further investigation.

According to this Report the oldest rocks in the State are Lower Carboniferous. The Coal-measures occupy the surface of Eastern Kansas over an area of 17,000 square miles, and dip beneath the Permian to the westward. They contain not less than 80 separate beds of limestone. No additional evidence appears to have been obtained in regard to the age of the gypsum-bearing strata immediately above the Permian, and none relating to the more recent formations.

The report contains a chapter on economical geology, which, with the separate Reports appended, furnishes much information of value to all interested in Kansas.

2. *First Annual Report of the Geological Survey of Iowa;* by C. A. WHITE, M.D., State Geologist. 4 pp., 8vo. Des Moines, 1867.—This Report is merely a preliminary notice of the organization and commencement of the present survey during the past year. A brief Report by the State Chemist, Prof. Hinrichs, is appended.

3. *Report of the Progress of the Geological Survey of North Carolina*, 1866; by Prof. W. C. KERR, State Geologist. 56 pp., 8vo. Raleigh, 1867.—A brief Report, containing some information on the geology of the State, but mainly interesting as showing that its geological exploration is begun again in good earnest.

4. *Geological Survey of Canada*, Sir WM. E. LOGAN, Director. Report of Progress from 1863 to 1866. 322 pp., large 8vo. Ottawa, 1866.—This Report reached us too late for a notice in this place.

5. *On the Rock-Salt Deposit of Petit Anse, Louisiana Rock-Salt Company.* Report of the American Bureau of Mines. 36 pp., 4to, with maps.—This important report is based mainly on the investigations of Dr. C. A. Goessmann. Dr. Goessmann obtained for the composition of the salt of Petit Anse, chlorid of sodium 98·8823, sulphate of lime 0·7825, chlorid of magnesium 0·0030, chl. of calcium 0·0036, moisture 0·3286=100.

6. *Plane Problems in Elementary Geometry: or Problems on the Elementary Conic Sections, the Point, Straight line, and Circle;* by S. EDWARD WARREN, C.E., Prof. of Descriptive Geometry, etc., in the Rensselaer Polytechnic Institute. 162 pp., 12mo, with a plate and numerous figures. New York, 1867 (John Wiley & Son).—This little volume is prepared by one who is master of his subject both theoretically and practically, and is an excellent manual for the student or artizan. It gives directions with regard to the use of drawing instruments, is clear and precise in its definitions and demonstrations, and very varied in its problems.

7. *The American Naturalist, a Popular illustrated Magazine of Natural History.* Vol. I, March, 1867, No. 1. 56 pp., 8vo. Salem, Essex Institute.—This first number of the monthly American Naturalist, announced in this volume, at page 136, sustains fully all that was promised. Among its illustrations are two plates, one, of the crater of Kilauea in 1864–5, and the other, of the structure of the Land Snails, with reference especially to those of New England.

8. *Description of Fossil Plants from the Chinese Coal-bearing rocks;* by J. S. NEWBERRY, M.D., being Appendix No. 1 of Geological Researches in China, Mongolia and Japan, by Raphael Pumpelly. 5 pp., 8vo, with a plate. Smithsonian Contrib. to Knowledge, 1867.—The species are those referred to by Dr. Newberry in his paper in this Journal, vol. xlii, p. 151.

9. *Musée Teyler:* Catalogue systématique de la Collection Paléontologique, par T. C. WINKLER. Quatrième Livraison. Harlem, 1865.—This is a continuation of the Catalogue noticed in vol. xli, at page 287.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. XXXI.—*On certain recent contributions to Astro-Meteorology;* by H. A. Newton.

1. *Radiant points, or radiant areas.*

For more than twenty years a Committee of the British Association for the Advancement of Science has annually made an extended report on *Observations of Luminous Meteors,* in which have been given in detail the times, paths, physical appearances, and other phenomena, of meteors seen during the years immediately preceding. No special effort has been made until recently, to elaborate this mass of material. R. P. Greg, Esq., of Manchester, assisted by Mr. A. S. Herschel, at last undertook the task of plotting the paths contained in the voluminous records. By this means they have determined between fifty and sixty radiants, for different periods of the year. Prof. E. Heis of Münster, has in like manner, from observations made by himself and his assistants during a period of twelve years, deduced a similar and, to a considerable extent a corresponding series of radiant points. The latter series is in the Monthly Notices of the Roy. Astro. Soc., xxiv, 213. Both series are in the Report of the British Association for 1864, and in the Proceedings of the British Meteorological Society for Jan. 18th, 1865. From the latter source we give the following table. The general results of Mr. Greg's investigations as regards *meteor showers* are thus summed up in the Report of the Committee on Luminous Meteors.

"They appear to endure for almost any period, from twenty-four hours to eight or possibly ten weeks, differing from one another in rich-

Comparison of the epochs and positions of radiant-points of shooting stars, concluded independently by R. P. Greg, Esq., and Dr. E. Heis.

Reference No.	From observations contained in the Brit. Assoc. Catalogues, &c., 1845–63. (R. P. Greg.)					Observed at Munster, 1849–61. (E. Heis.)			
	Epochs in their order of commencement.	No. meteors mapped.	Distinctive numbers (Greg).	Position of radiant. Right Ascension.	Position of radiant. North Declination.	Distinctive letters.	Right Ascension.	North Declination.	Epochs to the nearest half-month.
				°	°		°	°	
1	Dec. 20–Jan. 30	20	ii	22	75	A_1	29	50	Jan. 1–15.
						A_2	15	63	Jan. 16–31.
2	Dec. 20–Jan. 30	18	ii *a*	5	85	N_1	285	84	Jan. 1–15.
						N_2	0	90	Jan. 16–31.
3	Dec. 21–Feb. 4	28	iii	68	17	AG_1			
4	Jan. 2–Jan. 3	52	i	234	51	K_2	235	52	Dec. 16–31.
						K_1	242	51	Jan. 1–15.
5	Jan. 2–Feb. 4	30	iv	133	40	? M_2	166	52	Jan. 16–31.
6	Jan. 5–Jan. 25	15	iv *a*	173	32	MG_1			
7	Feb. 4–Feb. 26	36	v	147	•34	M_3	150	60	Feb. 1–14.
8	Feb. 7–Feb. 26	20	vi	136	70	M_4	130	63	Feb. 15–28.
9	Feb. 9–Feb. 17	13	vii	76	40	A_3	65	51	Feb. 1–14.
						A_4	91	37	Feb. 15–28.
10	Feb. 10–Mar. 17	21	viii	168	9	S_1	170	11	" "
						S_2	178	7	Mar. 1–15.
						S_3	173	23	Mar. 16–31.
11	Feb. 11–Mar. 16	10	viii *a*	37	1	SG_1			
12	Feb. 19–Feb. 26	10	vi *a*	220	84	N_3	0	90	Feb. 1–14.
						N_4	250	83	Feb. 15–28.
13	Mar. 3–Mar. 27	11	xiii	44	72	N_5	340	80	Mar. 1–15.
14	Mar. 3–Mar. 31	30	ix	145	67	M_5	125	52	" "
						M_6	140	50	Mar. 16–31.
15	Mar. 3–Mar. 31	18	x	186	58	? M_2	140	50	" "
16	Mar. 12–Mar. 20	20	xii	223	39	MG_2			
17	Apr. 1–June 2	52	xi	194	52	M_7	160	53	Apr. 1–15.
						M_8	150	61	Apr. 16–30.
18	Apr. 2–May 1	20	xiv	189	4	S_5	194	5	" "
19	Apr. 8–May 28	20	xix	227	−8	SG_2			
20	Apr. 12–Apr. 13	17	xvi	276	26	QG			
21	Apr. 16–May 3	30	xv	96	87	N_8	265	83	Apr. 16–30.
22	Apr. 19–Apr. 20	25	xvii	282	33	DG_1			
23	Apr. 25–June 4	28	xviii	255	48	DG_2			
24	Apr. 30–June 4	15	xx	243	20	Q_1	218	20	May 1–31.
25	May 9–June 3	16	xviii *a*	277	42	D			
26	May 9–June 4	8	xxi	286	21	W	292	15	June 1–30.
27	May 29–June 17	18	xxii	336	45	B_1	332	60	May 1–31.
						B_2	333	42	June 1–30.
28	June 1–June 30	9	xx *a*	236	30	Q_2	242	12	" "
29	June 1–June 30	12	xxiii	300	85	N_9	290	80	May 1–31.
						N_{10}	150	83	June 1–30.
30	July 2–July 24	51	xxiv	291	53	B_3	315	54	July 1–15.
				to 313	43				
31	July 10–Aug. 6	26	xxvii	257	13	Q_3	262	12	July 1–15.
32	July 20–Aug. 4	46	xxv	359	70	N_{11}	20	85	" "
						N_0	337	86	July 16 to Aug. 15.*
33	July 22–Aug. 10	70	xxvi	344	12	T_1	314	15	Aug. 16–31.
				to 327	10				
34	July 29–Aug. 22	123	xxiv *a*	302	44	B_4	306	59	Aug. 16–31.
				to 288	42	B_0	302	65	July 16 to Aug. 15.*
				and 298	58				

TABLE—continued.

Reference No.	From observations contained in the Brit. Assoc. Catalogues, &c., 1845-63. (R. P. Greg.)					Observed at Munster, 1849-61. (E. Heis.)			
	Epochs in their order of commencement.	No. meteors mapped.	Distinctive numbers (Greg).	Position of radiant. Right Ascension.	Position of radiant. North Declination.	Distinctive letters.	Right Ascension.	North Declination.	Epochs to the nearest half-month.
35	Aug. 6–Sept. 10	80	xxix	0°	90°	N_{12}	295°	79°	Aug. 16–31.
						N_{13}	130	84	Sept. 1–15.
36	Aug. 7–Aug. 16	...	xxviii	45	55	A_0	50	51	July 16 to Aug. 15.*
				to 20	62				
37	Aug. 17–Sept. 12	9	xxvii *a*	245	5	Q_3	262	12	July 1–15.
				to 262	12				
38	Aug. 17–Sept. 30	18	xxiv *b* *or* xxx *a*	282	42	B_5	293	57	Sept. 1–15.
39	Aug. 17–Sept. 30	150	xxx	333	50	EG			
				i.e. 314	52	E ?	330	50	Oct. 16–31.
				to 347	47	A_{11}	35	63	Sept. 1–15.
				and 333	41	A_{12}	44	63	Sept. 16–30.
				to 333	62	A_{13}	51	61	Oct. 1–15.
40	Aug. 18–Sept. 29	27	xxxi *or* xxx *b*	13	34	R_1	53	35	Sept. 1–15.
						R_2	46	37	Sept. 16–30.
41	Aug. 22–Nov. 5	27	xxxii	1	15	T_2	343	10	Sept. 1–15.
						T_3	1	11	Sept. 16–30.
						T_4	3	11	Oct. 1–15.
42	Sept. 6–Nov. 23	18	xxxiv	22	−9	TG			
						U	10	−11	Oct. 16–31.
43	Sept. 20–Oct. 11	35	xxxv	83	48	AG_2			
44	Sept. 25–Oct. 10	16	xxxvi	51	84	N_{14}	65	84	Sept. 16–30.
45	Sept. 27–Nov. 2	67	xxxiii	14	58	A_{14}	20	42	Oct. 16–31.*
						A_{15}	25	40	Dec. 1–15.*
46	Oct. 3–Oct. 20	11	xxxvii	140	45	LG			
						? L_1	115	55	Dec. 1–15.*
47	Oct. 4–Nov. 10	35	xxxviii	45	33	R_3	45	32	Oct. 1–15.
48	Oct. 18–Nov. 3	30	xxxix	83	12	O			
49	Oct. 20–Nov. 21	33	xl	91	56	F	75	40	Oct. 16–31.*
50	Oct. 31–Dec. 9	14	xliii	139	7	LH			
51	Nov. 1–Nov. 23	75	xli	16	49	AG_3			
52	Nov. 7–Nov. 15	...	xlii	153	22	L_0	150	28	Nov. 1–30.*
53	Nov. 23–Dec. 9	9	xlv	279	56	DG_3			
54	Nov. 24–Dec. 10	37	xliv	59	58	A_{16}	37	59	Dec. 16–31.
55	Nov. 26–Dec. 30	84	xlvii	96	36	G			
						? L_1	115	55	Dec. 1–15.*
56	Nov. 27–Dec. 19	10	xlvi	157	71	KG			

Total meteors, 1746; days, 1655; meteor-showers, 56.

(*) Radiants marked thus are extracted from the work by Dr. Heis, entitled 'Die Periodische Sternschnuppen.' (4to. Cöln, 1849.)

ness or intensity of display. In some there appears to be a tendency to maximum display on particular days, as for example xlvii, lasting from November 26th, to December 30th; but the most abundant display occurs from December 9th to 13th. In others no such maximum can be perceived. Their number, of fully fifty as yet ascertained, will probably not be much exceeded, unless by short-lived showers, and by others whose radiants culminate just before dawn. There is no confusion or chance in their return, but, on the contrary, the showers are very regularly recurrent every year, and, allowing a *radiant-region* of 10° to 15° in diameter for each, the so-called "sporadic" meteors will become extremely scarce, now that the principal showers and their radiants have been pointed out. A well-marked instance of long persistence and remarkable for having its radiant very small and fixed, is the shower of August 6th to September 10th, No. xxix. The great majority have, at the present time, been as clearly defined (as regards the time of their occurrence, duration, and positions of their radiants) as in the case with the older and better known showers of August and November. On the average of many years, the radiant-regions of a few are, however, still very extensive. In all, a plane, oval, or double-headed region of radiation appears to represent the conditions of the showers more correctly than a point. This elongation of the radiant-region is in most cases perpendicular to the ecliptic, or parallel to the *via lactea*, in or near which the greater number of the radiants in the latter half of the year are placed. The meteors of particular showers vary in their distinctive characters, some being larger and brighter than others, some whiter, some more ruddy than others; some swifter, and drawing after them more persistent trains than those of other showers. Their connection with the epochs and directions of large meteors still remains to be established."

From a private letter by Mr. Greg to Mr. B. V. Marsh we learn that some minor changes are found neccessary, by further observation and investigation, in the duration of the showers and the places of the radiants. Mr. Greg's charts containing the paths of nearly 2000 shooting stars are about to be published by the British Association. We may hope to receive them within a few months. We evidently need these charts in order to discuss intelligently this important subject. While waiting for them, however, one or two remarks may not be out of place.

That the so-called *sporadic* shooting stars should belong largely to rings or streams, as do the August and November meteors, is in the present state of our knowledge probable, or at the least is not improbable. The reasonings of Mr. Schiaparelli, which will be spoken of further on in this article, strengthens this probability.

But we meet with some difficulty in accepting the proposition that a ring or stream may be of such breadth as to require eight or ten weeks for the earth to traverse it, that is, that the ring may extend 60° or 70° along the ecliptic; or rather, if there were so broad a ring or stream, it would not appear to have a radiant area so small, and so well marked, as to be detected.

The position of the radiant indicates that point of the heavens from which the *relative* motion of the meteoroids with reference to the earth is directed. This direction is the resultant of two *absolute* motions, that of the meteoroids and that of the earth. If either of these should change, the place of the radiant will change.

But during these eight or ten weeks the direction of the earth's motion would change 60° or 70°. If the direction of the meteoroids' motions were supposed parallel throughout the breadth of the stream, yet this change in the direction of the earth's motion alone appears to necessitate a change of the position of the radiant by a distance on the heavens of not less than 30° or 40°.

But for a group of such thickness, we can hardly suppose the absolute motions of the meteoroid parallel throughout its breadth. Each meteoroid must move about the sun in its own orbit, and though this is not entirely inconsistent with a parallelism of the paths where the group crosses the ecliptic, yet such a case is extremely improbable. Again it appears necessary that a meteoroid which is now on one side of the stream should be after half a revolution on the opposite side. Hence, we might reasonably expect that at the center of the stream we should find their paths crossing each other at large angles,—angles comparable in magnitude to the 60° or 70° which measures on the ecliptic the breadth of the stream. Such divergence of directions of the individual members of the group, would make the existence of an apparant radiant of moderate area impossible.

Again a stream whose thickness is so great, may be expected to have also large breadth in direction of the radius vector. This again would make the parellelism of the paths, and consequently the apparent radiation improbable.

In fact a ring of such enormous thickness as to require two months for the earth to cross it, would seem not only to lose all the essential characteristics of a distinct group, but also to be unable to manifest its existence by a constant and small radiant area.

The conclusions of Mr. Greg and Dr. Heis, are derived almost entirely from meteors seen in evening hours. But the phenomenon of radiation caused by parallelism of absolute motions should be more distinctly evident as the radiant is nearer the meridian. This occurs, in general, in the morning hours.

While, then, the existence of rings or streams is *a priori* probable, and so the existence of radiants for *very short* periods is to be looked for, yet the series now proposed will doubtless undergo essential changes, as we accumulate observations, or else some other cause than ring-formations be found to account for the radiation.

There should, in any case, be a tendency to a radiation, both from the zenith and from the point to which the earth is moving; hence from the region lying between these points, i. e., from the N.E. quarter of the heavens.

2. Influence of the August and November meteors upon the temperature of the atmosphere.

Erman early asserted the existence of cold periods, from the 5th to the 12th of February, and from 10th to the 13th of May. These he attributed to the influence of the August and November meteors, assuming that they passed at those epochs between the earth and the sun. To the same cause he attributed certain dark days, and other appearances, said to have occurred in the years, A.D. 1106, 1206, 1208, 1706, and 1547.

In a series of papers read before the Paris Academy of Sciences, and published in the Comptes Rendus,* Mr. Ch. St. Claire Deville has given the results of an elaborate investigation of the alleged abnormal changes of temperature in these months, as well as those alleged for corresponding days of August and November.

Mr. Faye in response to the first of these papers, shows conclusively that the dark days, &c., adduced by Erman, cannot be referred with any probability to the meteors as their cause.

In his earlier papers, Mr. St. Claire Deville undertakes to show that there are periodic variations of the temperature of the critical days in February, May, August, and November, that correspond to secular maxima and minima of the August and November meteors. For the August meteors he assumes a maximum in 1847 or 1848, relying upon the assertion of Mr. Coulvier-Gravier.

The existence of a maximum for the meteors in or near those years, is in itself exceedingly doubtful, and the evidence adduced by Mr. Deville to prove corresponding changes of temperature, is also very far from satisfactory.

Mr. Deville's own conclusions, as given in his later papers themselves throw doubt upon the existence of any important connection between the meteors and the temperature of the air. He finds that there is an accordance, between the movements of the thermometer in the several months, February, May, August, and November; and that the 12*th day* of each of these months is the critical day of a marked inflection. But this accordance (*or solidarity*) between the several months is entirely lost when the days are so combined as to compare not the days of the same name in the month, but those corresponding to points 90° apart on the ecliptic. But in what possible way can the meteors create oscillations in the temperature of the atmosphere, whose maxima and minima, shall in November be one or two days *before* we reach them, shall in May be at the time of the passage of the earth across the plane of the November group, in Au-

*. Vol. lx, 577, 655, 696, 909; lxi, 5, 61, 350; lxii, 1054, 1149, 1209, and lxiii, 1030.

gust shall be one or two days *after* the shower, and in February five or six days *after* the earth crosses the plane of the August ring?

3. The paths and probable origin of Shooting Stars.

The most important recent contribution to the theory of shooting stars is by Mr. Schiaparelli of the Brera Observatory at Milan. It is contained in a series of five letters to P. Secchi, published in the Bullettino Meteorologico of Rome.*

By a course of reasoning similar to that which led the writer to the same conclusion,† he argues that the mean velocity of the meteoroids, is considerably greater than that of the earth in its orbit. Hence their orbits are in general, long ellipses, or parabolas.

Assuming then (which is not improbable) that the meteoroids form in the planetary spaces a multitude of currents, or continuous rings, having all possible inclinations to the ecliptic, he proceeds to inquire in what way so singular a form of grouping of cosmical matter, could have been produced.

Notwithstanding the uncertainty of the determinations of the velocity of the solar system and of the stars in space, he considers it reasonable to assume that the velocities relative to the sun of the various bodies which are scattered through stellar spaces, are comparable in magnitude to those of the planets in their orbits.

Suppose now one of these bodies, a comet for instance, to come by its proper motion so near to the sun, that solar attraction far exceeds the attraction of the stars, and yet to be at such a distance that its annual parallax is but a few seconds. Its orbit about the sun will then be a conic section. Suppose now the sun to be at rest, and regard the relative velocity of the comet as the real velocity. Let fall a perpendicular from the sun upon the direction of the comet's motion. The area described about the sun in a unit of time, will be equal to one-half the product of this perpendicular into the comet's velocity.

As, however, the velocity is, in general, comparable in magnitude to the planetary velocities, and the perpendicular is in general, enormously greater than the distances of the planets from the sun, it follows that the areas described in a unit of time are, in general, very much larger than corresponding planetary areas. But these areas are as the parameters of their corresponding orbits. Hence, in general, the orbits of such comets would have enormous dimensions in every direction, and the bodies themselves would remain invisible to us, because of their great distance from the earth.

* Vol. v, Nos. 8, 10, 11, 12, and vol. vi, No. 2.

† This Journal, xxxix, 205–7, and Mem. Nat. Acad. of Sciences, vol. i, p. 309–311.

In two cases only would they come within our field of vision. When the perpendicular is very small, a hyperbolic orbit would result, differing in general not much from a right line. As the radius of the sphere of our vision is only about four times the distance from the earth to the sun, this case would rarely happen.

The second case is when the relative motion of the comet is very small, that is, when the comet and sun are moving in nearly parallel paths, with nearly equal velocities. An orbit very nearly a parabola would result. This case would likewise be very rare, since of all possible velocities of the bodies in the stellar spaces, very few would be nearly equal and parallel to that of the sun.

The parabolic form of the cometary orbits should not then surprise us. This is not the only possible form. On the contrary it is one that is very rare. But owing to the nature of comets, and to our feeble powers of vision, we can see only those which describe just these orbits. Nor is there reason for wonder that the planes of their orbits have no relation to the plane of the ecliptic.

The characteristics peculiar to planets can be accounted for by their formation in the solar system; those peculiar to the orbits of comets depend on the manner in which the sun attracts them to itself from the depths of space. The latter then should have an origin foreign to our system. To which of these two classes belong the shooting stars? Are they planets, or are they comets?

The planetary hypothesis has hitherto been favored by astronomers. The ring theory, however, as Mr. Schiaparelli believes, leads to serious difficulties respecting the origin of the shooting stars, whether the rings be regarded as integral parts of the solar system from the beginning, or they be supposed to have come from space, being attracted hither by the sun.

There are two arguments which show that the meteoroids should be classed with the comets as originally strangers to our system, rather than with the planets. The first is that their orbits seem to be inclined at all angles to the ecliptic;* the second, that their velocity requires a long if not a parabolic orbit.

* That the inclinations of the orbits of the meteoroids are of all magnitudes, Mr. Schiaparelli infers, principally, from the positions of the radiants given by Messrs. Greg, Herschel, and Heis. Although these radiants are open to criticism, yet the above conclusion is undoubtedly true. It is readily seen that if the orbits of the meteoroids are but little inclined to the earth's orbit, the apparent paths of the meteors should themselves rarely be seen to cut the ecliptic, and that the paths produced forward should rarely cut the ecliptic above the horizon. In other words, the paths as seen in the sky should, with rare exceptions, appear to lead away from that circle. So far as my own observation is concerned, I find no such regularity. The meteors go toward the ecliptic as often as from it. Apparent radiation from points of such considerable latitude as those given in the table on pp. 286, 287, shows also that many of the orbits of the meteoroids, at least, are inclined at large angles to the earth's orbit.

Admit, then, that the shooting stars come from stellar space, and we have no longer closed rings of short period, but streams of a parabolic form, for which the period of revolution, if there is one, is very great. Now this parabolic current, which at first seems so strange a form, is not only possible, but it is the *only* form in which a cosmical cloud drawn from stellar space by solar attraction can approach the sun and become visible to us.

To prove this, he supposes a cosmic cloud of the size of the sun, to be at first at a distance equal to 20,000 (the mean distance from the earth to the sun being unity). The rarity of the matter in this cloud is regarded such that the mutual attraction of the particles may be disregarded. This cloud of particles is then supposed to have a velocity (relative to the sun) perpendicular to a line drawn to the sun, one twenty-thousandth of the mean velocity of the earth, or about one hundred yards a minute.

The several particles will move in elliptic orbits about the sun, but these ellipses will not be exactly equal. Mr. Schiaparelli shows that a cloud, of spherical form at first, would be deformed, little by little, and ultimately drawn out so as to have a very small transverse section. It will now lie along a parabolic arc, of which the sun is the focus. When the particle originally at the center of the globe reaches its perihelion, at a distance from the sun equal to $\frac{1}{2}$, the anterior portion of the group will have passed its perihelion 193·5 days, and have already crossed in its outward course the orbits of the minor planets. The end of the group will not have reached these orbits in its descent to the sun. The whole extends along 267° of anomaly on the parabolic orbit. The breadth of the group at its center, in direction of the radius vector, will be 96 meters, and in the direction perpendicular to the plane of the orbit, 37 kilometers. Its density at this place will be 400 millions of times the density of the original group.

If the primitive form of the group was other than spherical the same reasoning would apply, and similar results follow.

The apparent diameter of the assumed globe, as seen from the sun, is about 0″·1. But if the original cloud be supposed to have an apparent diameter of one minute, the resulting stream would require 636 years to pass the perihelion. Some of the nebulæ have apparent diameters exceeding that of the sun. A globe of such a size (1924″) would be transformed into a parabolic stream which would require more than 20,000 years to pass the perihelion. The cross section of this stream would be much greater than in the preceding case, but yet not so great but that the earth might cross it in a few hours, or at most, in one or two days. We may, then, without extravagant hypotheses account for the existence of meteoric currents which have been observed for hundreds or thousands of years, like that of August.

For facility of reasoning, the original position of the supposed spherical group was placed at the aphelion of a long ellipse. But results similar in kind, and comparable in degree, would result, had the group been supposed at any point of a conic section of very great length.

If the orbit is an ellipse, the original form of the cloud would never be regained. At each perihelion passage, the length of the stream would be increased until it formed a closed circuit. The stream would be, at first, periodic, but finally constant. If the orbit is open, there would be a single passage only.

The supposed cloud was deemed to exert no sensible attraction upon its particles. To justify such an assumption, Mr. Schiaparelli makes an estimate of the density of the August ring. For the mean distance from each other, of the bodies of the August group, he obtains by computation about 100 (geographic) miles. This is obtained by quite arbitrary suppositions, but the result is very nearly that which is obtained by computations from the best data in our possession (see this Journal, xxxix, 207), combined with observations at Hartford in 1863, when six observers counted 153 different meteors in a half hour.*

For the size of the individual meteoroids, he assumes one gram, relying upon the conclusions of Mr. A. S. Herschel who compared the light of the meteors with the light of a candle, and hence inferred their weight. The estimate seems too small, for some of the trains fill cubic miles of space with matter of sufficient consistency to form a cloud visible for minutes (see this vol., p. 86). Yet the probable size of these bodies is so small that Mr. Schiaparelli's reasoning is still conclusive.

To each sphere whose radius is fifty miles he assigns, therefore, one gram of matter. The cloud first supposed had only $\frac{1}{400,000,000}$ the density of the resultant stream at the perihelion. Suppose, however, the space originally occupied by the meteoroids of the August stream, to be only one million times that now filled at the place where the earth traverses it. To each gram of matter would originally have belonged, in that case, a volume equal to that of a sphere 10,000 miles in diameter.

He then shows that a spherical group of bodies, each body weighing one gram, whatever be the dimensions of the group, must have at a distance from the sun equal to the earth's mean distance, a density such that the mutual distances of the members shall be less than 1·86 meters (2 yards), in order that the attraction of the sun shall not dissolve the group. If the mutual distances of the members exceed $1{\cdot}86^m$, the sun acts to separate the individuals from each other, not at the surface simply, but throughout the whole extent of the system.

* The corresponding mean distance from each other of the members of the November group, where we crossed it last year, is 30 or 40 miles.

But if the mutual distances are, as before determined, 100 miles, the dissolving power of the sun is 10^{15} times the mutual attraction of the particles. In like manner, the dissolving power of the sun's attraction upon a group of similar bodies distant 20,000 from the sun, the mutual distance of the bodies being 10,000 miles, is 125,000,000 times the attraction which the group has for one of its particles. This latter force then may be safely neglected. The dissolution or deformation of the system must, moreover, begin much farther away from the sun than the assumed position of the cosmic cloud, out even in the stellar spaces. It can enter the solar system only as a parabolic current.

Even if we suppose a group that is tolerably dense, approaching the sun, as, for instance, a comet without a nucleus, there is a certain limiting distance within which the differences of solar attraction tend to dissolve it. If such a group passes this limit, in its descent to perihelion, the members will be scattered, and the original formation will never be restored. We have thus a most singular effect of attractive force, namely, the dispersion of a system that lacks coherence.

If now a dense cloud of bodies is supposed to pass near one of the larger planets, its orbit will be changed, and may become one of short period, like those of certain comets. If, moreover, its perihelion distance is less than the distance at which solar attraction disintegrates the groups, the cloud is dissolved into independent particles. Diversity of planetary perturbations produces in the orbits of these particles a variety of elements, especially variety in the periodic times. The group is gradually lengthened along the ellipse, and after a certain number of revolutions the cloud becomes a continuous ring. The meteors of November belong to such a group, while the ring is partially formed. The August meteors probably represent a group after it is transformed into a continuous ring.

Mr. Schiaparelli gives a summary of the consequences which result from the preceding discussions in the following propositions, which establish the basis for a new theory of falling stars.

"I. Matter is disseminated in celestial space in all possible grades of division. The first grade consists of the larger stars, either isolated, or collected in systems of few members. The second is made up of large agglomerations of small stars, the *star dust* of Herschel, into which many nebulæ are seen to be resolved by large telescopes. Then follow smaller bodies, which are invisible except when they approach the sun under the form of comets. Finally the last grade consists of cosmical clouds, composed of very minute elements, which have a weight comparable to that of objects which we are accustomed to handle or transport on the earth.

"II. This last class of bodies may have been formed in space, by the local concentration of the celestial matter, in a manner analogous to the crystallization of substances chemically dissolved in liquids. From what occurs in these crystallizations we are even led to think that such a form of aggregation is much more probable and more frequent than the others, which take place by large masses. Hence the volume occupied by the cosmical clouds may be a notable fraction of the stellar space.

"III. The movements of such clouds among the bodies of the universe, are comparable to those of the fixed stars, and are probably due to analogous causes. When any one of them enters the sphere of attraction of the sun, it cannot be visible to us unless its orbit relative to this great luminary is a very greatly elongated conic section.

"IV. Whatever may be the form and extent of a cosmical cloud, it cannot (with very rare exceptions) penetrate to the interior of the solar system, unless it has been transformed into a parabolic current, which may consume years, centuries, and myriads of years in passing, part by part, its perihelion, forming in space a river, whose transverse dimensions are very small with respect to its length. Of such currents, those which are encountered by the earth in its annual motion, are rendered visible to us under the form of showers of meteors diverging from a certain radiant.

"V. The number of meteoric currents crossing the spaces of the solar system, at all possible distances, and in all directions, is probably very great. The exceeding rarity of the matter contained in them, allows these currents to intersect mutually, without causing any disturbance to one another. They may undergo progressive transpositions and deformations in space, like rivers which slowly change their bed. They may be interrupted, and thence become double or multiple, and they may even in particular circumstances become closed elliptical rings. The November meteoroids are apparently portions of such a ring in process of formation.

"VI. The cosmical clouds having short periods of revolution around the sun, by which some are inclined to explain the appearance of shooting stars, cannot have a permanent existence without violating the known laws of universal gravitation.

"VII. The matter of the parabolic currents, after having passed the perihelion, returns into space in a state of dispersion, greater than that which it had before the passage. In particular cases, as when the current meets a planet, very great perturbations may ensue, and a separation of some of the meteoric stars into special orbits. Such stars from that moment may be called truly *sporadic*.

"VIII. Thus the meteoric stars, and other celestial products of analogous nature, which in past ages were commonly regarded as atmospheric phenomena, which Olbers and Laplace first ventured to make to come from the moon, and which at a later period were raised to the dignity of members of the planetary system, truly belong to the category of the fixed stars; and the name *falling stars* expresses simply and precisely the truth respecting them. These bodies have the same relation to comets, that the small planets between Mars and Jupiter have to the larger planets. The smallness of the mass is in each case compensated by the very great number.

"IX. Since we may safely regard it as certain that falling stars, bolides, and aërolites differ in nothing except their magnitude, we may conclude that the matter which has fallen from the sky is a fragment of that of which the stellar universe is formed. And as in such matter there is no chemical element that is not found upon the earth, the similarity of composition of all the visible bodies in the universe, already rendered probable by researches with the spectroscope, acquires a new argument for its credibility."

The further question is then broached, whether it is necessary for the original cloud to be made up of such small elements; whether, for example, it may not consist of a moderate number of comets. In such a case, we ought to meet, from time to time, with orbits somewhat unlike, which intersect each other in the depths of space, but which lose the characteristics of a common system, owing to considerable intervals between the times of perihelion passage.

The question is not a new one. Prof. Hoek of Utrecht has found several double and triple systems of comets,* which at a remote epoch were near each other in space, although their perihelion passages have differed by years. The most notable of these systems, is that of the comets 1860 III, 1863 I, 1863 VI, which at the end of the year 760, A. D., were at distances from the sun respectively 600·00, 600·42, and 600·25, and distant from each other 12·8, 16·3, and 8·1. To a spectator from the sun their apparent maximum distance was 1° 33′. Hoek believes that the comets of 1677, and of 1683, belong also to this system. The antecedent probability of a chance coincidence like that of these comets is exceedingly small.

We find thus analogies between the systems of shooting stars, and systems of comets. Can we not imagine mixed systems, in which a cloud of meteoroids are grouped in space about one or more larger nuclei, that is, about one or more comets?

If a system of this kind is drawn from solar attraction into the figure of a parabolic current, the parabola described by the principal body (or those described by the principal bodies) should evidently differ very little from the line along the center of the parabolic stream, consequently the preceding question is answered affirmatively whenever we find a meteoric current forming a parabola identical in magnitude and position with any parabolic cometary orbit. In such a case the comet will evidently form part of the current, and be one of its elements.

To test this question, Mr. Schiaparelli computed the following elements of the mean orbit of the August meteors, supposing it a parabola, assuming the radiant to be R. A. 44°, N. Dec. 56°, and the time of crossing the center of the group in 1866 to be Aug. 10·75. With these elements are placed those of the comet 1862 III, according to the latest determination of Dr. Oppolzer.†

* Monthly Notices, xxv, 243, and xxvi, 1 and 204. † Astr. Nach., No. 1384.

	Elements of August meteors.	Elements of Comet 1862 III.
Long. of perihelion,	343° 38′	344° 41′
Long. of node,	138° 16′	137° 27′
Inclination,	64° 3′	66° 25′
Perihelion distance,	0·9643	0·9626
Motion,	retrograde	retrograde
Perihelion passage,	July 23·62	Aug. 22·9, 1860
Period,		123·4 years

These elements do not differ by quantities greater than can be accounted for by the want of precision in the data for computing the paths of the meteors. We come thus to the unexpected conclusion, *that the great comet of* 1862 *is nothing else than one of the August meteoroids, and probably the largest of them all.*

At the time of announcing this relation of the comet of 1862 with the August meteors, Mr. Schiaparelli found no comet having similar relations with the November meteors. But upon the publication by Oppolzer shortly after,* of the corrected orbit of the comet 1866 I, the resemblance of its elements to those of the orbit of the November group on the supposition of a period of 33·25 years was strikingly manifest, attracting at once the notice of several astronomers.† The following comparative elements are given by Schiaparelli (Bullettino Meteor., Feb. 28, 1867).

	Nov. Meteors.	Comet 1866 I.
Perihelion passage,	Nov. 10·092, 1866.	Jan. 11·160, 1866.
Passage of descending node,	Nov. 13·576	
Long. of Perih.,	56° 25′·9	60° 28′·0
Long. of Asc. Node,	231° 28′·2	231° 26′.1
Inclination,	17° 44′·5	17° 18′·1
Perihelion dist.,	0·9873	0·9765
Eccentricity,	0·9046	0·9054
Semi-major axis,	10·340	10·324
Periodic time,	33·250	33·176
Motion,	retrograde.	retrograde.

The comet of Tempel, he adds, not only describes, therefore, the same orbit as the November group of meteoroids, but is in the same portion of the orbit, and probably nearer the head than the tail of the group.‡ The observations of November 13th, 1865, showed that the earth traversed the anterior portion of the swarm at that time. Two months later the comet passed the node, and ten months afterward the earth, returning to the node, encountered a dense portion of the stream.§

* Astr. Nach., No. 1624.

† Peters, Astr. Nach., No. 1624; Oppolzer, ibid. No. 1626; Schiaparelli, ibid.

‡ The computed elements of the comet of 1366, though very uncertain, resemble those of comet 1866 I, and may belong to the same body. There was a remarkable star-shower in 1366 shortly after the computed perihelion passage of the comet.

§ The total length of the stream would exceed 500,000,000 miles.

The comet 1862 III (sometimes called 1862 II by not counting Encke's comet), which seems thus to have such interesting relations with the August meteors, was discovered on the evening of the 18th of July, 1862, by Mr. H. P. Tuttle at Cambridge, Mass., and a little later on the same evening by Mr. Thomas Simons at Albany, N. Y.* It was first seen in Europe on the 22d of July, and remained visible more than two months. At its brightest its nucleus was equal to a star of the second or third magnitude, and its tail, according to some observers, was as much as 25° in length. The changes that took place in the coma and tail were quite remarkable, and were carefully observed. They will now possess a double interest.

The telescopic comet 1866 I was discovered by Tempel on the 19th of December, 1865, and was visible about a month. Its minimum distance from the earth's orbit was ·00660, about two and a half times the distance from the earth to the moon. This distance for Tuttle's comet is ·00472, or about 430,000 miles.

4. *Age of the November group of shooting stars.*

In the Paris Academy of Sciences, Jan. 21st, 1867, LeVerrier spoke of the November meteors (Comptes Rendus, lxiv, 94). Inasmuch as the group is not a complete ring, he argues that it is of comparatively recent formation, having come into the solar system, and been turned into its present orbit within a few centuries.

Now a body coming from a great distance and so having a great velocity in the vicinity of the earth could not be thrown into an orbit nearly circular by the feeble action of the lower planets. Computation leads to this result, which is fully confirmed by the fact that the swarm passes every 33 years near the earth and yet returns at *regular* intervals.

Assuming then an orbit whose period is 33¼ years, whose perihelion distance is 0·989, viz., the earth's distance from the sun on the 14th of November, and assuming the position of the radiant to be long. 142°, N. lat. 8½°, he computes corresponding elements.

The group, when it came into the system, could not be thrown into its present orbit except by a powerful perturbing cause, as was the case with the comet of 1770. Moreover, comets so acted upon that the newly acquired orbit has a small perihelion distance, return necessarily to the orbit of disturbing body, just as the comet of 1770 returned to Jupiter. We cannot help then being struck with the circumstance that the November group extends to the orbit of Uranus and a very little farther; and

* Mr. Swift, of Marathon, N. Y., claims to have seen it two or three days earlier, but he made no announcement of the discovery, supposing it to be another comet.

that these orbits intersect, very nearly, just after the group passes its aphelion, and above the plane of the ecliptic.

The question then arises whether the group and Uranus have ever been together at this point. By calculation it is found that no such meeting could have taken place since the year 126 of our era, and that by a change of the computed node for that epoch by 1° 48′, and by placing the perihelion 4° from the descending node in November, the group would then actually strike the planet Uranus. These two changes are not greater than the possible errors of our observations.

LeVerrier's researches farther show that a globular group one-third of the diameter of Uranus (more or less) might at that time have been then thrown into a shape and an orbit which should by this time give all the phenomena of the November meteors. Its previous orbit might have been an ellipse, a parabola, or a hyperbola. Its motion might even have been direct in an elliptic or parabolic orbit.

In the course of future time, he argues, the phenomena will extend over a larger and larger number of consecutive years, diminishing, at the same time, in intensity. But no change in perihelion distance will make them disappear entirely. Even if this group again meets Uranus, the planet can act only upon a part of its matter, and cannot throw it all into a new orbit as Jupiter did the comet of Lexell.

These reasonings of Schiaparelli and LeVerrier have certainly great force, and make it probable that of the five possible periodic times of the November meteors (this Journal, xxxviii, 57), that of 33·25 years is the true one. The strongest objection to this conclusion is that the radiant in November does not seem to be a point, but rather a small area. This area cannot be of great breadth in latitude since the ring is only twenty-five or fifty thousands of miles in thickness. If, as observations *seem* to require, the radiant extends in longitude two or three degrees only, then the lines of apsides of the orbits of the several members of the group differ considerably. In this case it is more reasonable to suppose the orbits themselves grouped about an exact circle than about a long ellipse.

If upon examination it shall be found that the center of the radiant area was decidedly more or less than 89½° from the sun, on the morning of the 14th of November last, then this objection will lose much of its force. Again, if there shall not be seen on the morning of May 12th, 1867, between 1 o'clock and dawn, a few scattering members of the November group, radiating from a point 180° from Leo, this also will tend, to a certain extent, to strengthen Schiaparelli's reasonings.

ART. XXXII.—*Observations upon the Drift phenomena of Southwestern Iowa;* by C. A. WHITE, M.D.

[In advance of his final report upon the Geology of Iowa.]

IN the year 1858 I discovered distinct glacial scratches upon an exposed layer of the Upper Burlington limestone (Subcarboniferous), and made full notes and drawings of the same, which having been unfortunately destroyed by fire within a year afterward, no account of the observations was ever published. No opportunity has since presented itself to verify those observations, but I think I am not mistaken in the recollection that there was but one set of scratches, which were straight, distinct, and rather numerous; having a direction south, about twenty-two degrees east. This, so far as I am aware, was the first observation of glacial scratches upon rocks *in situ* in the state of Iowa, although boulders with similar scratches upon them are often seen in various parts of the state.

During my official labors last season, although considerable attention was given to the drift deposit, no similar traces of glacial phenomena were ever discovered until I reached the Missouri river in Mills county, where, on section 16, township 71, range 43, west of the fifth principal meridian, very distinct glacial scratches were found upon limestone of the Upper Coal-measures, not far from the middle of the series.

The locality is upon the western abrupt slope of the bluffs which border the bottom land of the Missouri river. The river being distant nearly three miles to the westward, the exact height of the scratches above it was not definitely ascertained, but it is probably not much less than one hundred feet above the ordinary stage of water. About four feet in thickness of ordinary drift material rested upon the striated surface. This had been partially removed by the quarrymen, exposing the scratches to view. Resting upon this light deposit of drift, and sloping upward to the high lands, are about one hundred and fifty feet of that peculiar lacustrine deposit called by Dr. Owen "siliceous marl," and by Prof. Swallow the "Bluff formation," which deeply covers the drift and underlying rocks of this region, except where they have been exposed by fluviatile denudation.

The boulders and pebbles contained in the drift material of this locality were both granitic and metamorphic. They were well rounded and worn, and striated faces were observed upon quite a number of them, thus as nearly as possible detecting them in the very act of scoring the rocks *in situ.*

The scratches here are in two sets, a coarser and a finer; those of the latter more numerous than the former, but those of both sets being perfectly parallel with their fellows, distinct and straight. The surface of the rock had been ground level and smooth, removing all unevenness of the natural bedding surface. The directions of the striæ were determined by a very good pocket compass. That of the coarser set (No. 1) was found to be S. 20° E., and that of the finer set (No. 2) S. 51° E. No allowance was made in either case for the variation of the magnetic needle, which the local surveyors calculate at about eleven degrees east of north.

At an exposure of the same limestone one mile below Omaha, the capital of Nebraska, immediately upon the right bank of the Missouri river, and only some six or eight feet above the ordinary stage of water, other scratches of a similar character were observed. They were found upon the upper surface of a firm layer, which the workmen had exposed and were removing for building purposes. Here, however, there is but one set of scratches, their direction being S. 41° W. (set No. 3), not allowing for variation of the magnetic needle. The surface of the rock is nearly or quite level, but the roughness of the natural bedding surface has not been entirely removed, yet the striæ were so distinct that no difficulty was found in ascertaining their true direction.

The drift at this locality is principally composed of a dark colored, stiff, clayey material, intermixed with sand, gravel and boulders, and varies from one foot to eight feet in thickness. Upon this rests the bluff formation as before described. The face of the bluff at the locality where the latter observations were made is nearly at right angles with the direction of the striæ.

Considering that the whole region surrounding these localities, and for a long distance to the northward of them, is an entirely open country; that the present prominently uneven features of the region had their origin at a period subsequent to the drift; and the extreme simplicity and uniformity of the strata over which the glaciers must have moved, the direction of their currents which these scratches apparently indicate seems very remarkable. We not only see at the Mills county locality that the scratches upon one and the same surface prove that two separate currents existed there during some portions of the glacial period, having a divergence of thirty-one degrees with each other, but also, only about twenty miles to the northward, we find the evidence that another current moved in a direction which formed an angle of ninety-three degrees with one of those in Mills county.

Since we see no evidence of the cotemporaneous existence of obstructions which might have deflected the current of a regular southerly moving glacier, and thus have produced the scratches in the various directions shown, it seems necessary that we should seek for some other explanation of them. Observations thus far made certainly afford very inadequate data upon which to base a definite theory concerning the real direction of glacial currents over this part of the continent, but the coincidence of the direction of those scratches which have been observed with the general course of the drainage of the region in which they occur, is worthy of careful consideration. By reference to the mention of the locality, near Burlington, at the commencement of this article, and to a map of Iowa, it will be seen that the direction of the scratches observed there, coincides pretty nearly with the general direction of the drainage of the eastern water-shed of the state.

That the close of the drift period left the surface of our state unmarked by strong features, and with shallow, longitudinal depressions which gave initial direction to the courses of the streams, and that these subsequently cut out their own valleys by erosion, there seems to be no reason to doubt. It seems not improbable, also, that these initial depressions in the surface, whether primarily caused by flexures of the earth's crust, as Whitney has suggested, or not, may be regarded to some extent as indices of the general direction of ancient glacial currents.

There is another interesting matter in connection with these observations of drift phenomena along the Missouri river, and the existence of the important lacustrine deposit there. The close of the Drift period evidently left a large depression of the general surface in the region, a portion of which is now occupied in part by the counties of Fremont, Mills, Pottawatomie, Harrison and Monona. This depression became a large fresh-water lake, the borders of which have not yet been definitely ascertained, but no satisfactory evidence of its existence eastward of the East Nishnabotany river has been observed in Iowa. The Missouri river evidently emptied into this lake, and flowed from it, until it became filled with the peculiar deposit of fine, siliceous, marly material, known as the Bluff formation, the character of which is very much the same as that of the muddy material which would now be deposited from the waters of the river if it were possible to throw a permanent obstruction across it. As the valley of the river was gradually deepened during the Terrace epoch, its waters found no difficulty in sweeping out the fine homogeneous material which they had before deposited, leaving those high peculiar bluffs upon each side of its broad bottom. Fresh-water and land shells of existing species, principally Gasteropods, are often found in this deposit, from base to top, and its thickness sometimes reaches more than two hundred feet above the drift material upon which it rests.

Seventy or eighty miles to the eastward of the Missouri river, in the southern tier of counties, there are evidences that the drift deposit reaches a thickness of more than a hundred and fifty feet. Westward from that region a sensible diminution of its thickness is seen, and, reaching the region of the Bluff formation along the Missouri river, the drift material is found in all cases comparatively thin, being thinnest where the bluff material is thickest.

At the localities where the scratches were observed, the drift material showed evidences of unusual violence of glacial action, being, as before remarked, only a few feet in thickness; and in some places in the same neighborhood it was entirely wanting, the bluff material resting directly upon the Coal-measure limestone.

An explanation of these facts is naturally sought for. The most plausible seems to be, that glacial action extended more deeply beneath the general surface here than elsewhere, and that the direction and character of the currents were such that the greater part of the drift material was swept away to other places, leaving the lake basin to be filled with water at the close of the glacial period. Further investigations, however, are needed to decide such questions as these.

It is understood that the most reliable information we can obtain in relation to the general direction of ancient glacial currents will be the identification of the transported materials with those at the places of their origin. Very few observations of this kind have yet been attempted in Iowa, and it is but fair to state that those few are not now seen to harmonize clearly with the directions of the glacial scratches just described. I refer to the reputed discoveries of galena and native copper in several of the counties upon the eastern watershed of the state. The only *known* localities from which such materials might have been derived lie to the northeastward, in a direction nearly at right angles with the eastern drainage lines. Again, profusely scattered over the region between the Missouri river and the middle of the state, as far northward as the fourth tier of counties and probably much farther, are boulders and fragments of reddish colored quartzite, closely answering the description given by Dr. Hayden of the rock which encloses the pipestone of southwestern Minnesota, and suspected to be of the same origin.* Should this be the case, it is not easy to see how they could have reached their present locations with glacial currents in the direction of the drainage of the western watershed, particularly if they are of the age to which Dr. Hayden has referred the rocks of that famous locality; for in that case they cannot be presumed to have ever existed much farther to the eastward.

* See F. V. Hayden on the Geology of Northeastern Dakota; this Journal, January, 1867.

The quartzite boulders in the region referred to are promiscuously intermixed with those of other metamorphic and of granitic origin, but those of the red quartzite are everywhere a little less waterworn and more angular than the others, suggesting a less distance of transportation, which would really be the case if derived from the pipestone region.

Iowa City, Iowa, Feb. 14th, 1867.

ART. XXXIII.—*On the General Metallurgical method of Messrs. Whelpley and Storer*; by T. STERRY HUNT, F.R.S.

THE processes having reference to the working of metallic ores, designed and introduced by Dr. James D. Whelpley and Col. Jacob J. Storer of Boston, offer numerous points of interest both mechanical and chemical, which it is proposed to notice briefly in the present paper.

1. The first step in the treatment of ores is their sub-division, which is effected by two novel and ingenious machines, called respectively the breaker and pulverizer. The first of these consists of a horizontal circular table of heavy iron, forty-two inches in diameter, revolving about one thousand times in a minute, having bolted to its upper surface four or more radial bars or blocks of chilled iron, and surrounded by a fixed upright perforated screen. The ore in fragments not more than six inches in diameter, falling into this aperture, is broken by the revolving bars into dust and small grains which are ejected through the perforated screen or curb, from which the larger particles are thrown back to complete the breaking. Such a machine with fifteen horse-power will break to the size of sand and coarse gravel eighteen or twenty tons of quartz or hard ore per hour.

The pulverizer is properly designated as an air-mill, and consists of a horizontal shaft, furnished with arms or paddles, which are made to revolve from one to three thousand times a minute, within an inch of the inner surface of a steel-lined cylinder varying from eighteen to forty inches in diameter. The previously crushed ore is introduced through an opening in the center of a plate, which covers one end of the cylinder, and is perforated with numerous small holes. The other end is connected through a diaphragm having an axial opening, with an ordinary fan-blower generally attached to the same shaft that carries the paddles. The mutual attrition of the particles of ore at the rapid rate of revolution communicated to them in the peripheral space of the mill, reduces them to fine dust, which as soon as formed is removed from the cylinder by the current of air drawn by the fan through the perforated end, and blown into large chambers, where it is deposited. While the interaction of their particles in the mill rapidly pulverizes brittle bodies, malleable metals, in the same conditions, are soon beaten into rounded pellets. It is proposed to apply this principle to the treatment of the native copper of Lake Superior, which may then be readily separated from its earthy gangue reduced to dust by the pulverizer. This air-mill has been employed for the pulverization of various drugs, of coal, for use as a combustible in the manner about to be described, and even for the grinding of cereals, for all of which purposes it may be adapted. It has also been employed, on a large scale, to pulverize bones for use as a fertilizer. One of these air-mills forty-two inches in diameter, and moved by fifteen horse-power will reduce from 2,000 to 3,000 pounds per hour of quartz, or hard ores, to a powder many times finer than can be obtained by the use of stamps.

2. The calcination of the pulverized ores is effected in what Messrs. Whelpley and Storer call the Water-furnace. This consists of a fire-tower, from twenty to thirty feet high, built of brick, with double walls, and somewhat conical in form, being from three to four feet in diameter at the top, and from four to six at the bottom. Around its upper part are built four fire-boxes, opening into the tower near its summit, which is closed and connected with a large fan-blower. By means of this, besides an abundant supply of air, more or less heated by passing between the two walls of the tower, ore and fuel, in the state of dust, are carried downward into the furnace. The effects obtained by the combustion of charcoal or other fuel pulverized and borne in a current of hot air, are very surprising. The finely divided combustible, being kindled by the flame drawn from the fire-boxes, burns in the descending current with great energy, and from the comparatively large surface exposed to the action of the air, generates a great amount of heat, and, with an excess of fuel, an intense light. The great fiery blast, nearly filling the tower, can at pleasure be made oxydizing or reducing in its action, by regulating the supplies of fuel and of air. I have seen it, at twelve feet from the top, so potent as to heat rapidly to whiteness two feet of a wrought iron bar an inch in diameter, and cause it, though supported at both ends, to bend like wax beneath its own weight in thirty seconds after it was placed in the blast. The powerful heating effects which may be obtained by this use of pulverized fuel are readily understood when we consider that a cubic inch of coal, reduced to particles one five-hundredth of an inch in diameter, will present to the action of the atmospheric oxygen a surface equal to not less than twenty-one square feet. This application of fuel promises to have important results for heating reverberatory, muffle

and glass furnaces, for the working of iron, and even for the generation of steam. Solid combustibles are by this method practically volatilized, and broken and refuse fuel is made available.

The calcination of sulphuretted ores, however, requires but a comparatively low temperature, and an abundant supply of oxygen. The fire-tower of the water-furnace, being heated to redness, the ore, with or without addition of pulverized fuel, is driven by a small fan into the great current of air down the tower; the sulphur and the base metals are rapidly oxydized and the calcined material falls into the water-tank beneath, while the current of air passes through successive chambers, built over this tank, and open to it beneath. This movement is aided by a large fan-wheel placed at the end of the series, which being furnished with paddles dipping into the water, produces in the final chamber a great amount of spray, serving alike to precipitate the suspended dust, and promote the absorption of the sulphurous acid gas. The escape of the excess of this into the air, provided it is not required for farther use, is prevented by a second spray-wheel beyond, supplied with milk of lime or some other absorbent.

In the case of sulphuretted ores of copper, the water tank is filled with a solution of the chlorids of sodium and calcium, by which, with the aid of the spray-wheel, the sulphurous acid is absorbed, and the oxyd of copper converted into dichlorid. This beautiful process, devised by Messrs. Whelpley and Storer, I have submitted to examination, and have found that the reaction taking place may be represented as involving one equivalent of chlorid of calcium, one of sulphurous acid, and two of cupric oxyd, and giving rise to one equivalent of sulphate of lime, and one of dichlorid of copper,

$$CaCl+SO_2+Cu_2O_2=SCaO_4+Cu_2Cl.$$

A solution of chlorid of calcium holding oxyd of copper in suspension, rapidly absorbs sulphurous acid gas, and if sufficiently concentrated, is converted into a white crystalline magma of gypsum and dichlorid of copper. This latter salt I find to be soluble in a boiling hot solution of chlorid of calcium, which, however, again deposits it on cooling, a reaction which may probably be found available on a large scale in separating copper from some other metals. In ordinary cases, however, the precipitation of the dichlorid of copper in the furnace-tank is prevented by the presence in the bath of chlorid of sodium, in which, as is well known, the cuprous chlorid is readily soluble.

The calcined and oxydized ore falling into the tank which extends sixty feet or more beneath the furnace and its chambers, is carried forward, with constant agitation, by means of a submerged rotating helix, and at length falls into a well at the extremity, from which it is withdrawn, freed from oxyd of copper, but generally containing a small residuum of unoxydized sulphid, which, if of sufficient importance, is separated by a repetition of the process with the Water-furnace, or by a rapid calcination in a reverberatory, of the mass impregnated with chlorids, by which means the residual copper left by imperfect burning becomes readily soluble in the sulphurous chlorid bath of the water-tank.

A small but variable proportion of protochlorid of iron generally accompanies the chlorid of copper, and may be separated from the cuprous solution by a simple reaction which I also studied. Three equivalents of cupric oxyd, and two of ferrous chlorid, yield by their reaction one equivalent each of cuprous and cupric chlorids, and one of sesquioxyd of iron,

$$Cu_3O_3+Fe_2Cl_2=Cu_2Cl+CuCl+Fe_2O_3.$$

The addition to the heated solution, separated from gypsum and insoluble matters, of a portion of cupric oxyd therefore suffices to precipitate the whole of the dissolved iron, and the dinoxyd of copper in the presence of air rapidly produces a similar result. The addition of milk of lime now throws down, from the solution of cuprous chlorid, the whole of the copper as pure hydrous dinoxyd, whose subsequent reduction to the metallic state is a very simple operation. Meanwhile the chlorid of calcium is regenerated, and the bath restored to its original condition may thus be used an indefinite number of times, the only reagent consumed in the process, in addition to the elements of the ore, and the oxygen of the air, being the equivalent of lime used to precipitate cuprous oxyd.

It will be seen that for sulphuretted ores containing gold, the treatment in the fire-tower, with the aid of a bath of water only, affords a simple mode of desulphurization, and leaves the gold particles in a state most favorable for amalgamation, while in the case of auriferous ores containing copper, a similar result may be obtained, and the copper, which is lost in the ordinary method of working such ores, recovered by means of the chlorid bath.

It is claimed by the designers of this series of processes, that copper can in this way be produced, at about one-third the cost of the ordinary method. The small consumption of fuel, and the mechanical facilities afforded for handling great masses of material, are such, that the new method will probably be found especially advantageous, in the treatment of low grade ores, in regions where transportation is difficult, and fuel scarce. The patentees have a small experimental furnace eighteen feet high, at East Boston, but are now erecting at the Harvey Hill mine, near Quebec, a furnace thirty feet high, which, it is expected, will enable them to treat fifty tons of seven per cent ore in twenty-four hours.

The application of the Water-furnace to the treatment of the sulphuretted ores of other metals, presents many points of interest, whose consideration is reserved for another time.

Montreal, Feb. 21, 1867.

ART. XXXIV.—*The Repsold Portable Vertical Circle;* by CLEVELAND ABBE.

(Continued from page 216.)

As to the methods and formulæ used in connection with the vertical circle, it is evident that we need first some means of orientation on arriving at a new station. An observation of any terrestrial object will give an approximate knowledge of the zenith point, and an approximate value of the latitude is easily had from a map or by estimation. With one pointing upon any recognizable celestial object, we have then its azimuth and zenith distance for a given observed moment, whence the following computation gives us the approximate north point of the azimuth circle and the hour angle.

Put $90° - \delta = a$ $\qquad s - a = \alpha$ $\qquad \varkappa = \sqrt{\dfrac{\sin\alpha \sin\beta \sin\gamma}{\sin s}}$

$90° - \varphi = b$ $\qquad s - b = \beta$

$z = c$ $\qquad s - c = \gamma$ $\qquad \Sigma = \dfrac{\varkappa}{\sin s}$

$\overline{2s = a + b + c}$ $\qquad \overline{2s = \alpha + \beta + \gamma}$

The Gaussian formulæ give for the azimuth, parallactic angle and hour angle,

$$\text{(B.)} \qquad \tan\tfrac{1}{2}A = \frac{\varkappa}{\sin\alpha} \qquad \tan\tfrac{1}{2}p = \frac{\varkappa}{\sin\beta} \qquad \tan\tfrac{1}{2}t = \frac{\varkappa}{\sin\gamma}$$

$$\tan\tfrac{1}{2}A \tan\tfrac{1}{2}p \tan\tfrac{1}{2}t = \Sigma.$$

The computation with its controls is of course performed with 4-figure logarithms. The observed azimuth, plus or minus the computed A, gives the north point of the circle. The computed t, plus the tabular R.A., gives the sidereal time, whence is found the clock correction.

A previously computed ephemeris of the stars to be observed enables us now to point upon any one. Polaris will naturally be first chosen, as by it we may more accurately determine the north point or adjust the azimuth circle to N.P.=0°, as is most convenient if any number of observations is to be made.

An ephemeris of the azimuths and zenith distances of the principal stars, if computed for every 5° of latitude, will serve by interpolation for any intermediate position. The formulæ for the computation of finding ephemerides as given by Mr. Döllen are very simple.

Put $z-(\varphi-\delta)=r$; the well known formula,

$$\cos z=\cos(\varphi-\delta)-2\cos\varphi\cos\delta\sin^2\tfrac{1}{2}t,$$

gives

$$\text{(C.)}\qquad \sin\tfrac{1}{2}r=\cos\varphi\sin^2\tfrac{1}{2}t\frac{\cos\delta}{\sin(\varphi-\delta+\frac{1}{2}r)}.$$

Another well known formula may be written

$$\text{(D.)}\qquad \sin A=\sin t\,\frac{\cos\delta}{\sin(\varphi-\delta+r)}.$$

Or by a transformation of

$$\sin z\cos A=-\cos\varphi\sin\delta+\sin\varphi\cos\delta\cos t,$$

these results, approximately,

$$\text{(D'.)}\qquad \sin^2\tfrac{1}{2}A=\sin\varphi\sin^2\tfrac{1}{2}t\,\frac{\cos\delta}{\sin(\varphi-\delta)}.$$

Neglecting the r in the second members of these equations, they admit of a very simple arrangement for the computation of an ephemeris whose argument is the time for stars near the meridian, being sufficiently accurate within the limits

$$\varphi-\delta>10^\circ \text{ and } t<15^\circ.$$

For an ephemeris in the neighborhood of the prime vertical we may use the azimuth as argument; counting it from the west point northward, we have

$$\text{(E.)}\qquad \sin\delta=\sin\varphi\cos z+\cos\varphi\sin z\sin A$$

$$\text{(F.)}\qquad \tan\delta=\frac{1}{\cos\varphi}\sin t\tan A+\tan\varphi\cos t.$$

Put $\tan\zeta=\dfrac{\sin A}{\tan\varphi}$ and $p=\dfrac{\cos\zeta}{\sin\varphi}$;

the first formula (E) becomes

$$\text{(G.)}\qquad \cos z'=\cos(z-\zeta)=p\sin\delta;$$

whence $z=z'\pm\zeta.$

Put $\tan\omega=\dfrac{\tan A}{\sin\varphi}$ and $q=\dfrac{\cos\omega}{\tan\varphi}$;

the second formula (F) becomes

$$\text{(H.)}\qquad \cos t'=\cos(t-\omega)=q\tan\delta;$$

whence $t=t'\pm\omega.$

The arrangement of these computations can be made exceedingly convenient. Extensive ephemerides for latitude 35° to 70° north have been published by General Tenner; provided with these or similar special ones the observer loses no time in selecting the pair of stars to be observed. The latitude stars are of course observed on the meridian as nearly as possible, excepting the polars, which are observed at any hour angle.

In the accurate computation of the results, the following formulæ are used by Mr. Döllen, following Struve's habit of separately reducing each observation.

a. For the polars, all observed zenith distances are reduced to the upper culmination. The formula (C) may be written

$$\text{(I.)} \qquad \sin\tfrac{1}{2}(z-\zeta)=\cos\varphi\cos\delta\,\frac{\sin^2\frac{1}{2}t}{\sin\frac{1}{2}(z+\zeta)},$$

or approximately

$$\text{(J.)} \qquad r=z-\zeta=\frac{2\cos\varphi\cos\delta}{\sin 1''}\cdot\frac{1}{\sin\frac{1}{2}(z+\zeta)}\cdot\sin^2\tfrac{1}{2}t,$$

where $\zeta=\varphi-\delta.$

Provided with the Wrangell or other convenient extended tables of $\sin^2\frac{1}{2}t$, and assuming an approximate φ and zenith point and using the value of $z+\zeta$ for the middle of the series as a constant throughout the whole, we easily compute the individual values of r whence result the circle readings for each observation as if it had been made at the upper culmination. The mean of the four observations circle right and the four circle left gives the correct zenith point, the zenith distance ζ and the approximate latitude. With these a second approximation is made, and more will not generally be required. In the second approximation the new refractions and $\sin\frac{1}{2}(z+\zeta)=\sin(\varphi-\delta+\frac{1}{2}r)$ need not be anew computed, since the first differences of the logarithmic tables will give the $\Delta\log r$ corresponding to the $\Delta\varphi$ and Δz.

If the zenith point and latitude are sufficiently well known, it will be equally expeditious to compute the direct formula

$$\cos\zeta=\cos z+2\cos\varphi\cos\delta\sin^2\tfrac{1}{2}t,$$

using of course convenient tables for $\sin^2\frac{1}{2}t$ and Zech's tables for addition.

b. For other stars than the polars observed near the meridian, the direct computation of $\log r$ by means of the following series will be found convenient. We have from (C)

$$\text{(K.)} \qquad \sin r+2\sin^2\tfrac{1}{2}r\cot\zeta=2\frac{\cos\varphi\cos\delta}{\sin\zeta}\sin^2\tfrac{1}{2}t;$$

whence

$$\text{(L.)} \qquad r+\frac{r^2}{2}\cot\zeta\sin 1''-\frac{1}{6}r^3\sin^2 1'',\ \&c.=2\frac{\cos\varphi\cos\delta}{\sin\zeta\sin 1''}\sin^2\frac{t}{2}.$$

Regarding the second member as a first approximation to r, and developing the $\sin^2\frac{1}{2}t$, we obtain the following, which is due to Mr. Döllen,

$$\text{(M.)} \qquad \log r=\log(pt^2)-qt^2;$$

in which we have put

g=hourly gain on sidereal time, $f=\frac{3600^s}{3600+g}$,

$\beta=3\frac{\cos\varphi\cos\delta}{\sin\zeta}$, $\gamma=\cot\zeta$,

$p=\frac{37\cdot5}{R}f^2\beta=[6\cdot25961]f^2\beta$,

$q=\frac{\text{Mod}}{2R}\,p(\frac{1}{\beta}\pm\gamma)=[9\cdot0223]\,p(\frac{1}{\beta}\pm\gamma)$.

c. For the computation of the hour angle from the observed zenith distances in the prime vertical, we have the simple formula

$$\text{(N.)}\qquad \sin^2\tfrac{1}{2}t=\frac{\cos\zeta}{2\cos\varphi\cos\delta}\left(1-\frac{1}{\frac{\cos\zeta}{\cos z}}\right);$$

the computation of which is sufficiently expeditious even with six-figure logarithms, if we are provided with the tables previously mentioned. The second approximation, using a correct zenith point, is made if necessary as before, by using the tabular first differences.

As the formula (A) shows the flexure of the tube to be not symmetrical with respect to the zenith, it is necessary for greater accuracy to correct the results given by each star of a pair, according to the formula

$$f=b\sin(z+B).$$

The correction, f, is directly applicable to the zenith distances observed for latitude.

For the time determination we have the differential formula

$$\text{(P.)}\qquad dt^s=\frac{\sin z}{15\cos\varphi\cos\delta\sin t}\,dz''.$$

The application of these corrections is, especially for the latitude, necessary in order to entirely free the result from a pair of opposite stars from the influence of flexure.

To the preceding sketch of the instrument and its formulæ may be added a few words as to the conduct of the field work, which may be carried on without inconvenience at a temperature of 15° or 20° Fahrenheit.

In the Russian empire, where railroads do not offer sufficient accommodation to the geodesist, it is necessary that an expedition should be provided with an easy spring-van drawn by two or three horses (the Russian officer is only perfectly happy when rushing along with his *troika*). In this covered wagon the twelve or fifteen chronometers are as well as possible protected against rapid changes of temperature and disturbing jars. One or two barometers with thermometers are provided; the barometers of Brauer's construction have been found to endure surprisingly well the rough usage to which they must needs be subjected in journeys of thousands of miles. A heavy tripod is provided, and the means for leaving a suitable simple mark at any station. The vertical circle, without being in the least taken to pieces, is received as a whole into its small neat case in which two clamps firmly fasten it, an outer thick leather cover with handles protects the whole, which is carried with ease by two men, or by one if need be, as it scarcely weighs sixty pounds. The entire load occupies a space of some twenty cubic feet.

Arrived at the previously reconnoitred station, five or ten minutes suffice for the two attendants to erect the tripod and set the vertical circle upon it; sometimes a block of stone or three stakes of wood support the feet of the tripod and remain to mark the station. Meantime the horses having been unhitched and the barometer and thermometers hung up, the chronometers (including the extremely under- or over-compensated ones) are, by means of the one beating 13 times in 6 seconds, very rapidly compared with the one to be used in the observations. The examination of the state of the instrument and the adjustment of the verticality of the vertical axis follow, and in a few minutes after observing the Sun or Moon, *Polaris* is in the field of view. Although one determination only of time is necessary, it is better to make two, arranging the work as follows:

1. Comparison of chronometer.
2. Reading of barometer and thermometer.
3. Observation of pair of stars for time.
4. Reading of barometer and thermometer.
5. Observation of pair of stars for latitude.
6. Reading of barometer and thermometer.
7. Observation of pair of stars for time.
8. Reading of barometer and thermometer.
9. Comparison of chronometer.

The observations are now complete and the party may proceed to the next station; if any considerable time elapses the departure should be immediately preceded by another comparison of chronometers.

The time spent at any station must depend upon the skill, energy and self-devotion of the observer. In the expedition by Döllen and Hübner in 1855–56 in the province of Perm, cases occur where three stations, distant twenty-five to forty miles from each other, have been thus occupied within the space of thirty-six hours, the time spent at each being about three hours, the intervening distances being travelled over very ordinary roads. It is often very advisable to work expeditiously in order to improve a few days of consecutive clear weather and secure a quick return to the starting point, without having exposed the chronometers to a long absence or dangerous temperature changes. This latter point is one requiring especial and intelligent watchfulness on the part of the observer. Captain Bolscheff, having charge of the determination of some two hundred points in Finnland, mentioned to me the difficulties that he had to contend with arising from the sudden fall in the atmospheric temperature during the night, obliging him sometimes to stop while proceeding from one station to another, not only to make extra comparisons of his chronometers, but by artificial warmth to endeavor to counteract the influence of the rapid fall in the exterior temperature.

Without here farther entering into the details of the methods pursued by Colonel Smyssloff in obtaining the final corrections for the rates of his chronometers and the longitudes of his stations relative to Poulkova, we will note that the twenty stations here given cover an area of some 135 miles square in the provinces of Novgorod and St. Petersburg, and the expeditions occupied him from the 18th of June to the 31st of July, 1859. Two journeys were undertaken, the first leaving Poulkova June 18th, visited stations I, 2, II, 2, III, 3, 4, 5, 6, I, returning to Poulkova July 3d. The second left Poulkova July 5th, and visited IV, VI, 7, 8, 9, IV, arriving at Nova Ladoga the 13th of July; the same day leaving Nova Lagoda, and visiting 10, IV, 9, 13, V, 14, 15, I, it returned to Poulkova July 31st. The whole distance travelled in this six weeks expedition was 1400 miles, of which 175 were by railroad. Each latitude depends upon eight pointings upon Polaris and eight upon some southern star; the probable error of each resulted in general $\pm 0''\cdot 3$. Each longitude (as to the fourteen secondary stations) depends in general upon one time determination; the probable error of each is given below. Ten chronometers were carried, besides the non-compensated one and the one beating $\frac{6}{13}$ seconds and the one used in observing. There were in all twenty-nine determinations of time and fifteen of latitude.

Station.	Latitude. Probable error ±0″·3.	Longitude from Poulkova.	Prob. error. ±
	° ′ ″	m. s.	s.
1. Spasska Orlayno,	59 15 53·8	− 0 53·43	0·08
2. Kamenni Polarne,	58 48 39·8	+ 1 28·34	0·07
3. Arm Spasska Poleust,	58 55 15·7	+ 4 44·91	0·09
4. Korovay Roustchay,	59 13 24·8	+ 3 25·33	0·08
5. Samost,	59 29 31·8	+ 3 46·20	0·09
6. Uspensko,	59 41 45·9	+ 3 9·00	0·10
7. Rougoi,	59 28 13·8	+10 7·61	0·12
8. Oskoua,	59 16 43·5	+ 7 2·95	0·12
9. Podzopie,	59 38 43·6	+ 7 10·61	0·10
10. Schassenske,	60 3 28·2	+12 34·52	0·10
11. Taykvayn,	59 38 48·5	+12 44·35	0·08
12. Podsosno,	59 14 32·2	+12 52·73	0·10
13. Krayvar Gora,	59 3 8·1	+11 7·87	0·09
14. Morkonnayzi,	58 50 24·0	+10 29·38	0·09
15. Malar Veschera,	58 50 51·0	+ 7 33·91	0·08
16. Nova Ladoga,	60 6 40·3	+ 7 58·78	0·05

As fundamental points of reference for the longitudes the following list was selected of points determined in previous years.

Station.	Latitude.	Longitude.
I. Poulkova,	59° 46′	0^h 0^m 0^s
II. Louga,	58 43	−0 1 54·20
III. Novgorod,	58 30	+0 3 47·86
IV. Nova Ladoga,	60 7	+0 7 58·80
V. Borovaytsche,	58 24	+0 14 19·93
VI. Taykvayn,	59 39	+0 12 44

Of these, however, it was preferred to include IV and VI among those to be independently determined on the present occasion, and they have received the numbers 16 and 11 in the previous list.

Among several similar expeditions that have come to my notice, I may mention those before referred to, of Messrs. Döllen and Hübner in 1855–56 in the government of Perm, where many points have been unusually carefully determined with reference to Perm and Ekaterineberg; and that of Captain Bolscheff in Finnland in 1863–66, each of whose 150 points has been twice independently determined.

An extensive series of observations made at Poulkova with a vertical circle, made in 1857 by Messrs. Repsold, still farther attests, if any farther proof were wanted of the reliability of the results afforded by this instrument—to observe with which is in fact a luxury of convenience. The observations made on distant terrestrial signals—the reflection from gilded church domes—gave for perfect condition of images the probable accidental error of a zenith distance resulting from two pointings in opposite positions of the circle $\pm 0''{\cdot}52$, a large portion of which may fall upon the level, which was afterwards improved by the addition of a narrow mirror reflecting the divisions horizontally to the observer's eye.

A suggestion of Mr. Döllen as to the interest that would attach to a comparison of the results obtained by the vertical circle with those obtained by using the Talcott zenith telescope —and the suggestion that by clamping the vertical circle and observing stars of exactly equal zenith distances, thus freeing the results from errors arising from imperfect graduation of the circle, by converting the vertical circle into a very convenient zenith telescope—both seem to be well worthy of being put into execution. In the determination of time I have been able to apply this latter method of using the vertical circle: it remains to attempt the same in the determination of latitude.

37 East 20th st., New York, January, 1867.

ART. XXXV.—*On the Reduction of Meteorological Observations;* by ERASTUS L. DEFOREST.

THE system of twelve equations for correcting monthly means for the unequal length of the months, given by me in this Journal, vol. xlii, page 155, was obtained on the supposition that the year consists of 365¼ days. The true length of the year being a very little less than this, it follows that the equations referred to are not exactly correct. The amount of inaccuracy in their results is indeed very small, but still it seems desirable that fundamental formulas of this kind should not involve any unnecessary errors, however small they may be. The equations can be computed just as well by giving the year its true length, care being taken to assign the true values to the arcs n_1, n_2, n_3, and c, which measure the lengths of the months, and also to the small arc x_1, which measures the time from the middle of a calendar month to the middle of the corresponding mean month.

On the assumption that the year contains 365·24224 days, a mean month will contain 30·43685 days, and the calendar month of February 28·24224 days. A month of 31 days will be represented by the arc 30° 33′ 18″·2, a month of 30 days by 29° 34′ 9″·9, and the month of February by 27° 50′ 12″·8. The values of x_1 for the several months are therefore

January,	−0° 16′ 39″·1	July,	1° 4′ 53″·6
February,	+0 31 35 ·4	August,	0 31 35 ·4
March,	1 19 49 ·9	September,	0 27 51 ·3
April,	1 16 5 ·8	October,	0 24 7 ·3
May,	1 12 21 ·7	November,	0 20 23 ·2
June,	1 8 37 ·7	December,	0 16 39 ·1

and the twelve equations are found to be

$$
\begin{aligned}
M_1 &= m_1 + \cdot0037\, m_1 + \cdot0030\, m_{12} - \cdot0067\, m_2 \\
M_2 &= m_2 - \cdot0127\, m_2 - \cdot0031\, m_1 + \cdot0158\, m_3 \\
M_3 &= m_3 + \cdot0028\, m_3 - \cdot0249\, m_2 + \cdot0221\, m_4 \\
M_4 &= m_4 - \cdot0042\, m_4 - \cdot0200\, m_3 + \cdot0242\, m_5 \\
M_5 &= m_5 + \cdot0016\, m_5 - \cdot0218\, m_4 + \cdot0202\, m_6 \\
M_6 &= m_6 - \cdot0039\, m_6 - \cdot0180\, m_5 + \cdot0219\, m_7 \\
M_7 &= m_7 + \cdot0026\, m_7 - \cdot0200\, m_6 + \cdot0174\, m_8 \\
M_8 &= m_8 + \cdot0025\, m_8 - \cdot0103\, m_7 + \cdot0078\, m_9 \\
M_9 &= m_9 - \cdot0027\, m_9 - \cdot0067\, m_8 + \cdot0094\, m_{10} \\
M_{10} &= m_{10} + \cdot0030\, m_{10} - \cdot0085\, m_9 + \cdot0055\, m_{11} \\
M_{11} &= m_{11} - \cdot0026\, m_{11} - \cdot0046\, m_{10} + \cdot0072\, m_{12} \\
M_{12} &= m_{12} + \cdot0032\, m_{12} - \cdot0064\, m_{11} + \cdot0032\, m_1
\end{aligned}
$$

It will be seen that the numerical coëfficients here given differ from the previous ones to the amount, in some cases, of a single unit in the fourth decimal place. They are, I believe, as nearly exact as they can be made without extending them beyond the fourth place, a degree of refinement which would be practically useless. The computation, however, was carefully made to six places, so as to secure the nearest value for the last figure. In rejecting the fifth and sixth places, care has been taken not to impair the condition that in any single equation the sum of the three decimal coëfficients must be zero. The first and seventh equations, as computed to six places, are

$$M_1 = m_1 + \cdot 003668\, m_1 + \cdot 003060\, m_{12} - \cdot 006728\, m_2$$
$$M_7 = m_7 + \cdot 002541\, m_7 - \cdot 019981\, m_6 + \cdot 017440\, m_8.$$

When these are reduced to four places in the usual way, they become

$$M_1 = m_1 + \cdot 0037\, m_1 + \cdot 0031\, m_{12} - \cdot 0067\, m_2$$
$$M_7 = m_7 + \cdot 0025\, m_7 - \cdot 0200\, m_6 + \cdot 0174\, m_8.$$

The sums of the three decimal coëfficients differ from zero to the amount of a single unit in the fourth place; and to correct this, the unit has been added to or subtracted from that coëfficient which is least altered by it, as compared with its true value to six places.

Since the length of a calendar year is either 365 or 366 days, the assumption that the year consists of 365·24224 days is not strictly applicable to meteorological observations for any single year. But the average length of a considerable number of consecutive calendar years approaches very closely to that of the true or astronomical year, and the greater the number of years the closer will be the approximation. Therefore when we are considering the mean results of observations which have extended over a long course of years, the assumption that calendar years and astronomical years are equal will lead to no error. In the same way we are justified in assigning 28·24224 days to February, because this is the average length of that month for a series of many consecutive years.

When the equation of the curve representing the annual course of any meteorological phenomenon, as the mean daily temperature for instance, has been found for a given place by the method of mean months, and it is required to interpolate from it the mean temperature of a particular day, care should be taken to assign the proper value to the abscissa. Take for example the 15th day of March. The time elapsed from the beginning of the year to the middle of that day is $31 + 28{\cdot}2422 + 14\frac{1}{2} = 73{\cdot}7422$ days, and the corresponding arc is found by the proportion

$$365{\cdot}2422 \text{ days} : 73{\cdot}7422 \text{ days} = 360^\circ : 72^\circ\ 41'.$$

The value $72^\circ\ 41'$ being given to the abscissa in the equation of the curve, the resulting value of the ordinate will be the mean daily temperature at the given place on the 15th of March. The abscissa must be reckoned up to the middle of the day, because the small arc of the curve which belongs to any one day may be regarded as approximately a straight line, so that the mean of all its ordinates is equal to its middle ordinate, which therefore represents the mean temperature of the day. The subjoined table will be found to facilitate computations. It gives the abscissa for the middle point of each day in the year, correct to the nearest minute, one minute of arc here corresponding to about twenty-four minutes of time.

Arcs representing the mean interval of time from the beginning of the year to the middle of each day.

	Jan.	Feb.	M'ch.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0° 30′	31° 3′	58° 53′	89° 26′	119° 1′	149° 34′	179° 8′	209° 41′	240° 15′	269° 49′	300° 22′	329° 56′
2	1 29	32 2	59 52	90 26	120 0	150 33	180 7	210 40	241 14	270 48	301 21	330 55
3	2 28	33 1	60 51	91 25	120 59	151 32	181 6	211 40	242 13	271 47	302 20	331 55
4	3 27	34 0	61 51	92 24	121 58	152 31	182 5	212 39	243 12	272 46	303 20	332 54
5	4 26	34 59	62 50	93 23	122 57	153 30	183 5	213 38	244 11	273 45	304 19	333 53
6	5 25	35 59	63 49	94 22	123 56	154 30	184 4	214 37	245 10	274 44	305 18	334 52
7	6 24	36 58	64 48	95 21	124 55	155 29	185 3	215 36	246 9	275 44	306 17	335 51
8	7 24	37 57	65 47	96 20	125 55	156 28	186 2	216 35	247 9	276 43	307 16	336 50
9	8 23	38 56	66 46	97 19	126 54	157 27	187 1	217 34	248 8	277 42	308 15	337 49
10	9 22	39 55	67 45	98 19	127 53	158 26	188 0	218 34	249 7	278 41	309 14	338 49
11	10 21	40 54	68 44	99 18	128 52	159 25	188 59	219 33	250 6	279 40	310 13	339 48
12	11 20	41 53	69 44	100 17	129 51	160 24	189 59	220 32	251 5	280 39	311 13	340 47
13	12 19	42 53	70 43	101 16	130 50	161 24	190 58	221 31	252 4	281 38	312 12	341 46
14	13 18	43 52	71 42	102 15	131 49	162 23	191 57	222 30	253 3	282 38	313 11	342 45
15	14 18	44 51	72 41	103 14	132 48	163 22	192 56	223 29	254 3	283 37	314 10	343 44
16	15 17	45 50	73 40	104 13	133 48	164 21	193 55	224 28	255 2	284 36	315 9	344 43
17	16 16	46 49	74 39	105 13	134 47	165 20	194 54	225 28	256 1	285 35	316 8	345 42
18	17 15	47 48	75 38	106 12	135 46	166 19	195 53	226 27	257 0	286 34	317 7	346 42
19	18 14	48 47	76 38	107 11	136 45	167 18	196 53	227 26	257 59	287 33	318 7	347 41
20	19 13	49 47	77 37	108 10	137 44	168 17	197 52	228 25	258 58	288 32	319 6	348 40
21	20 12	50 46	78 36	109 9	138 43	169 17	198 51	229 24	259 57	289 32	320 5	349 39
22	21 11	51 45	79 35	110 8	139 42	170 16	199 50	230 23	260 57	290 31	321 4	350 38
23	22 11	52 44	80 34	111 7	140 42	171 15	200 49	231 22	261 56	291 30	322 3	351 37
24	23 10	53 43	81 33	112 7	141 41	172 14	201 48	232 22	262 55	292 29	323 2	352 36
25	24 9	54 42	82 32	113 6	142 40	173 13	202 47	233 21	263 54	293 28	324 1	353 36
26	25 8	55 41	83 32	114 5	143 39	174 12	203 46	234 20	264 53	294 27	325 1	354 35
27	26 7	56 40	84 31	115 4	144 38	175 11	204 46	235 19	265 52	295 26	326 0	355 34
28	27 6	57 40	85 30	116 3	145 37	176 11	205 45	236 18	266 51	296 26	326 59	356 33
29	28 5	58 16	86 29	117 2	146 36	177 10	206 44	237 17	267 51	297 25	327 58	357 32
30	29 5		87 28	118 1	147 36	178 9	207 43	238 16	268 50	298 24	328 57	358 31
31	30 4		88 27		148 35		208 42	239 15		299 23		359 30

When the mean daily temperatures at a given place have been tabulated for every day in the year, it seems to have been the usual practice hitherto to omit giving the temperature for the 29th of February. It cannot be said that the meteorological phenomena which occur on a single intercalary day are less important, or less worthy of being observed and recorded and combined with others to form the monthly mean, than are those of any other single day. The interval of time between the mean position of the beginning of the calendar year and the mean position of the middle of the intercalary day is assignable with great precision, and when an equation of temperatures has been found by the use of mean months, the mean temperature of the 29th day of February can be interpolated with as much accuracy as that of any other day whatever. The time elapsed from the beginning of the year to the middle of the intercalary day is $31+28+\frac{1}{2}$ of $0{\cdot}2422=59{\cdot}1211$ days, and the corresponding abscissa is found to be $58°\ 16'$.

The monthly means of temperature at New Haven, as given in the Transactions of the Connecticut Academy of Arts and Sciences, from 86 years' observations, are

26·53	46·84	71·66	51·10
28·11	57·28	70·32	40·32
36·09	66·96	62·50	30·42

When reduced to mean months they become

26·5311	47·3076	71·7307	50·9438
28·2410	57·7031	70·2452	40·1992
36·5263	67·2372	62·3404	30·3442

From these data I have obtained the equation of mean daily temperatures throughout the year, in the way already stated in this Journal, xli, 373, except that instead of finally reducing it from the usual form,

$$y=a+a_1\sin(x+E_1)+a_2\sin(2x+E_2)+a_3\sin(3x+E_3)+\ \&c.,$$

into a form where the signs before the terms are sometimes plus and sometimes minus, I have reduced it to

$$y=a+a_1\sin(x-e_1)+a_2\sin 2(x-e_2)+a_3\sin 3(x-e_3)+\ \&c.,$$

in accordance with the formula

$$\sin(nx+E_n)=\sin n\left\{x-\frac{1}{n}(360°-E_n)\right\}.$$

This prevents confusion of signs, and at the same time preserves the significance of the arc e_n, making it measure the time elapsed from the beginning of the year to the *first ascending node* of the term in which it occurs.

The New Haven equation of temperatures then is

$$\begin{aligned}y=49{\cdot}112&+22{\cdot}902\sin(x-110°\ 39'\ 22'')+{\cdot}289\sin 2(x-20°\ 56')\\&+{\cdot}443\sin 3(x-57°\ 42')+{\cdot}022\sin 4(x-75°\ 22')\\&+{\cdot}402\sin 5(x-3°\ 53')+{\cdot}093\sin 6x.\end{aligned}$$

An equation of this kind, to be perfect, ought to express accurately all the facts implied in the observed series of monthly means, so that the mean for any one of the calendar months may be derived from it with precision, by integrating ydx between the proper limits for the beginning and end of the month, and dividing by the arc which measures its length. Let the general form,

$$y=a+a_1\sin(x-e_1)+a_2\sin 2(x-e_2)+a_3\sin 3(x-e_3)+\ \&c.,$$

be treated in this way between the limits x' and x'' corresponding to the beginning and end of a month whose mean is m, and let us make

$$\tfrac{1}{2}(x''-x')=\alpha, \qquad \tfrac{1}{2}(x''+x')=\beta;$$

then the monthly mean will be expressed thus:

$$m=a+a_1\frac{\sin\alpha}{\alpha}\sin(\beta-e_1)+a_2\frac{\sin 2\alpha}{2\alpha}\sin 2(\beta-e_2)+a_3\frac{\sin 3\alpha}{3\alpha}\sin 3(\beta-e_3)+\text{\&c.}$$

The values of $\frac{\sin\alpha}{\alpha}$, $\frac{\sin 2\alpha}{2\alpha}$, &c., depend only on the length of the month, and their logarithms are given in the subjoined table, for months of all the different lengths.

	Month of 31 days.	Month of 30 days.	February.	Mean months.
$\log\frac{\sin\alpha}{\alpha}$	9·994840	9·995169	9·995719	9·995027
$\log\frac{\sin 2\alpha}{2\alpha}$	9·979214	9·980547	9·982777	9·979971
$\log\frac{\sin 3\alpha}{3\alpha}$	9·952651	9·955722	9·960852	9·954395
$\log\frac{\sin 4\alpha}{4\alpha}$	9·914288	9·919945	9·929367	9·917502
$\log\frac{\sin 5\alpha}{5\alpha}$	9·862723	9·872015	9·887409	9·868005
$\log\frac{\sin 6\alpha}{6\alpha}$	9·795732	9·810048	9·833588	9·803880

The values of the arc β, which measures the time from the beginning of the year to the middle of a month, are for the calendar months

15° 16′ 39″	103° 43′ 54″	193° 55′ 6″	284° 35′ 53″
44 28 25	133 47 38	224 28 25	314 39 37
73 40 10	163 51 22	254 32 9	344 43 21

and for mean months they are 15°, 45°, 75°, &c.

Now in the expression for the monthly mean m, let the constants a, a_1, e_1, a_2, e_2, &c., take those values which have been found for them in the New Haven equation, and the following monthly means for the calendar months may be obtained.

26·530	46·870	71·668	51·093
28·111	57·278	70·313	40·324
36·056	66·949	62·512	30·424

The errors of these computed values as compared with the monthly means actually observed are

·0	+·030	+·008	−·007
+·001	−·002	−·007	+·004
−·034	−·011	+·012	+·004

This example shows the degree of accuracy with which an equation obtained by the method of mean months may be expected to represent any observed series of means for calendar months. The reason why the computed values do not agree exactly with the observed ones is, that the curve of the form

$$y = a + a_1 \sin(x - e_1),$$

by means of which my system of twelve equations was obtained, is only an approximation to the true curve for any month, and is not the same as the computed curve whose equation contains twelve constants. The two curves approach each other closely, and intersect at several points, but they do not coincide. They both include the same monthly mean for the mean month, but not for the calendar month. It is probable, however, that no other method of reduction of equal simplicity will give an equation which expresses the means for the calendar months so accurately as this.

It should be noticed that when monthly means of rain-fall are to be corrected for the inequality of the months by my system of equations, the correction must be applied not to the mean *total* amount of rain for any month, but to the mean *daily* amount for that month. Take, for instance, the results of 24 years' observation at Albany, from 1826 to 1849 inclusive, given by F. B. Hough in the "New York Meteorology." The mean total amounts of rain and melted snow and hail for the calendar months, in inches of depth, are

2·91	2·88	4·09	3·76
2·62	4·04	3·44	3·30
3·02	4·50	3·47	2·98

Dividing each of these by the number of days in the month, we have the following values of the mean daily rain-fall, for calendar months, in decimals of an inch:

·0939	·0960	·1319	·1213
·0928	·1303	·1110	·1100
·0974	·1500	·1157	·0961

Now applying the correction, we obtain the mean daily rain-fall for mean months,

·0939	·0968	·1312	·1213
·0929	·1314	·1108	·1098
·0975	·1500	·1158	·0960

and the equation of the curve is found to be

$$y = \cdot 1123 + \cdot 0202 \sin(x - 106^\circ\ 43') + \cdot 0106 \sin 2(x - 107^\circ\ 10')$$
$$+ \cdot 0112 \sin 3(x - 14^\circ\ 11') + \cdot 0031 \sin 4(x - 51^\circ\ 7')$$
$$+ \cdot 0024 \sin 5(x - 56^\circ\ 40') + \cdot 0015 \sin 6x.$$

If we assign to x the value appropriate for any given day in the year, the resulting value of y will be the average depth of rain-fall at Albany for that day, expressed in decimals of an inch.

After an equation has been obtained, there ought to be some check to show whether it is free from errors of computation. This may be secured by deriving from it the mean for any one of the mean months. When the constants in the Albany equation are transferred to the general expression for the monthly mean, and α and β take the values appropriate for the third mean month for instance, the result is $m = \cdot0975$; the agreement of this with the daily mean for the third mean month as previously found, is evidence that the equation of the curve has been computed correctly.

January 11th, 1867.

ART. XXXVI.—*Researches on Solar Physics;* by WARREN DE LA RUE, Esq., Pres. R.A.S., BALFOUR STEWART, Esq., Super intendent of the Kew Observatory, and BENJAMIN LOEWY, Esq., Observer and Computer to the Kew Observatory.

Second Series (in continuation of First Series). Area-measurement of the Sun-spots observed by Carrington during the seven years from* 1854–1860 *inclusive, and deduction therefrom.*

34. In our first paper (Art. 13) we stated that Mr. Carrington had very kindly placed at our disposal all his original drawings of sun-spots. Our first step was to arrive at some estimate of the accuracy of these sketches, and we requested Dr. von Bose, who assisted Mr. Carrington in the greater part of his observations, to give us a short outline of the method employed in obtaining them.

From his account, it would appear that the sun's disk was thrown upon a screen, and that each group as represented on the screen was separately drawn on a sheet of paper. The groups on paper were then each separately compared with those on the screen and modified where faulty; and this process was continued until the paper sketches agreed as nearly as possible with the groups on the screen. It would thus appear that very great care was taken with these sketches. [Engravings of several of Carrington's sketches alongside of those of corresponding groups as taken by the Kew Heliograph are given in the original memoir, showing that Carrington has obtained by the method above described a very great accuracy of delineation.]

35. The trustworthiness of Carrington's sun-pictures being thus established, it seemed to us that the labor of measuring for each group the amount of spotted area would be well bestowed, inasmuch as the method hitherto employed, namely, the mere statement of the number of sun-spots occurring at any pe-

* From a memoir printed for private circulation; tables and plates, and many paragraphs omitted. For First Series, see p. 179.

riod, can only be supposed to afford very approximate means of estimating the extent of solar activity at that period; while, again, if we wish to study the behavior with respect to size of each group as it passes over the visible disk, this can only be done accurately by the laborious but sure method of measurement.

36. *Method adopted in measuring Carrington's groups.*—In order to accomplish this task, the following method was adopted:—In the first place, in order to obtain the apparent area of any group, a piece of plate glass had a number of lines etched upon it, by means of which it was cut up into squares, the side of each square being $\frac{1}{40}$th of an inch. In order to facilitate reading, each fifth line was painted red.

This piece of glass was then applied (the engraved face toward the drawing) to the group whose apparent area it was desired to measure, and the number of squares and fractional parts of a square occupied by the umbra, the penumbra, and the whole spot was *separately* reckoned and noted down. If it was found that the number of squares reckoned for the whole spot was equal to the sum of those reckoned for the umbra and penumbra together, it was concluded that the measurement was correct.

This method of checking the accuracy of the measurement had the further advantage of giving separately the areas of the umbra and penumbra, thus affording determinations which may be made use of in advancing our knowledge of the subject, although not used by us in our present research.

37. But it is evident that after the apparent area of a group has thus been correctly estimated, this apparent area will not indicate the real size of the group, unless allowance is made for the foreshortening occasioned by its angular distance from the visual center of the disk.

[The practical methods by which this allowance for foreshortening was made are given in detail. The final results of the measurements form an extensive table and give the material for a graphical representation of the observed spotted area for each clear day from the beginning of 1854 to the end of 1860.]

40. *Distribution of Spotted Area over Disk.*—Our next inquiry has reference to the relative distribution of spotted area over different parts of the solar disk. We use the word *disk* in contradistinction to *surface*, because it is evident that, on account of the sun's rotation, the center of his visible disk on one day does not represent the same portion of the solar surface as on another day; indeed from this cause it is well known that sun-spots travel over the visible disk from left to right. It is therefore *one* inquiry to study from day to day the relative distribution of spotted area over different parts of the sun's actual surface, and *another* to study the same from day to day over different

parts of his apparent disk. We have not hitherto attempted the former inquiry (although the subject is not lost sight of, but may come within the range of our future researches), but have confined ourselves entirely to the latter, and now proceed to describe the method of observation adopted.

41. Suppose the visible disk of the sun to be cut up into sections by great circles passing through these poles. These great circles may be regarded as lines of longitude, only, in the present instance, they are not supposed to move round with the sun's surface, but rather to be connected with the earth in such a manner that the plane which passes through the earth is always reckoned the zero or meridian.

Now it is well known that the pole of the sun differs very little from that of the ecliptic, and therefore, in an approximate investigation like the present, we may suppose the two to coincide; these longitudes will thus denote ecliptical longitudes, and the longitude in which the earth is placed being called zero, we may with propriety reckon those to the left negative, and those to the right positive. A sun-spot as it moves across the disk on account of rotation will thus appear at a longitude $-90°$, and vanish at a longitude $+90°$.

The same course will be pursued by the inferior planets Mercury and Venus, which move faster than the Earth; while, on the other hand, the superior planets, which move slower than the Earth, may be supposed to pursue an opposite course, passing across the circles of longitude from right to left.

42. It will thus be apparent that, if the behavior of sun-spots is at all influenced by the positions of the planets, the fact is likely to be discovered by this means. Thus if all the prominent planets be in the same longitude as the Earth, if there be a bond between sun-spots and planets, we should be entitled to expect in such a case some change in appearance or size when the spots for that period pass the central line; if, on the other hand, these planets be together at 20° to the right of the Earth, we might expect some change at 20° to the right, and so on. In fine, one of our objects in the present research is to ascertain the comparative size, at the different ecliptical longitudes in the visible disk, of the whole spotted area for any period, the mass of observations being broken up for this purpose into periods embracing perhaps three or four months, so as to comprehend in each a sufficient number of groups.

43. For this purpose the following plan was adopted. A subsidiary table was formed in which the whole visible disk was portioned out into thirteen parts, each part denoting a day's progress of a spot and embracing every 14° of longitude from $-90°$ to $+90°$. Each of these parts had in this table two columns allotted to it, in one of which the exact longitude of the

spot (with reference to the earth or central point) was noted, while in the other the area *at this longitude* of the whole spot, including umbra and penumbra, was given. *This longitude* of a spot was determined in the following manner. In each of Carrington's large pictures the position of the sun's axis is given. A circular sheet of transparent tracing-calico, of the size of Carrington's sun, had drawn on it lines of longitude for every 10° from $-90°$ to $+90°$. This sheet being applied in a proper manner to each of Carrington's pictures, the longitude of a spot was thus at once read off to the nearest degree.

The subsidiary table having been thus formed, it was then carefully examined, and all those groups were rejected for which (either on account of their exceedingly small size and consequently doubtful area, or from paucity of observations) a reasonably good line representing their behavior in passing over the disk could not be obtained. Each non-rejected group was then dealt with in the following manner. A curve was drawn, in which the abscissæ represented the longitudes of the visible disk from $-90°$ to $+90°$, while the ordinates denoted the corresponding area of the group in millionths of the whole hemispherical surface at each of these longitudes. This curve was formed simply by connecting together by means of straight lines the summits of the consecutive ordinates denoting observed areas. From these curves a table was then formed denoting the probable area of each non-rejected group from longitude $-62°$ to longitude $+64°$, it being thought inadvisable to go nearer the sun's border on either side. Finally, the groups of this table were arranged into consecutive series, each series embracing two or three months, it being supposed that during the course of any one series the planetary configurations retained to a considerable extent the same character. In the following table the results of this subdivision are exhibited.

[The last two columns have been added from a plate in which the positions of Venus and Jupiter are exhibited in connection with a graphical representation of the series of numbers in the table.]

45. Now, *in the first place*, it is evident that during the time embraced in a series the amount of spotted area which crosses one ecliptical longitude is different from that which crosses another,—that is to say, the average size of a spot varies with the ecliptical longitude. This will be seen from a very cursory glance; thus in series IX, X, the average size of a spot attains a maximum at about the longitude of the earth, while in series XI this maximum is much to the right. Since most of these series embrace a considerable number of spots, this behavior may, we think, be considered to be an observational fact.

Table exhibiting the area of the non-rejected groups for the different ecliptical longitudes of the visible disk (longitude of Earth =0°).

No. of series.	Average date of series.	Average size of a group in millionths of the hemispherical area at the following longitudes :—										Longitude of Venus.	Longitude of Jupiter.
		−62°	−48°	−34°	−20°	−6°	+8°	+22°	+36°	+50°	+64°		
I.	1854, Mar. 5	81	90	113	155	229	271	311	330	358	366	+ 10	+120
II.	May 20	105	100	96	80	70	77	78	72	57	39	+ 60	+ 50
III.	Nov. 18	225	261	299	299	298	289	243	239	254	246	+170	−110
IV.	1855, Aug. 25	28	24	21	22	32	43	54	73	84	151	− 20	− 10
V.	1856, Aug. 24	73	78	76	79	82	67	84	60	41	33	−150	+ 40
VI.	1857, Mar. 15	88	94	117	125	167	178	206	211	187	158	− 30	−160
VII.	Aug. 16	111	102	107	106	120	128	108	120	130	135	+ 70	+ 80
VIII.	Nov. 7	94	104	124	132	121	110	108	97	88	81	+140	− 10
IX.	1858, Feb. 1	351	378	394	389	392	401	405	374	325	261	+160	− 80
X.	Apr. 26	141	192	240	295	343	367	365	361	304	211	−120	−140
XI.	July 17	111	118	147	162	173	199	224	238	261	264	− 90	+120
XII.	Nov. 3	231	255	288	316	330	337	349	370	394	418	− 40	+ 30
XIII.	1859, Mar. 8	..	240	229	233	228	218	221	222	197		+ 60	− 70
XIV.	June 22	145	136	128	118	107	100	91	83	79	75	+130	+170
XV.	Aug. 5	342	353	372	405	426	429	414	415	413	410	+150	+150
XVI.	Nov. 11	175	183	195	203	213	226	227	223	213	205	−160	+ 60
XVII.	1860, Feb. 24	123	140	157	168	182	200	195	180	173	161	− 90	− 40
XVIII.	May 16	100	122	141	165	175	185	181	186	184	180	− 30	−110
XIX.	July 2	313	326	321	306	284	271	272	288	251	241	− 10	−160
XX.	Oct. 12	210	225	254	263	255	251	243	221	214	191	+ 60	+110

46. *In the second place*, there seems to be a periodical recurrence of the same sort of behavior. Thus in series I, IV, VI, (XI and XII), XVIII, there is a maximum considerably to the right. The mean dates of these series are:—

I, March, 1854 ....
IV, August, 1855 ....
VI, March, 1857 ....
XI and XII, July to Nov. 1858
XVIII, May, 1860 ......

hence

..............IV=I+17 months.
............VI=IV+19 "
... (XI and XII)=VI+18 "
XVIII=(XI and XII)+20 "

Mean period, 18·5 "

Also in series II, (after IV), VIII, (XIII and XIV), (XIX and XX), there is a maximum considerably to the left. The dates of these series are:—

II, May, 1854........
after IV, (say) Dec. 1855 ...
VIII, November, 1857...
(XIII and XIV), March to June 1859, ...
(XIX and XX), July to Oct. 1860

hence

...................IV=II+19 mos.
.... VIII=IV+23 "
.... (XIII and XIV)=VIII+18 "
(XIX & XX)=(XIII & XIV)+15 "

Mean period, 19 "

Again, in series III, V, (IX and X), (XV, XVI, and XVII) the maximum is not far from the center. The dates are:—

III, November, 1854 ..
V, August, 1856.....
(IX and X), Feb. to April, 1858
(XV, XVI, XVII) Aug. 1859 to Feb. 1860..

hence

..................V=III+21 mos.
.... (IX and X)=V+19 "
(XV, XVI, XVII)=(IX, X)+20 "

Mean period, 20 "

Finally, in series IV, VII, XIII, and XIX we have probably a minimum near the center accompanied with a somewhat undecided action. The dates of these series are:—

IV, August, 1855......	hence	..............VII=IV+24 months.
VII, August, 1857......		............XIII=VII+19 "
XIII, March, 1859		...........XIX=XIII+16 "
XIX, July, 1860		
		Mean, 20 "

The period of recurrence of the same behavior would thus appear to be nineteen or twenty months.

47. *In the third place*, in all these recurrences the progress of the maximum is from left to right, *not* right to left. Thus in series III the maximum is near the center, while in series IV it has gone to the right. The same order is observable in series X and XI, and in fact, throughout the whole twenty series.

48. We cannot see that these phenomena can possibly be explained, unless it be admitted that the behavior of the sun-spots is subject to some external influence, the nature of which will best be determined by the order of recurrence and length of period of the phenomena in question.

In the first place, it is clear that the influence is not stationary, otherwise its period would be one year, that being the time in which the earth (which must be regarded as the standpoint from which these phenomena are viewed) accomplishes one revolution round the sun. Again, since the march of the phenomena is from the left to the right of the earth, this would seem to identify the influence with one of the inferior planets which passes over the sun's disk in this direction (Art. 41), the superior planets going the opposite way.

The period of twenty months will now enable us to determine which of the inferior planets exercises the predominent influence on sun-spots. We have to ask which of the two inferior planets takes twenty months to return to the same position with respect to the earth. This evidently points to Venus, for which the synodical period is 583 days, or between nineteen and twenty months. We may remark that, apart from all observation, if we suppose the various planets to affect the behavior of sun-spots, the influence of Venus should be very great, on account of its nearness to the sun combined with its very considerable size. An examination of the table on p. 326 will give us some idea of the nature of the influence probably exerted by Venus. The average size of a spot would appear to attain its maximum on that side of the sun which is turned away from Venus, and to have its minimum in the neighborhood of this planet.

But, it will be asked, does not Jupiter appear to exert any influence? for although its distance is much greater than that of Venus yet its mass is very great. A reference to the table will, we think, show that the influence of Jupiter is very great, although not apparently predominating. Thus when Venus and Jupiter are both in opposition to the earth, we might expect a very large average size of spots at the longitude of the earth; but if, Venus being in opposition, Jupiter is in conjunction with the earth, the average size ought to be much smaller. In series X and XV the former is the case, and for these the average size of a spot is exceptionally large. In series V, VIII, and XVI the latter is the case, and for these the average size of a spot is exceptionally small.

We ought here to remark that, although Venus has *apparently* a predominating influence, it may not have so in reality; for it is clear that by the method of observation employed, the effect of Jupiter is more equalized than that of Venus, the former separating from the earth or point of view more rapidly than the latter. Thus, if at the beginning of three months' observation Jupiter were in opposition, it would at the end be 96° distant from the earth,—that is to say, its angular motion with respect to the earth during this period would have been nearly 84°, whereas the angular motion of Venus with respect to the earth under similar circumstances would be only 54°. Thus the effect of Venus during this period would be more nearly equal to the maximum effect of Venus than the effect of Jupiter would be to its maximum effect.

[Having thus endeavored to trace the effect of these two planets on the behavior, with respect to size, of sun-spots in crossing the visible disk, the authors supplement the evidence by means of a curve, exhibiting from month to month the whole amount of spotted area for the whole disk. It is evident that in such a curve we ought to have a high point or great amount of area when Venus is in opposition to the earth; in such a case our *standpoint* is favorable. But, again, we ought to have a maximum when the two influential planets, Venus and Jupiter, unite together in acting upon the sun, even although the standpoint of the earth may not be in the most favorable position. The various maxima of such a curve ought thus to be referable to one of two causes, or to both combined—(1) either to a favorable position of the standpoint, or (2) to a favorable conjunction of planets for action upon the sun. The maxima are shown to be in fact regulated by planetary configurations, and especially by the two causes named.]

50. While the preceding portion of this paper was being printed, a circular issued by Mr. Chacornac has been the means of calling our attention to Carrington's diagram exhibiting the distribution of spotted area in heliographical latitude from time to time, and to the minor fluctuations which occur in his diagram.

We had previously proposed to ourselves a complete investigation into this as the subject of a third series of these researches; but a preliminary investigation of Carrington's diagram has led us to a conclusion which we think of sufficient importance to communicate at once, reserving a more elaborate and accurate investigation to a future occasion.

We think it will very likely be found that, at those periods when the planets Jupiter and Venus cross the solar equator, there will be a tendency of the spotted area to approach the equator, and at those periods when the heliographical latitude of these planets is greatest there will be a tendency for spots to spread out from the solar equator.

Reserving the action of Jupiter to a more complete investigation, we have derived the following result regarding the action of Venus from an approximate method of treating Carrington's diagram. *It would appear that spots are nearest to the solar equator when the heliographical latitude of Venus is* 0°, *and are most distant from the solar equator when this planet attains its greatest heliographical latitude.*

51. *Concluding remarks.*—The following question may occur to our readers, How is it possible that a planet so far from the sun as Venus or Jupiter can cause mechanical changes so vast as those which sun-spots exhibit? We would reply in the following terms to this objection.

We do not, of course, imagine that we have as yet determined the nature of the influence exerted by these planets on the sun; but we would, nevertheless, refer to an opinion expressed by Professor Tait, "that the properties of a body, especially those with respect to heat and light, may be influenced by the neighborhood of a large body." Now an influence of this kind would naturally be most powerful upon a body such as the sun, which possesses a very high temperature, just as a poker thrust into a hot furnace will create a greater disturbance of the heat than if thrust into a chamber very little hotter than itself. In the next place, it is not to be inferred that the mechanical equivalent of the energy exhibited in sun-spots is derived from the influencing planet any more than it is to be inferred that the energy of a cannon-ball is derived from the force with which the trigger is pulled.*

The molecular state of the sun, just as that of the cannon or of fulminating powder, may be extremely sensitive to impressions from without; indeed we have independent grounds for supposing that such is the case. We may infer from certain experiments, especially those of Cagniard de Latour, that at a very high temperature and under a very great pressure the latent heat of vaporization is very small, so that a comparatively small

* It is, however, a possible inquiry whether these phenomena do not imply a certain loss of motion in the influencing planets.

increment of heat will cause a considerable mass of liquid to assume the gaseous form, and *vice versâ.* We may thus very well suppose that an extremely small withdrawal of heat from the sun might cause a copious condensation; and this change of molecular state would, of course, by means of altered reflection, &c., alter to a considerable extent the distribution over the various particles of the sun's surface of an enormous quantity of heat, and great mechanical changes might very easily result.

Again, although we cannot suppose our earth to be nearly so sensitive as the sun, yet the question may be entertained, Does the moon exert an influence of this kind upon the earth?

52. Our readers will, we think, agree with us in dividing the results of this paper into three classes.

We have, *in the first place*, the pure results of observation.

In the second place, we have put forth as an immediate deduction from these observational results a connection between sun-spots and planets. The evidence in favor of this deduction appears to us to be very strong, and we have placed it before our readers in detail that every one may judge for himself.

In the third place, we have, in paragraph 50, ventured to adopt an hypothesis regarding the nature of this action, which must, in the meantime, be considered as a working hypothesis, which may, perhaps, serve to extend our knowledge of the subject.

53. A few words may be allowed us with regard to the history of this question. Professor Wolf has, it is well known, directed attention to a probable connection between sun-spots and planets, derived from the periodicity of the former. With regard to his success in this matter we do not venture to give an opinion; we would only remark that our evidence is of a different nature to that which is capable of being derived from periodicity in the number of spots.

Since our preliminary research into the behavior of sun-spots, a suggestion of the illustrious Galileo, which he appears not to have published from want of evidence, has been brought to our notice by the Rev. William Selwyn. This suggestion advocates a method of research allied to that which we have pursued, and we should be happy to think that our present investigation has tended in any measure to vindicate the sagacity of that renowned philosopher. We venture to think that we have succeeded in demonstrating the great probability of planetary influence, and to hope that this probability may be converted into a certainty, and the subject very far advanced before the next ten-yearly maximum, by the labors in solar photography of the Kew Observatory and other similar institutions.

Art. XXXVII.—*Research on the Ethers of Silicic Acid;* by C. Friedel and J. M. Crafts.

[Concluded from p. 171.]

The first distillations were made in vacuo (3–5 millimeters pressure), and the substance used consisted in residues from various preparations of the normal silicate, and of the hexethylic disilicic silicate; both these products had as far as possible already been extracted.

After eight distillations we obtained—

at 60°–115° (Centigrade.)	6 grs.	of liquid.	
115 –135	16	"	
135 –150	8	"	
150 –165	14	"	
165 –180	30	"	Si=18·73 per ct.
180 –200	16	"	Si=19·58 "
200 –220	8	"	Si=20·78 "
220 –260	4	"	Si=21·96 "
260 –300	3	"	Si=22·78 "
300 –320	3	"	Si=23·59 "

The largest portion within narrow limits of temperature, that which distilled 165°–180°, was redistilled in the air; it commenced to distill at 285°, and between this point and 305°, 25 grs. of liquid passed; above 305° there were only 8 grs. This last product contained 19·34 per cent Si.

All the products distilled above, except those which had passed at a temperature higher than 200° in vacuo, were redistilled under the ordinary pressure. There was obtained on the 6th distillation,

175°–215°	6·5	grs.	
215 –235	6.5	"	
235 –243	25·0	"	=hexethylic disilicic ether.
243 –260	10·0	"	
260 –276	15.0	"	
276 –286	10·0	"	Si=17·85 per ct.
286 –294	12·0	"	Si=18·22 "
294 –310	5·0	"	
	90·0		

The portion of the above products containing the more condensed ethers, i. e., the part boiling 243°–310°, was redistilled under a pressure of 58–60mm. (=$\frac{1}{12}$ the ordinary pressure of the air), until the amount of liquid distilling at a given point remained nearly constant in successive distillations.

There was obtained—

	4th distillation.	5th distillation.	
170°–195°	7·0 grs.	6·5 grs.	
195 –205	10·0 "	9·5 "	Si=18·26 p. c.
205 –215	7·0 "	7·0 "	
215 –230	8·5 "	9·2 "	
230 –240	6·0 "	5·0 "	Si=19·50 p. c.
240 –285	7·0 "	6·8 "	
	45·5	44·0	

The portion distilling above 200° in vacuo, and that which distilled above 285° under a pressure 58–60 mm., were redistilled three times under a pressure of 9–10 mm.

220°–235°	5·0 grs.	Si=20·60, C=37·01, H=7·64 p. c.
235 –245	2·2 "	Si=20·99 per ct.
245 –280	6·0 "	Si=21·40 "

Finally, the portion remaining above 280°, was distilled under a pressure of 1–3mm.

270°–320°	1·0 grs.	
320 –360	3·0 "	Si=22·79 per ct.
above 360	2·1 "	Si=23.91 "

The formula of Ebelmen's bisilicate requires 20·90 per ct. Si. The quadrisilicate 28·66 per ct. Si.

We made other distillations of the higher products in vacuo, analyzing the liquid, which passed at different temperatures, and found the results to agree with the foregoing.

Thus after a very prolonged series of fractionated distillations, we not only failed to obtain the bisilicate among the products distilling in the neighborhood of its supposed boiling point, but we also failed to isolate any body having a definite composition and a constant boiling point. The proportion of silica in these condensed ethers increases with the temperature, at which they distill, while that of carbon and hydrogen diminishes, and the relations between these constituents do not lead to any simple formula. Products from different preparations having the same boiling points have nearly the same composition.

It is probable that there are several condensed silicates belonging to some of the types mentioned (p. 166) and that they can not be separated by distillation. It is worthy of notice that in all the bodies analyzed the ratio of carbon to hydrogen is the same as in the radical ethyl.

We also attempted to prepare the bisilicate by following exactly the method given by Ebelmen, but failed to obtain it, either because some precaution was omitted in repeating his experiments, or because the bisilicate does not exist. We will observe that the method of preparation given (distillation without thermometer, above the boiling point of mercury) does not offer a very good guaranty for the purity of the substance.

Silicates of methyl.—When we commenced our research, we tried the reaction of methylic alcohol on the chlorid of silicium; but like Ebelmen* we only obtained a product, that it was impossible to purify, turning brown in the air and possessing a fetid odor. We noticed, that this product always contained chlorine.

After having observed that the radicals contained in the alcohols may replace those contained in the ethers of acids† we thought that this reaction might furnish a method of obtaining the silicate of methyl.

With this object, we purified wood-spirit by a treatment with chlorid of calcium, and after decomposing the chlorid of calcium compound with water and rectifying the alcohol several times with sodium, we sealed it in a tube with silicate of ethyl, and heated the mixture during 20 hours at 210°.

After several fractionated distillations the principal product, isolated from the contents of the tube, was a liquid boiling at 143°–147°, together with products with a much higher boiling point.

The portion boiling at 143°–147° gave on analysis numbers which correspond with the composition of a mixed silicate diethylic dimethylic silicic ether.

I.	Substance, weight, - - - -	0·3035 gr.
	CO_2, - - - - - -	0·4320 "
	H_2O, - - - - - -	0·2435 "
II.	Substance, weight, - - - -	0·3450 "
	SiO_2, - - - - - -	0·1150 "
III.	Product redistilled, 143°–147°.	
	Substance, weight, - - - -	0·2220 "
	CO_2, - - - - - -	0·3250 "
	H_2O, - - - - - -	0·1840 "
IV.	Another preparation, portion distilling, 145°–147°	
	Substance, weight, - - - -	0·2900 "
	CO_2, - - - - - -	0·4315 "
	H_2O, - - - - - -	0·2350 "

	I.	II.	III.	IV.	Theory. $SiC_6H_{16}O_4$.
C,	38·90		39·89	40·61	40·00
H,	8·94		9·20	9·00	8·88
Si,		15·51			15·55

It is remarkable, that in these experiments the principal product formed, and the only one that was easy to isolate, was this mixed ether, and not the silicate of methyl or the trimethylic mono-ethylic ether, although the methylic alcohol was used in large excess.

* Ann. de Chim. et Phys., [3], xvi, 129. † This Journal, [2], xl, 34.

In an experiment, made with the special object of obtaining an ether containing a larger proportion of methyl, we heated silicate of ethyl during 15 hours at 250° with a large excess of methylic alcohol, then distilled, and heated a second time with methylic alcohol, the liquid, boiling below 150°, but still the greater part of the product passed at 143°–147°. This product redistilled at 145°–147° furnished us the material for analysis No. IV. If the mono-methylic and mono-ethylic mixed ethers are formed, as is probable, it is in a much smaller proportion.

The simultaneous production of condensed ethers with a higher boiling point, noticed above, could only be accounted for by the presence of water in the methylic alcohol used, since we convinced ourselves by experiment, that there was no formation of ordinary methylic or ethylic ether, bodies whose production would equally have accounted for the formation of condensed silicates. The methylic alcohol really loses water by the process; for on employing the same alcohol for a second preparation, there was production of more of the mixed ethers and less of the condensed silicates.

This observation induced us to give greater attention to rendering the methylic alcohol anhydrous; and we discovered, that even 8–10 distillations with sodium and methylate of sodium were not sufficient to make the alcohol perfectly anhydrous. It is probable, that when the percentage of water is reduced to a certain limit, the methylate of sodium is no longer decomposed.

We were more successful in drying methylic alcohol by means of anhydrous phosphoric acids.

Methylic alcohol, distilled twice with sodium, and then with a small quantity of phosphoric acid, boils at 65°·5, loses the disagreeable odor, that it usually has, and smells like common alcohol, and does not turn brown with soda. Purified in this manner, it no longer gives, when heated with silicic ether, more than traces of condensed silicates.

The preceding observations on the difficulty of purifying and drying methylic alcohol led us to suspect, that the bad success of the attempts of Ebelmen and our own to obtain methylic silicic ether by the direct action of chlorid of silicium on the alcohol, arose merely from the impurity of the material employed. The following experiment shows, that this was the case.

Methylic alcohol, purified with the precautions mentioned above and added in small quantities at a time to chlorid of silicium, reacts upon it in exactly the same manner as ordinary alcohol. It does not turn brown more than the latter. Hydrochloric acid is given off in abundance, reducing the temperature of the liquid. When the theoretical quantity of alcohol has been added, the product is distilled, and after a small number of fractionated distillations, it is easy to separate two principal products, one boiling at 120°–122°, and the other at 201°–202°·5. The first product is almost the only one formed, where the alcohol is perfectly anhydrous; it is the normal silicate of ethyl. The second is the hexamethylic disilicic ether.

The products, obtained in the first preparations, were not entirely pure, and analysis showed that a small quantity of an ethylic compound was present; it therefore became necessary to employ a methylic alcohol, obtained by saponification of the oxalate, and all the preparations were subsequently made with this product rectified successively with sodium and phosphoric acid.

In one operation, made with a portion of methylic alcohol, which had been heated with silicate of methyl in a sealed tube, an excellent means of rendering it quite anhydrous, the whole product of the reaction distilled at 121°–126°. Of this the portion boiling at 121°–122° was analyzed.

I.	Substance, weight, - - - -	0·3400 grs.
	$ЄΘ_2$, - - - - - -	0·3930 "
	$H_2Θ$, - - - - - -	0·2440 "
II.	Substance, weight, - - - -	0·9275 "
	$SiΘ_2$, - - - - - -	0·3680 "

This product contained $\frac{27}{100}$ of a per cent of chlorine and we found, that the only way to free the methylic ethers completely from chlorine (probably contained in a chlorhydrine) is to heat them in a sealed tube at 180° with an excess of methylic alcohol. After this treatment the product was distilled again at 121°–122° and on analysis gave:

III.	Substance, weight, - - - -	0·2800 grs.
	$ЄΘ_2$, - - - - - -	0·3255 "
	$H_2Θ$, - - - - - -	0·2005 "
IV.	Substance, weight, - - - -	0·4025 "
	$SiΘ_2$, - - - - - -	0·1610 "

	I.	II.	III.	IV.	Theory. $Si(ЄH_3)_4Θ_4$.
C,	31·56		31·68		31·58
H,	7·98		7·95		7·89
Si,		18·52		18·57	18·42

The density of vapor =5·380. The theory requires 5·264.

Difference between 2 weights of bulb, -	0·9730 gr.
Temperature of the balance, - - -	20°
" " oil bath, - - -	190°
Height of barometer, - - - -	760 mm.
Capacity of bulb, - - -	333·5 cc.
Air remaining, - - - - -	0·2 cc.

The density of the ether at 0°=1·0589.

The normal silicate of methyl is a colorless liquid, possessing an etheric and rather agreeable odor. It is soluble in considerable quantity in water, and the solution only gives a gelatinous deposit of silica at the end of some weeks. Moisture or aqueous alcohol decomposes it rapidly with formation of condensed products and ultimately of silica. It burns with a white smoke composed of silica.

Hexamethylic disilicic ether is formed, whenever the normal ether is prepared with aqueous alcohol, and it may also be obtained by heating the normal ether with methylic alcohol containing water. It boils, as we have already said, at 201°–202°·5, and resembles the hexethylic disilicic ether very much in its properties.

An analysis gave—

I.	Substance, weight, - - - -	0·2880 gr.
	CO_2, - - - - - -	0·2960 "
	H_2O, - - - - - -	0·1800 "
II.	Substance, weight, - - - -	0·5655 "
	SiO_2, - - - - - -	0·2665 "

III. Product remaining in the bulb after the determination of the vapor-density.

Substance, weight, - - - -	0·3335 gr.
CO_2, - - - - - -	0·3400 "
H_2O, - - - - - -	0·2100 "

	I.	II.	III.	Theory. $Si_2(CH_3)_6O_7$.
C,	28·04		27·80	27·90
H,	6·95		6·99	6·97
Si,		22·00		21·70

The vapor density =9·19. The theory requires 8·93.

Difference of 2 weights of bulb, -	1·2422 gr.
Temperature of balance, - -	24°
" " oil-bath, - - -	266°·5 mercury therm.
" " " " - - -	263° air thermometer.
Barometric height, - - - -	759·1 mm.
Capacity of bulb, - - - -	253·25 cc.
Air remaining, - - - -	0·2 cc.

The density of this ether at 0°=1·144.

We have not succeeded in isolating any product of a definite composition with a boiling point higher than that of the hexamethylic disilicic ether, and the result of our experiments has been exactly the same as in the case of the ethylic condensed ethers. The per-centage amount of silicic acid rises with the boiling point. We did not extend our investigations so far as was done with ethylic ethers.

We call attention to the small difference in the boiling points of the methylic and ethylic normal silicate =44°, only 11° for each difference of CH_2. The difference in the case of methylic and ethylic-disilicic ethers is 33° or 5½° for each difference of CH_2.

The monochlorhydrine of the normal methylic silicic ether was obtained, in the same way as the ethylic chlorhydrine, by heating together during one hour at 150°, three molecules of the ether with one molecule of chlorid of silicium. Almost the whole product boiled at 113°–117° and after several distillations the portion boiling at 114°·5–115°·5 gave on analysis—

I.	Substance, weight, - - - -	0·5965 gr.
	SiO_2 - - - - - - -	0.2295 "
II.	Substance, weight, - - - -	0·2695 "
	CO_2, - - - - - - -	0·2305 "
	H_2O, - - - - - - -	0·1420 "
III.	Substance, weight, - - - -	0·7255 "
	AgCl, - - - - - - -	0·6625 "

	I.	II.	III.	Theory. $SiCl(CH_3)_3O_3$.
C,		23·31		23·00
H,		5·85		5·75
Si,	17·95			17·89
Cl,			22·59	22·68

The density of vapor =5·578. Theory 5·420.

Difference between 2 weights of bulb,	1·2147 gr.
Temperature of the balance, - -	19°
" " oil bath, - -	170°·5
Barometric height, - - - -	766·5 mm.
Capacity of bulb, - - - -	369·5 cc.
No air remaining.	

The density of the liquid at 0°=1·1954.

The monochlorhydrine is a liquid with an etheric odor, burning with a green chlorine flame and giving off a siliceous smoke. It is very easily decomposed by moisture. With methylic alcohol it regenerates the normal methylic silicate. It will be seen in the sequel, that the chlorhydrine can be used for the preparation of mixed ethers.

The Dichlorhydrine of methylic-silicic ether was obtained by heating two molecules of monochlorhydrine with one molecule of chlorid of silicium during one hour at 160°. The reaction is somewhat less easy than in the case of the formation of the monochlorhydrine. The larger part of the product distilled at 98°–103°, and the liquid obtained, boiling at this temperature, after four distillations was analyzed.

I.	Substance, weight, - - - -	0·2565 gr.
	CO_2, - - - - - - -	0·1400 "
	H_2O, - - - - - - -	0·0855 "

II. Substance, weight,	- - - -	0·4480 gr.
SiO_2,	- - - - - -	0·1700 "
III. Substance, weight,	- - - -	0·9325 "
AgCl,	- - - - - -	0·1669 "

	I.	II.	III.	Theory. $Si,Cl_2,(CH_3)_2O_2$.
C,	14·85			14·90
H,	3·70			3·72
Si,		17·68		17·39
Cl,			44·28	44·10

Density of vapor =5·66. Theory 5·57.

Difference between 2 weights of bulb, -	0·8755 gr.
Temperature of balance, - - -	20°
" " oil-bath, - - -	182°·5
Barometric height, - - - -	761·4 mm.
Capacity of bulb, - - - -	272·75 cc.
Air remaining, - - - - -	0·5 cc.

The density of liquid at 0°=1·2595. The physical properties of the dichlorhydrine resemble those of the monochlorhydrine.

The Trichlorhydrine of the methylic-silicic ether was obtained by heating one molecule of chlorid of silicium with one molecule of the dichlorhydrine during twelve hours at 220°. It is formed much less easily than the preceding bodies; even after the tube had been heated so long a time, a portion of the chlorid of silicium remained intact. The principal product distilled at near 84°. After several fractionated distillations, the portion boiling at 82°–86° was separated and analyzed.

I. Substance, weight,	- - - -	0·2980 gr.
CO_2,	- - - - - -	0·0800 "
H_2O,	- - - - - -	0·0485 "
II. Substance, weight,	- - - -	0·2510 "
SiO_2,	- - - - - -	0·0920 "
III. Substance, weight,	- - - -	0·4105 "
Cl,	- - - - - -	0·0700 "

	I.	II.	III.	Theory. $SiCl_3CH_3O$.
C,	7·29			7·25
H,	1·81			1·81
Si,		17·05		16·92
Cl,			64·46	64·35

Vapor density =5·66. Theory, 5·73.

The density was taken by the method of Gay Lussac.

Weight of substance employed, -	0·445 gr.
Temperature of the oil-bath, - -	134°·5 "
Volume of vapor, - - - -	109·0 cc.
Height of barometer, - - -	759 mm. at 23°·5
Height of the mercury in the bell glass above the level of the mercury in bath,	128·2 mm.

Mixed methylic-silicic ethers.—Where the chlorhydrines are treated with an alcohol, they exchange the Cl, for the radical of the alcohol and Θ, and in this manner, by employing different alcohols, mixed normal ethers may be obtained. Ordinary alcohol reacts immediately on the monochlorhydrine with evolution of HCl, and the principal product is trimethylic monoethylic-silicic ether. No chlorhydrine remains undecomposed, and there is no formation of silicate of ethyl, and after the excess of alcohol has distilled, the liquid commences to boil at 133°. There is also a small quantity of a product with a boiling point which corresponds to that of the dimethylic diethylic ether formed.

The product boiling at 133°–135 gave on analysis—

I.	Substance, weight, - - - -	0·2890 gr.
	$Si\Theta_2$, - - - - - - -	0·1060 "
II.	Substance, weight, - - - -	0·2450 "
	$C\Theta_2$, - - - - - - -	0·3240 "
	$H_2\Theta$, - - - - - - -	0·1885 "

	II.	I.	Theory. $Si(CH_3)_2(C_2H_5)_2,\Theta_4$.
C,	36·03		36·14
H,	8·55		8·43
Si,		17·14	16·86

The density of the liquid at 0°=1·0230.

In order to explain to ourselves the formation of the dimethylic diethylic silicic ether, we examined the alcohol, which distilled after the completion of the reaction.

It distilled in great part at 72°–74°. It was treated with powdered caustic potash to remove the hydrochloric acid it contained in solution, distilled and then left over night in contact with freshly calcinated carbonate of potash.

An analysis of this alcohol gave,

Substance, weight, - - - - -	0·1995 gr.
$C\Theta_2$, - - - - - - -	0·3000 "
$H_2\Theta$, - - - - - - -	0·2250 "

		$CH_4\Theta$.	$C_2H_6\Theta$.
C,	40·94	37·5	52·17
H,	12·53	12·5	13·04

Common ethylic alcohol containing 21 p. c. of water would have the same composition; but we ascertained that, when aqueous alcohol was treated in the same way with carbonate of potash, it marks 96 p. ct. on the alcoholometer of Gay-Lussac. The alcohol contained a certain quantity of methylic alcohol, which could only have been formed by direct elimination from the methylic-silicic ether with production of an ether, containing a larger proportion of the radical ethyl. We have before observed, that the dimethylic disilicic ether is the one most readily produced.

This had already been obtained by the action of methylic alcohol on the normal silicate of ethyl.* It is also produced, when the methylic dichlorhydrine is treated with ethylic alcohol.

A product, obtained in this way, and boiling at 143°–146°, was analyzed.

I.	Substance, weight, - - - -	0·2700 gr.
	$Si\Theta_2$, - - - - - -	0·0910 "
II.	Substance, weight, - - - -	0·2400 "
	$Є\Theta_2$, - - - - - -	0·3485 "
	$H_2\Theta$, - - - - - -	0·1910 "
III.	Substance, weight, - - - -	0·3635 "
	$Si\Theta_2$, - - - - - -	0·1225 "

	I.	II.	III.	Theory. $Si(ЄH_3)_2(Є_2H_5)_2,\Theta_4$.
C,		39·56		40·00
H,		8·83		8·88
Si,	15·73		15·71	15·55

The product used in analysis No. III was that which remained in the bulb after a determination of vapor-density.

Density of vapor =6·178. Theory 6·233.

Difference between 2 weights of bulb, -	0·9569 gr.
Temperature of balance, - - -	21°·5
" " oil-bath, - - -	192°
Height of barometer, - - - -	763·7 mm.
Capacity of bulb, - - - -	279·75 cc.
Air remaining, - - - - -	5·25 cc.

The density of liquid at 0°=1·004.

The monoethylic triethylic ether, was obtained by treating the monochlorhydrine of the normal ethylic silicate with methylic alcohol.

It boils at 155°–157°.

I.	Substance, weight, - - - -	0·3945 gr.
	$Si\Theta_2$, - - - - - -	0·1180 "
II.	Substance, weight, - - - -	0·2325 "
	$Є\Theta_2$, - - - - - -	0·3640 "
	$H_2\Theta$, - - - - - -	0·1925 "

	I.	II.	Theory. $SiЄH_3,(Є_2H_5)_3,\Theta_4$.
C,		42·71	43·30
H,		9·21	9·28
Si,	13·96		14·43

We repeated with the alcohol, that distilled, the same experiment, that was made, where the monoethylic trimethylic ether

* See page 158.

was prepared, and we found ethylic alcohol mixed with the portion of methylic alcohol, which distilled 73°–77°.

I.	Substance, weight,	0·1710 gr.
	$ЄΘ_2$,	0·2780 "
	$H_2Θ$,	0·0955 "
II.	Substance, weight,	0·1545 "
	$ЄΘ_2$,	0·2520 "
	$H_2Θ$,	0·1790 "

	I.	II.	$ЄH_4Θ$.	$Є_2H_6Θ$.
C,	44·34	44·51	37·5	52·17
H,	12·69	12·89	12·5	13·04

Therefore in this case there is a replacement of ethyl by methyl in the ether with formation of ethylic alcohol and the dimethylic silicic ether, and doubtless the presence of a small quantity of this latter body explains the small amount of carbon and hydrogen found in the analysis of the monomethylic triethylic silicic ether.

Dimethylic diamylic silicic ether.—In the reaction of amylic alcohol on the monochlorhydrine of methylic ether, the displacement of one alcoholic radical by another was still more strongly marked, for the principal product was a liquid boiling at 225°–235°, which did not have the composition of the trimethylic monoamylic ether, but very nearly that of the dimethylic diamylic ether.

An analysis of this product gave—

I.	Substance, weight,	0·2425 gr.
	$ЄΘ_2$,	0·4780 "
	$H_2Θ$,	0·2375 "
II.	Substance, weight,	0·3795 "
	$SiΘ_2$,	0·0865 "

	I.	II.	Theory. $Si(ЄH_5)_2(Є_5H_{11})_2Θ_4$.
C,	53·76		54·55
H,	10·89		10·61
Si,		10·64	10·61

The decomposition of this ether cannot be effected by an alcoholic solution of ammonia, and it is necessary to employ an alcoholic solution of soda for the determination of the silica.

In the production of this ether by the above reaction, we again notice the tendency to the production of mixed ethers containing two atoms of each alcoholic radical.

It should be noticed, that action of an alcohol upon an ether with interchange of alcoholic radicals, seems to take place more readily at the moment of the formation of the ethers from a chlorhydrine, than after the ether has been once formed.

The Actions of the Anhydrids of Acids on Silicic Ether.—After having observed the substitution of one alcoholic radical for another in ethers, we determined to try to obtain by a similar reaction the replacement of an alcoholic radical by one contained in an acid. The first experiment made was that of heating the chlorid of acetyl with silicic ether, but we have already stated that the chlorine, and not the acetyl, was introduced into the ether with formation of a monochlorhydrine and of acetate of ethyl.

It next occurred to us to try the action of anhydrous acetic acid, $\left.\begin{matrix}\text{Є}_2H_3\Theta\\ \text{Є}_2H_3\Theta\end{matrix}\right\}\Theta$, and we found, that by means of this reagent an acetine $Si(C_2H_5)_3, (\text{Є}_2H_3\Theta), \Theta_4$ could be formed.

35 grams of the normal silicate of ethyl and 13 grams of anhydrous acetic acid, boiling at 138°·5–140°,* were heated during 14 hours at 180°.

After 8 fractionated distillations, the following series of products was obtained—distilled—

77°– 80°	7·0	grs.
80°– 95°	2·5	"
95°–165°	4·0	"
165°–177°	3·0	"
177°–181°	2·5	"
181°–192°	5·0	"
192°–197°	2·5	"
197°–204°	1·25	"
204°–230°	1·6	"
above 230°	5·0	"
	33·75	

The first product, 77°–80°, was acetate of ethyl. According to the theory represented by the equation:

$$\left.\begin{matrix}Si\\ (\text{Є}_2H_5)_4\end{matrix}\right\}\Theta_4+\left.\begin{matrix}\text{Є}_2H_4\Theta\\ \text{Є}_2H_3\Theta\end{matrix}\right\}\Theta=\left.\begin{matrix}Si\\ (\text{Є}_2H_5)_3\\ \text{Є}_2H_3\Theta\end{matrix}\right\}\Theta_4+\left.\begin{matrix}\text{Є}_2H_3\Theta\\ \text{Є}_2H_5\end{matrix}\right\}\Theta,$$

11·2 grs. of acetate of ethyl ought to have been produced. About 9 grs. of pure acetate were really obtained.

The products boiling higher were analyzed.

I.	177°–181°—Substance, weight,	-	0·2420 gr.
	$\text{Є}\Theta_2$,	-	0·3900 "
	$H_2\Theta$,	-	0·1970 "
II.	178°–182°—Substance, weight,	-	0·3190 "
	$Si\Theta_2$,	-	0·0875 "

This product was obtained by redistilling No. I.

* A convenient way of obtaining anhydrous acetic acid is, after rectification on acetic of potash, to rectify on the alloy of zinc and sodium, until the disengagement of hydrogen has become very slight.

III. (obtained by redistilling 181°–192°)		
Substance, boiling 183°–193°, weight,	0·2865	gr.
$\text{Є}\Theta_2$, - - - - - - -	0·4580	"
$H_2\Theta$, - - - - - - -	0·2365	"
IV. 192°–197° Substance, weight, -	0·2790	"
$\text{Є}\Theta_2$, - - - - - - -	0·4400	"
$H_2\Theta$, - - - - - - -	0·2005	"

	I.	II.	III.	IV.	Theory. $Si(\text{Є}_2H_5)_3(\text{Є}_2H_3\Theta)\Theta_4$
C,	43·94		43·57	42·94	43·24
H,	9·06		9·09	7·99	8·11
Si,		12·80			12·61

The decomposition of the acetine by the alcoholic solution of ammonia is not complete, and an alcoholic solution of soda must be used to make the silicic determination.

The preceding analyses show, that the boiling point of the monoacetine $Si, (\text{Є}_2H_5)_3, \text{Є}_2H_3\Theta, \Theta_4$ must be near 190°; but we did not succeed in isolating a pure product by distillation. By the action of potash on the acetine, acetic acid is obtained, showing, that it is really an acetine, which is formed. The acetine is a somewhat oily liquid having an ethereal odor, with something of that of acetic acid in it. The odor of acetic acid becomes stronger, when the acetine has been exposed to the action of moisture.

The product of another operation was distilled under a pressure of only 52 millimeters of mercury, because we feared, that the compound might be decomposed by distillation at a high temperature. The liquid boiling at 135°–145° was first analyzed (I). This was redistilled several times and the product boiling at 135°–140° was analyzed (II).

I. Substance, weight, - - - - -	0·4740	gr.
$Si\Theta_2$, - - - - - - -	0·1285	"
II. Substance, weight, - - - - -	0·4360	"
$Si\Theta_2$, - - - - - - -	0·1185	"

	I.	II.	Theory.
Si,	12·64	12·68	12·61 per cent.

Action of Boric Acid on the Silicate of Ethyl.—In the hope of obtaining an ether containing boric acid and silicic acid together, we heated 3 grams of boric acid, which had been previously melted, with 28 grams of silicate of ethyl (2 molecules of boric acid for 3 of silicate of ethyl) during 12 hours at 240°.

The whole of the acid dissolved, and on opening the tube there was no evolution of gas. After six or eight fractionated distillations, products were obtained with a very high boiling point, and a considerable quantity of a liquid with a lower boiling point; of this latter there distilled:

Below 119°	2 gr.
119°–125°	8 "
125°–140°	5 "
	12 "

All these portions below 140° burnt with a green flame and did not contain a notable quantity of silica. They consisted in Ebelmen's boric ether in a state of almost complete purity. The true boiling point of this ether is 119°.

The portion 119°–125° was analyzed.

Substance, weight,	0·2105 gr.
$\mathrm{C}\Theta_2$,	0·3795 "
$H_2\Theta$,	0·1990 "

		Theory. $Bo(\mathrm{C}_2H_5)_3\Theta_3$.
C,	49·19	49·31
H,	10·51	10·27

Supposing all the boric acid to have been converted into boric ether, 12 grams of the latter ought to have been produced. The reaction therefore had resulted, not in the production of a mixed ether containing both the acids, but in the replacement of silicic acid by boric. The products boiling higher than 140° consisted in ethers, containing a large amount of silicic acid, and a residue of silica was left in the flask after the distillation. Boric acid acts on silicic ether in the same manner as water, and not like anhydrous acetic acid. It is possible that this reaction may serve as a means of preparing some of the ethers of other acids that have not yet been obtained.

From all the facts observed in this research, the tetratomic character of silicium appears to us proved in the most convincing manner. It is impossible to find simpler formulæ to represent the composition of the monochlorhydrines and trichlorhydrines of ethylic and methylic silicic ethers, or of the monoamylic-triethylic, monoethylic-trimethylic and monoethylic-triethylic ethers, or of the acetine; and only by returning to the old atomic weight of oxygen, can the hexethylic and hexamethylic-disilicic ethers be written with a simpler formula, since they contain Θ_7.

The existence of these compounds and their formulæ is interpreted most readily by supposing, as we have done, that the chlorid of silicium, $Si\ Cl_4$, silicic acid, $Si\Theta_2$, and the silicic hydrate $SiH_4\Theta_4$ act in the same way as the polybasic acids known in mineral and organic chemistry.

In another paper we intend to publish the results, that we have obtained in studying the compounds of silicium with the alcoholic radicals.

Boston, Dec. 5th, 1866.

ART. XXXVIII.—*On the supposed falsification of samples of California Petroleum;* by S. F. PECKHAM, late Chemist to the California Petroleum Company.

HAVING been almost exclusively engaged during the last eighteen months in both technical and scientific analyses of California bitumens, my attention has been repeatedly called to the small amount of light oils suitable for illumination yielded by these substances, when treated by the ordinary process of fractional distillation. This low percentage of light oil, and consequent inferior commercial value of the crude materials, early led me to compare my own results with those of other experimenters and analysts of California products.

The first reports that I obtained, were published in the prospectus of the Philadelphia and California Petroleum Company. These embraced the details of an examination made by Mr. Peter Collier, under the direction of Prof. Silliman; those of C. M. Warren, Esq., of Brookline, Mass., and those of Prof. J. M. Maisch of Philadelphia. I afterwards received a pamphlet containing an article published in this Journal, vol. xxxix, May, 1865. This article contained the results of the analysis made by Mr. Collier and the report of Mr. Warren, before mentioned. The report of Mr. Maisch was dated March 18th, 1865; that of Mr. Warren, March 31st, 1865; that of Prof. Silliman was without date.

The material operated upon by Prof. S. was said to have come from a spring upon the Simi ranch in Santa Barbara county; and that treated by Messrs. Warren and Maisch was said to be a portion of the same sample. Without concurrent testimony, the similarity of the results obtained by those gentlemen, even by different methods of operation, sufficiently proves the identity of the crude material.

My own results, which I propose to compare with those above mentioned, were obtained by the treatment of petroleums gathered from the natural outcrops known as the Cañada Laga and Pico springs, and two samples, of different density, from the estate of the Hayward Petroleum Co. The Stanford oil springs adjoining and resembling those of the H. P. Co., and a tunnel in the San Fernando mining district, the product of which is a little more dense but otherwise resembles that of the Pico spring, were the only other localities in Southern California, yielding petroleum in any other than the most insignificant quantities, at the time I left that region in June last.

I am perfectly familiar with each of these localities and their products. All the samples treated by me, with but one exception—the lightest sample from the H. P. Co.—were gathered under my own eye, most of them with my own hand. The exceptional sample was gathered and furnished me under the personal supervision of William H. Stone, Esq., at that time Superintendent of the California Petroleum Company.

My experiments were first confined to the petroleums of the Cañada Laga spring, and the tunnels of the H. P. Co. The great dissimilarity between my results and those detailed in the published reports, led me to inquire of persons familiar with the country, concerning the spring upon the Simi ranch, with the intention of procuring some of the oil for analysis. I was then and subsequently informed that no "green oil" (petroleum) springs existed upon that estate. I then sought the officers of the Philadelphia and California Petroleum Company resident upon their estate, and was informed by them that no oil of sp. gr. corresponding to that given in the reports (average ·8635 = 33·5° Baumé) was to be found upon their property, nor so far as they could learn in that part of the country. I was informed that the lightest oil yielded by any natural outcrop in that section, was that of the Pico spring, situated very near but without the boundary line of the San Francisco ranch. The sp. gr. of this oil, as estimated by myself, is ·8832=28·5° Baumé. I was assured by Mr. Lyon who had had charge of the spring for more than a year prior to June 1st, 1866, that no oil lighter than sp. gr. 28·5° Baumé had ever been obtained from it. I have reason to believe, that before I left Southern California, I visited more of the bituminous outcrops of Santa Barbara and Los Angeles counties, than had ever before been visited by any single person who had written upon this subject; and I was unable to discover any trace of the existence of a natural outflow, yielding lighter material than the Pico Spring.

The specimen of oil from the Pico spring examined by me, was dipped from the pool by Mr. Lyon, under my own eye, May 7th, 1866. The months of May and June are the most favorable season that occurs in that climate, for gathering specimens of the liquid varieties of bitumen. This arises from the fact, that the rains of the winter and spring months, have so swollen the springs, that water which almost invariably accompanies the bitumen comes to the surface, in much greater quantity, and much more rapidly than at any other season; consequently the oil reaches the surface quicker, is less oxydized and thickened, and of less density.

These facts prove, that no petroleum exists upon the Simi ranch, and that no oil had been discovered in Southern California from any natural outcrop, prior to June 1st, 1866, of lower sp. gr. than ·8832=28·5° B.

But one conclusion can be deduced from these premises, viz: the oil examined by Messrs. Silliman, Warren and Maisch, must have been falsified by admixture of lighter oil, or the oil must have experienced an "organic change" during transmission from San Francisco to New York. The latter supposition is simply ridiculous, even if its incorrectness were not established by proof. I last summer brought a sample from San Francisco to New York, from both the Cañada Laga and Pico springs. Neither of them experienced the slightest change in density.

Having become convinced of the probable falsification of the samples analyzed by the above named gentlemen I was led to more closely compare their results with my own. A study of the details of their analyses elicited the following as the characteristics of this sample of petroleum.

Color, "dark brown." (S.)*
Consistence, "thin and mobile as water." (S.)
Odor "not offensive," (S.) resembling refined Pennsylvania petroleum.
Density, ·861, (S), ·863 (M.), ·864 (W.), average ·863=33·5° B.
Distillation,

"Condensable vapor appeared at 60° C." (S.)
"Boiled at 123° C." (S.)
" Yielded below the boiling point of mercury, 50–60 pr. ct." (S.)
" do. above do. 35–45." (S. and W.)

Sp. gr. of 1st 10 per cent of distillate, ·755. (S.)

		S.	W.	M.
Reserved as naphtha,				
	per cent,	20	6	7·8
	sp. gr.	·765	·753	·756
Reserved as burning oil,				
	per cent,	50	42	50
	sp. gr.	·837	·805	·8219
Reserved as lubricating oil,				
	per cent,	26	25	42·2
	sp. gr.	·896	·910	Residue less in retort.
Loss,	per cent,	4	7	0

The portion reserved as naphtha is of the same sp. gr. at which refiners of Pennsylvania petroleum usually commence to run off burning oil. (M.) If this oil were fractionated the same as is customary in treating Pennsylvania oils, it would furnish, according to—

	Silliman.	Warren.	Maisch.
	60 per cent.	52 per cent.	57·8 per cent.
Sp. gr.	·815=42° B.	·805=44° B.	·920=41° B.

or about 55 per cent of sp. gr., ·810=43° Baumé.

The burning oil before treatment has very little odor, and that not at all disagreeable. (S., W., M.) Crude oil yields very readily to treatment with sulphuric acid and soda lye, furnishing a refined oil of light color and agreeable odor (S., W., M.), the illuminating qualities of which are not excelled by any.

* Quotations marked "S." are from the report of Prof. Silliman; those marked "W." are from that of Mr. Warren; those marked "M." are from that of Mr. Maisch.

The lubricating oils are of very low specific gravity; of a reddish color in the crude state, and easily rectified. (S.)

The crude oil yields a very large percentage of distillate. The lightest oils are not very light (W., M.), and the odor of the crude distilled oils not more disagreeable than that of many samples of so-called commercial refined oil. (S.)

I recently obtained from the office of the Philadelphia and California Petroleum Company, a small portion of a sample of oil said to have come from the Pico Spring. This was supposed to be a portion of the sample examined by Messrs. Silliman, Warren and Maisch. I also obtained from the same place a small bottle of oil, labelled "crude oil," and bearing upon the seal the initials "B. S." This bottle of oil accompanied specimens of illuminating and lubricating oils received from Prof. Silliman. These two oils were identical in specific gravity and other physical properties. The sp. gr. of these samples is ·868, a difference of only ·005 from that examined by those gentlemen; a difference which may be accounted for, as the result of oxydation during two years.

From an examination of 200 cc. of this oil, I note the following additional characteristics.

With the thermometer bulb immersed in the boiling oil, the oil boiled at 124° C., and with Mr. Warren's condensing apparatus, yielded with the boiling oil at 200° C., ·174; at 220° C., ·250; at 227° C., ·276; with the bath at 200° C., 200 cc. yielded 77·5 cc., or 38·75 per cent of colorless distillate. The sp. gr. of this distillate is ·785=50° Baumé.

From my own examinations of California oils of undoubted authenticity, I gather the following characteristics.

Color.—The color of genuine oils is dark green, when fresh, with marked dichroism. Three samples which I gathered in May and June of last year, when opened in Boston about ten weeks afterwards, appeared of a dark brownish black, having nearly lost their dichroism.

Consistence.—I have seen no oils from natural outcrops that could properly be called "thin and mobile." They are of about the consistence of olive or linseed oil. The oils from tunnels when fresh, are lighter colored, and more mobile fluids.

Odor.—The odor of Southern California petroleums is peculiar; not as offensive as those of Pennsylvania and Canada; but at the same time unlike refined kerosene.

Density.—The density of the oil from the

Cañada Laga spring is, - - - -	·9184=23° B.
Tunnel in "Brea. Cañon," H. P. Co., -	·9023=25° B.
Pico spring, - - - - - -	·8832=28·5° B.
Lightest oil examined by myself from H. P. Co.,	·875=30° B.
Lightest oil said to have been procured from the extremity of a tunnel 95 ft. in length, H. P. Co.,	·8525=34·5 B.

Petroleum springs existed upon the property of the H. P. Co., prior to the commencement of their operations. I have been told that the oil yielded by them was very dense; lower than 25° Baumé. Upon the property known as the Stanford Oil Springs, tunnels are said to have yielded oil of sp. gr. 31° Baumé, and a tunnel upon the property of the Wylie Springs Oil Co., yielded in June last, oil of sp. gr. 23° Baumé. All of these tunnels have been run since July, 1865.

Distillation.—No condensable vapor appeared from any sample at 100° C.

Pico spring boiled at	174° C.
Cañada Laga,	182° "
H. P. Co., heavy,	182° "
Pico spring yielded below the boiling point of mercury,	26·5, per ct.
Total amount of distillate from the Cañada Laga,	93·75 "

Sp. gr. of first 10 per cent of distillate,

	Cañada Laga,	·852
	Pico spring,	·805
Tunnels,	H. P. Co., heavy,	·785
	H. P. Co., light,	·766

None was reserved as naphtha.

Reserved as burning oil sp. gr. ·810=43° Baumé, by ordinary fractional distillation—

Cañada Laga,	3·5 per cent.
Pico spring,	13·5 "
H. P. Co., heavy,	28·5 "
H. P. Co., light,	35·9 "

The absence of either very light, or very dense oils, is a marked peculiarity of the distillate of Southern California petroleums, when they are treated by direct heat in the ordinary process of fractional distillation. The lubricating oils range in sp. gr. from 25°–29° Baumé.

The odor of the crude distillate is pungent, resembling that of the crude distillate of Pennsylvania petroleum. It yields readily to treatment, and furnishes a refined oil of great transparency, very free from color and of agreeable odor. I have never seen any refined California petroleum of illuminating power equal to the best refined Pennsylvania oil.

The lubricating oils are of very low sp. gr., of a reddish color, and easily rectified.

Mr. Warren's condensing apparatus, with the bath at 200° C., gave from the

Cañada Laga,	18·5 pr. ct., sp. gr.	·810
Pico springs,	18.416 " "	·800
H. P. Co.,	26·08 " "	·800

A comparison of the characteristics of the sample of petroleum examined by Messrs. Silliman, Warren and Maisch, with those of the samples of Southern California petroleum, examined by myself, exhibits the following very marked and important differences.

Consistence differing, as water and olive oil.

The odor of one is strikingly similar to that of refined Pennsylvania petroleum; that of the others without resemblance thereto, and peculiar though not offensive.

The density of the one is ·020=5° Baumé, lighter than any oil that could possibly have been procured in that region prior to July, 1865.

The boiling point of the one is 50° C. below, and the sp. gr. of 1st 10 per cent of distillate from the same is ·050 below that of the other.

The absence of light oils, that could be classed as naphtha.

The per-centage yield of burning oil of the same grade is 41·5 per cent more in the one than in the other. The odor of the crude distillate of the one is agreeable, that of the other pungent. The illuminating oils of the one are of superior quality, those of the other are not above the average.

One yields of light oils, not condensed at a temperature of 200° C., 38·75 per cent, of sp. gr., ·785; the others yield only from 11·5 to 18·416 per cent, of a sp. gr. from ·800 to ·810.

These differences all point to the falsification of the oil examined by those gentlemen, by admixture of light oil. It is further proved by the fact, that the lightest oils obtained from the sample furnished them are identical in sp. gr. with the lightest contained in refined Pennsylvania petroleum; by the ease with which the burning oils are rectified, and by their superior illuminating qualities. Finally, their partial California origin is proved by the low sp. gr. of the lubricating oils; by their peculiar red color, and the absence of paraffine.

The following remarkable coincidences seem to indicate that the falsification consisted in the addition of an equal portion of refined Pennsylvania oil of sp. gr. 43° Baumé =·810, to crude oil from the Cañada Laga spring. I tested four different samples of illuminating oil purchased in San Buena Ventura by the Cal. Pet. Co. The sp. gr. of each of them was ·810; and I was told that the larger portion of the illuminating oil sold on the Pacific coast, is of that density. The sp. gr. of the Cañada Laga oil is ·918, which added to ·810 and the sum divided by two, equals ·864 as the average density; ·864 is the sp. gr. of the oil examined by Mr. Warren.

I obtained by ordinary distillation from the Cañada Laga oil 3·5 per cent of distillate, of sp. gr. 43° B.=·810. The results obtained by Mr. Warren were equivalent to about 55 per cent of the same grade. This slight increase is a natural result of the distillation of a mixture of light and heavy oils, and is also due to the superiority of the results given by Mr. Warren's process over those obtained by ordinary fractional distillation.

Prof. Silliman notices the fact that when 485 cc. were distilled from 1000 cc., the mercury suddenly arose from 320° to 370° C. This remarkable phenomenon clearly indicates that when nearly 500 cc. or 50 per cent had passed into vapor, 485 cc. of which had passed into the receiver, the more dense oils remaining in the retort required a higher degree of heat for their distillation. This phenomenon would no doubt be observed, during the distillation of a mixture of equal parts of refined Pennsylvania petroleum, and a dense oil like that of the Cañada Laga, yielding a distillate, 90 per cent of which distills at a temperature at or above the boiling point of mercury.

It will also be observed, that by Warren's process the Cañada Laga oil yields 11·5 per cent of sp. gr. ·810 or 43° B, and that by the same process the oil examined by him yielded about 55 per cent of the same grade, or 50 per cent plus 5 per cent. I obtained by the ordinary process 93·75 per cent of distillate, a very large amount, the loss being 6·25 per cent. Prof. Silliman obtained 96 per cent, or 50 per cent plus 46 per cent, the loss being 4 per cent, or a little more than half that which I experienced. However these are mere coincidences, striking though they may be.

The foregoing details have been gathered from the results of a large number of experiments, made both in California and in the Eastern states, for the purpose of ascertaining the commercial value of California bitumens. They are offered for the purpose of correcting, what I am confident is an error, and to assist in the dissemination of reliable information respecting California Petroleums.

Providence, R. I., March 6th, 1867.

ART. XXXIX.—*Contributions from the Sheffield Laboratory of Yale College.*—XIV. *On Kaolinite and Pholerite;* by S. W. JOHNSON and JOHN M. BLAKE.

THE study of certain minerals termed pholerite, nacrite, steinmark, and kaolin, leads to the conclusion that a number of substances which are included under these various designations must be classed together and constituted into a mineral species in virtue of possessing chemical and physical properties which admit of precise definition. This species must have a new or unappropriated name, and we propose for it that of Kaolinite, in allusion to the material which furnishes it most commonly and abundantly.

The chemical composition of this mineral was first deduced by Forchhammer from the analysis of a number of kaolins. It is represented by the formula $4\ddot{S}i\,3\overset{\dots}{\mathrm{Al}}\,6\dot{H}$, or by $2\ddot{S}i\,\overset{\dots}{\mathrm{Al}}\,2\dot{H}$. The *per cent* proportions vary considerably according to the atomic weights employed in the calculation. In the table that follows, p. 358, are given the percentages reckoned on the atomic weights adopted by Gmelin (Handbook, English ed.), by Rammelsberg (Handbuch d. Mineralchemie), and by Fresenius (Quantitative Analysis, 4th ed.).

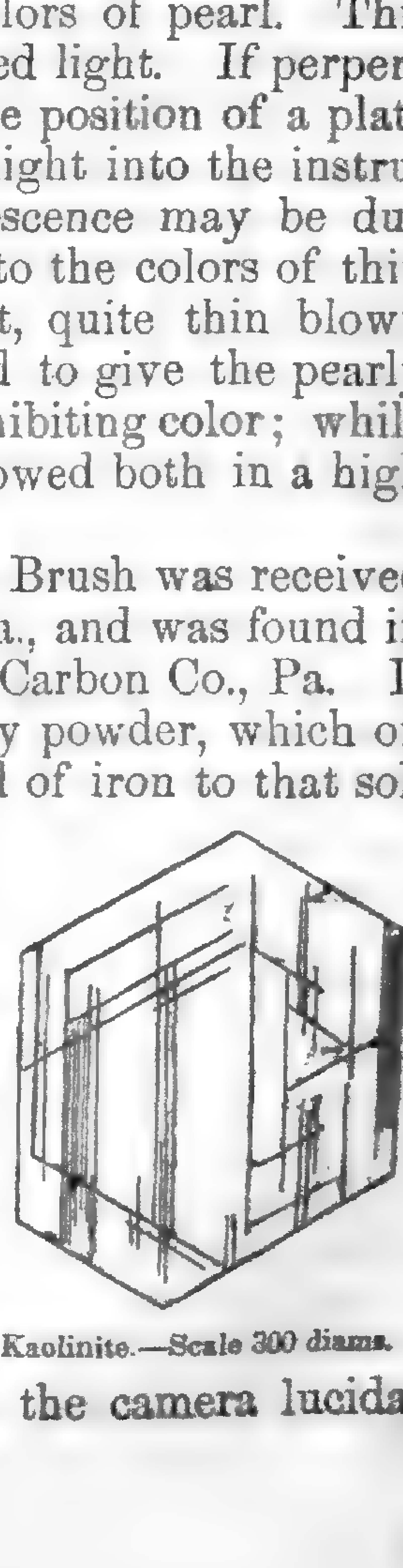
Of the substances which have come under our notice, having the above composition, the most striking is the so-called nacrite, from the Einigkeit mine at Brand, near Freiberg, Saxony. It is described by Breithaupt (Berg. u. Hüt. Zeit., No. 40, 1865) as occurring "in snow-white or yellowish six-sided tabular crystals in fan-shaped or reniform aggregates, and having pearly luster passing into adamantine. Sp. gr. 2·63." The analysis of this mineral made by Richard Müller appeared in Dana's 9th Supplement, and is quoted below.

DesCloizeaux, in the Supplement to his Manuel de Minéralogie, p. 549, remarks concerning this mineral as follows: "There has been recently discovered in Saxony a pholerite, at first called *nacrite*, which occurs in large macled hexagonal plates. These plates are composed of six triangular sectors, whose boundaries, though quite vague, nevertheless give indications of composition parallel to the faces of a right rhombic prism approximating the angles 120° and 60°. They cleave easily in the direction of the base of this prism; their interior structure is fibrous, and their surfaces are slightly undulated. Notwithstanding the plates are transparent when sufficiently thin, their action on a polarized beam of parallel rays is very irregular. In convergent light there are seen in each sector the hyperbolas which indicate two diverging optical axes whose plane is normal to the side situated upon the hexagonal contour and is consequently parallel to the principal diagonal of the base of the fundamental prism. The bisectrix is negative and evidently normal to the plane of cleavage. The dispersion of the axes is feeble: at 45° from the plane of polarization it is shown by the symmetrical distribution of the colors about the two hyperbolas, and the separation of the axes is greater for the red rays than for the violet," &c.

Our observations, made on a specimen in the cabinet of Professor Brush, are as follows. The crystals occur in hemispherical groups of about 4 mm. in diameter. These groups have a radiated structure, as is evident from their cleaving into quite thin wedge-shaped laminæ. The laminæ themselves appear to have a radiate structure at right angles to that indicated by the cleavage, for, when viewed by polarized light, dark shades of color branch out irregularly from near the center of the thin edge of the wedge, and these rotate with considerable uniformity as the plane of polarization is changed. When magnified, the surfaces of the laminæ are seen to be striated in three directions. These striæ intersect at angles of 60° and 120°. The microscopic structure under polarized light gives evidence that the ultimate plates of these groups are twin or compound crystals. In a section ground thin, parallel to the cleavage direction, crystals were seen superposed, the outline of one corresponding to the striæ of another, while, optically, they did not correspond. The portions of crystals thus distinguished by polarized light, were often elongated three or four diameters, and this elongation had the same relation to the plane of polarization as observed in the mineral from Summit Hill to be described presently. Sections of the groups often give an approximately hexagonal outline. The plates of this mineral are flexible, non-elastic, and have a soft, soapy feel.

The white pearly luster of the "nacrite" appears to be due to strata of air included between the separate crystalline plates composing a mass. It, as well as the crystals presently to be noticed from Summit Hill, exhibits the colors of pearl. This can be seen under the microscope by reflected light. If perpendicular illumination be not used, an oblique position of a plate on the slide is most favorable to reflect the light into the instrument and bring out the color. . This iridescence may be due either to the fine striæ upon the crystal or to the colors of thin plates of cleavage. As a comparative test, quite thin blown glass, when crushed into a mass, was found to give the pearly luster perfectly, without at the same time exhibiting color; while the thinnest glass in the same condition showed both in a high degree.

A second substance in possession of Prof. Brush was received from Prof. W. T. Rœpper, of Bethlehem, Pa., and was found in a cavity in a coal seam at Summit Hill, Carbon Co., Pa. It bore the label Pholerite. It is a brown scaly powder, which on digestion in hydrochloric acid gives up oxyd of iron to that solvent and becomes nearly white. It has a pearly luster and soapy feel. Magnified fifty diameters, the substance appears made up, for the most part, of well defined crystalline plates. The average size of the plates is ·003 of an inch, the largest are ·005 of an inch in breadth; they are in general extremely thin. They have, as nearly as the mode of measurement employed would show, the angles of perfect hexagons, 120° (see figure). The method used was to draw them upon paper under the camera lucida,



Kaolinite.—Scale 300 diams.

with the aid of a straight edge, to a scale of 650 diameters, and to measure the angles of the drawings with the hand goniometer. Many of these tables are elongated in a direction parallel to one of the sides of the hexagon, sometimes to two diameters. They are striated, and the principal striæ concur with this elongation.

Besides these extremely thin and isolated hexagonal plates, the substance contains prismatic aggregates of similar plates. These aggregates have all degrees of thickness, amounting in some instances to ·003 of an inch. Some of them are obviously homogeneous crystals, composed of closely parallel laminæ perfectly resembling in their aspect prisms of mica. When viewed laterally they are often quite transparent and have deep transverse striæ, which indicate perfect basal cleavage. In other cases the structure of these prisms is less compact and symmetrical; the plates being loosely combined and somewhat separated from each other on one side of the prism.

The longer tables, when seen in polarized light, cease to show a difference of shade on the field, or of tint with the use of selenite, when the plane of polarization of the analyzer is parallel with or at right angles to the axis of elongation. The same occurred with crystals on edge, when the plane of polarization was perpendicular or parallel to the cleavage plane.

The thicker plates, when not in the positions just mentioned, have very evident effect on the polarized beam. This indicates a considerable separation of the optical axes. Like the laminæ of "nacrite," the crystals of this substance exhibit, when properly illuminated, the colors of pearl. When ignited, the substance is seen to increase in bulk, and the microscope shows this to be the result of the exfoliation of the crystals due to the expulsion of their water of combination. This mineral differs from the so-called "nacrite" in not being macled. Some fragments from the exterior of the groups of nacrite crystals resemble this "pholerite" closely, showing evident hexagonal outlines and striæ with the angles 120° and 60°. We found the specific gravity of the purified mineral to be 2·59. An analysis made on 442 milligrams by fusion with carbonate of soda gave the following results:

Silica, - - - - -	45·93
Alumina, and trace of oxyd of iron, -	39·81
Water, - - - - -	14·02
	99·76

The substance described as pholerite by Dr. F. A. Genth (this Jour., [2], xxviii, 251) is of similar character and occurrence. It was found in coal mines at Tamaqua, Pa., in scales of a yellowish white color, which became white on treatment with dilute hydrochloric acid, and at Pottsville, Pa., in snow-white scales of a pearly luster. Dr. Genth remarks that under the microscope the scales appear to be clinorhombic. His analysis of this substance, after purification by hydrochloric acid, is given below.

The first mention of a crystalline substance with the composition of Forchhammer's kaolin that we have been able to find is by Wöhler, who describes, under the name steinmark, a pale yellow coherent mass which is converted by dilute hydrochloric acid, with solution of a little oxyd of iron, into a white shining powder. (Ann. d. Ch. u. Ph., lxxx, 122.) With help of a lens, Wöhler found it to consist of "shining laminæ, which, when magnified 200 diameters, were seen to be transparent and to consist in part of rhomboidal tables. Before treatment with dilute hydrochloric acid the mass had an earthy fracture which assumed luster by rubbing, an unctuous feel, and adhered strongly to the tongue. Sp. gr. 2·6." The locality was Schneckenstein, Saxony. The analysis by Prof. W. S. Clark, now of Amherst College, is given below.

In response to our application, Prof. Clark has kindly favored us with a fragment of this substance. We observed that it requires to be acted on with hot concentrated hydrochloric acid for some time before falling to a white powder. Microscopic examination of the substance thus purified confirmed our anticipation of its close physical resemblance to the minerals already noticed. It consists of plates and bundles of plates, the largest being ·001 of an inch or less in breadth, and when sufficiently magnified has a great similarity to the kaolinite from Summit Hill. The angles of the plates, as well as of the striæ which they exhibit, approximate 120°. Under a high power the striæ are seen to be formed by the edges of superposed and conformable plates; some loosely aggregated bundles resembled those to be noticed presently, as occurring in the kaolinite from near Richmond, Va. [See note on a subsequent page.]

In 1859, Knop analyzed a mineral of the same composition from Zeisigwald near Chemnitz, consisting of microscopic sharp rhombic plates. (Jahresbericht der Chem., 1859, p. 789.)

Stolba has also published an analysis (see below) of a substance occurring in the coal mines of Schlan, Bohemia, in the form of brilliant white scales, which is obviously kaolinite. (Jour. für prakt. Ch., xciv, 116.)

In his Manuel de Minéralogie, DesCloizeaux, in describing pholerite, remarks, p. 190: "a variety from Lodève, in somewhat contorted scales, exhibits under the polarizing microscope, indications of two quite divergent systems of axes, of which the negative bisectrix is almost normal to the plane of the laminæ; the interior structure otherwise appears highly irregular." This "variety" is the mineral analyzed by Pisani from the same locality (Comptes Rendus, liii, 1072, also Dana's 10th Supplement), and the words of DesCloizeaux, above quoted, appear to be the first recorded optical observations on kaolinite. Pisani's analysis is given in the subjoined table.

Kaolin is described by nearly all writers as an opake amorphous substance. Some have mentioned it to contain minute transparent plates, but have supposed them to be sheets of mica or other admixture. We have examined microscopically twenty specimens of kaolin, pipe- and fire-clay. Most of these are of unknown origin. In them all is found a greater or less proportion of transparent plates, and in the most of them these plates are abundant, evidently constituting the bulk of the substance. The kaolin from Diendorf (Bodenmais), Bavaria, is perhaps the most finely divided of all the white clays we have studied. When dusted dry upon a glass slide it appears to consist chiefly of masses of a white substance that are opake or nearly so in transmitted light, but, when fully illuminated above and below, have the translucent aspect of snow in the lump. Interspersed among these masses may be seen extremely minute transparent plates of irregular rounded outline. When brought into water the masses are almost entirely resolved into similar transparent plates, most of which are not more than ·0001 of an inch in breadth. This description applies to all the finer plastic clays. Even the dark-colored Stourbridge clay is made up in large part of transparent laminæ, as is a compact sedimentary brownish-gray pipe-clay from Table mountain, Tuolumne Co., Cal. The same is true of the blue fire-clay from Mt. Savage, Md., the white clays of Brandon, Vt., Perth Amboy, N. J., Reading, Pa., Chester Co., Pa., Long Island, and various other white and colored clays from unknown localities. On several specimens of kaolin, especially on one collected at one of the hematite mines at Beekmann, N. Y., we have observed pearly glistening surfaces on the interior of cavities. Viewed in reflected light, by the microscope, these surfaces were seen to be covered with minute scaly crystals, or crystalline aggregates, which, however, revealed no regular outlines.

A white, pulverulent substance, having much the appearance of powdered starch or wheat flour, found near Richmond, Va., was recently analyzed by Mr. Burton in the Sheffield Laboratory. Its composition agrees with Forchhammer's formula (see below), and under the microscope it is seen to be made up for the most part of transparent plates ·001 of an inch or less in breadth, and of prismoidal bundles, obviously composed of loosely aggregated plates, similar to those found in the kaolinite from Summit Hill. These bundles are usually curved, and their length is often several times greater than their breadth. The bundles are fan-shaped in some instances, and the plates are rarely parallel to each other. The edges of these bundles are frequently presented and in this position they have the greatest effect upon polarized light. They have least influence on the polarized beam when the plane of polarization is perpendicular or parallel to the plates in this position. The separate plates are of broken and irregular outline. Grains of quartz are intermingled.

In four other specimens of kaolin from unknown (probably European) localities, similar prismatic bundles were observed. The bundles were usually curved and irregular; in some instances their length was four or five times their breadth. One of these four kaolins contained hexagonal plates that could be made out with ease under a one-fourth inch objective. Two others, when rubbed between the fingers, assumed a distinct pearly luster; and after this treatment, by which the prismatic crystals were broken up, microscopic examination revealed abundance of hexagonal plates.

Prof. Brush has called our attention to a specimen of fluor from Zinnwald on which occurs a white powdery substance that passes for kaolin. It consists entirely of perfectly definite hexagonal tables averaging ·0005 of an inch in diameter, which are usually thin but sometimes are aggregated into short prisms.

The kaolin, pseudomorphous after prosopite, from Altenberg, Saxony, the analysis of which by Richter (Pogg., xc, 315) is given below, though compact in texture, is found by microscopic examination to be made up also of hexagonal plates and bundles of plates.

The plasticity of clay is a physical character, and appears to have a close connection with the fineness of the particles. The kaolinite of Summit Hill, consisting chiefly of crystal-plates averaging ·003 of an inch in diameter, is destitute of this quality. The nearly pure kaolinite from Richmond, Va., occurring mostly in bundles of much smaller dimensions, the largest being but ·001 of an inch in diameter, is scarcely plastic. The four kaolins of unknown origin which we have described as also consisting largely of prismoid crystals are scarcely plastic, though when rubbed between the fingers they become more soapy to the feel. So too the crystallized kaolinite accompanying fluor from Zinnwald is a scarcely coherent unplastic substance.

The more finely divided fire-clay from Long Island, is more "fat," while the Bodenmais porcelain earth and other clays, in which the bundles are absent and the plates are extremely small, are highly plastic. So, too, the Summit Hill crystals, when triturated in an agate mortar, yield a powder which, when breathed upon, acquires the argillaceous odor, under the microscope perfectly resembles the finer kaolins, and in the wet state is highly plastic and sticky.

Sommaruga has published analyses of two Passau kaolins, employed in the imperial porcelain manufacture at Vienna, one of which is "fat" and the other "short." The composition of the two is almost identical (see Chem. Centralblatt, 1865, p. 268), and the different degree of plasticity is thus evidently connected with their state of division.

It is possible also that the plasticity of a clay is related to the form of the plates of kaolinite, perhaps to their thickness, but this is a subject that requires further investigation. Our observations indicate that the impurer sedimentary clays are the most plastic. Some of these are perhaps not so fine as "shorter" kaolins. The plasticity may be, therefore, in part due to the impurities.

In the subjoined table are given the analyses of various crystallized kaolinites which have been previously referred to.

Analyses of crystallized Kaolinite.

	$\ddot{\text{Si}}$	$\bar{\dddot{\text{A}}}\text{l}$	$\dot{\text{H}}$	Other ingredients.
Kaolinite (Nacrite), Freiberg, Saxony, R. Müller,	47·74	39·48	14·07	....
" (*Pholerite*), Summit Hill, Pa., S. W. Johnson,	45·93	39·81	14·02	....
" ("), Tamaqua, Pa., F. A. Genth,	46·98	39·65	13·69	0·17
" (Kaolin), Richmond, Va., B. S. Burton,	48·56*	35·61	12·88	2·95
" (Steinmark), Schneckenstein, Saxony, W. S. Clark,	46·76	35·59	13·42	0·94
" (Kaolin), Zeisigwald, Sax., A. Knop,	49·91	35·23	14·86†	....
" ("), Altenberg, " R. Richter,	45·63	39·89	13·70	0·60
" (Pholerite), Lodève, France, Pisani,	47·00	39·40	14·40	....
" ("), Schlan, Bohemia, Stolba,	47·93	36·78	15·29	....
Calculation after Gmelin ($\ddot{\text{Si}}$=15, $\bar{\dddot{\text{A}}}\text{l}$=13·7) requires,	47·19	39·12	13·69	....
" " Rammelsberg ($\ddot{\text{Si}}$=14·8, $\bar{\dddot{\text{A}}}\text{l}$=13·68) requires,	47·05	39·21	13·74	....
" " Fresenius (Dumas) ($\ddot{\text{Si}}$=14, $\bar{\dddot{\text{A}}}\text{l}$=13·75) requires,	46·33	39·76	13·90	....

We find more than thirty analyses of clays, kaolins, and steinmarks, which obviously agree with the formula above given. Some of these analyses appear to have been made on the kaolin as it occurs in nature; others, however, were made on the washed kaolin as prepared for the porcelain manufacture; and in still other cases, as in Forchhammer's investigations, the clay was first exhausted with hydrochloric acid and the analysis was performed on the residue, allowance being made for quartz and substances insoluble in sulphuric acid.

It is obvious then that the basis of many kaolins and clays is a soft, white, transparent, infusible mineral, which crystallizes in forms probably belonging to the trimetric system, has a density of 2·6, when crystallized has usually a pearly luster, is insoluble in dilute hydrochloric acid, and in most of its forms is difficultly decomposed by hot concentrated hydrochloric acid, but is resolvable by hot oil of vitriol and dissolves completely in strong solutions of caustic alkalies. In chemical composition

* Including some quartz. † By difference.

it agrees with the formula deduced by Forchhammer from his analyses of porcelain clays, viz., $3\ddot{\bar{A}}l\,4\ddot{S}i\,6\dot{H}$.

This substance is not the nacrite of Vauquelin or Thomson, which contained at the most but one per cent of water. It is not the pholerite of Guillemin, as we shall presently see. The old terms kaolin, steinmark and lithomarge have been so loosely applied that they do not define it.

The massive yellow steinmark from Rochlitz has the composition of kaolinite, but with a portion of the alumina replaced by sesquioxyd of iron. Klaproth's analysis (Chemische Abhandlungen, vi, 287) is as follows:

Silica, - - -	45·25
Alumina, - - -	36·50
Sesquioxyd of iron, - -	2·75
Water, - - -	14·00
Potash, - - -	*trace.*
	98·50

Digested in hot concentrated hydrochloric acid it is scarcely acted upon, but retains its yellow color without falling to powder, as we have observed with a specimen in Professor Brush's cabinet.

The steinmark from Buchberg, analyzed by Zellner, that from Rumpelsberg examined by Rammelsberg (Ramm. Handbuch, p. 576), that from Saszka analyzed by v. Hauer (Jahresbericht der Chem., 1856, 860), and the *severite* of the latter (Ramm., Handbuch, p. 1012), are evidently impure indurated kaolinite.*

Brongniart and Malaguti have investigated a large number of kaolins, and some of the results of their analyses have led to the adoption of the formula $\ddot{\bar{A}}l\,\ddot{S}i\,2\dot{H}$ (or $2\ddot{\bar{A}}l\,3\ddot{S}i\,4\dot{H}$). But of the 31 analyses by B. and M. but four agree to the above formulæ within 1 per cent of silica, but six within 2 per cent, and but nine within 3 per cent. (See Dana's Min., 4th ed., vol. ii, pp. 249–50.)

Furthermore, the data from which this formula has been proposed, were not derived from the original analyses of the clay, but from these analyses "corrected" by deducting from the total silica (exclusive of quartz), the loss suffered by boiling the kao-

* Halloysite cannot be confounded with kaolinite although it is another hydrate of the same silicate of alumina that exists in the latter. Its formula is $4\ddot{S}i\,3\ddot{\bar{A}}l\,12\dot{H}$, or $2\ddot{S}i\,\ddot{\bar{A}}l\,4\dot{H}$. The specimens of this mineral from Guatequé analyzed by Boussingault, and those from Houscha and Anglar examined by Berthier, lost one-half their water (8–9 per cent) on drying at 212°, and thus acquired the formula of kaolinite. It cannot be assumed that this loss was due to hygroscopic water, for many substances when dried at 212°, or below that temperature, lose a part or all their crystal water. Thus selenite loses *about* three-fourths of its water at 212°. The quantity is not, however, definite. Halloysite is of much inferior density (sp. gr.=1) to kaolinite, is more easily decomposable by acids, and is without doubt a fairly characterized species.

lin for one and a half minutes with a five per cent solution of caustic potash, this loss being assumed to be accidental hydrated silica. This mode of correction is obviously of no value. On the one hand, the caustic potash might dissolve the kaolinite itself from the more finely divided specimens. Berthier and Rammelsberg have both observed the solution of kaolin in strong potash ley. On the other hand, treatment for so short a time would scarcely suffice to remove all the free silica from a kaolin that contains a large proportion of that substance, if our analytical experience enable us to judge. Again, the analyses appear to have been intended in the first place for technical purposes, and were made, not on specimens selected with reference to their purity, but on the clays in bulk employed in the porcelain manufacture. It is plain that they are not adapted to throw light on the chemical composition of the basis of kaolin. Least of all do they give evidence of the existence of the compound $\dddot{\bar{A}}l\,\ddot{\bar{S}}i\,2\dot{H}$ in the generality of clays.

We have been able to find but two analyses of kaolin made by Forchhammer's method that lead to this formula. On the other hand, eighteen of Malaguti's uncorrected analyses agree with Forchhammer's formula, and eight of them as closely as those of the crystallized varieties whose composition is given in our table above. It would be strange if, out of all the kaolins that have been studied some should not be nearly pure, except so far as containing fragments of quartz and other minerals insoluble in sulphuric acid. We find thirty kaolins agreeing with Forchhammer's formula and but two with Malaguti's.

The composition of the base of a material so heterogeneous as kaolin is likely to be, cannot in any case be deduced from analyses made on material not evidently pure, no matter how numerous they may be. But the fact that the composition of a substance whose purity cannot be ascertained by mechanical or optical means, agrees with that of another of like origin and occurrence seen to be homogeneous by the help of the microscope, is demonstration that the first is unmixed with foreign matters.

Pholerite.—That other crystallized hydrous silicates of alumina, infusible, insoluble in hydrochloric but decomposable by sulphuric acid, may exist in clays or may form the basis of clays is not at all improbable. In 1825 Guillemin first described, under the name pholerite, a pure white, pearly substance, occurring in the form of small convex scales, soft and friable to the touch, adherent to the tongue, and giving with water a plastic mass. (Ann. des Mines, xi, 489.)

In 1851 Prof. J. L. Smith published analyses of two minerals, one from Naxos, associated with emerylite, and another from Schemnitz, associated with diaspore, which he considered identical in composition with pholerite. (This Journal, [2], xi, 58.)

In 1859 Prof. A. Knop published an analysis of a substance found at Niederrabenstein near Chemnitz, the purest forms of which were white bolus-like masses, seen under the microscope to be aggregates of crystalline scales. This claystone (*felsittuff*) Knop referred to pholerite. (Jahrbuch für Min., 1859.)

The steinmark from Georgesstollen, examined by Dumenil, that from Schlackenwald (of radiate structure) analyzed by Rammelsberg, and the Tuesite of Scotland, analyzed by Thomson and by Richardson (Ramm. Handbuch, p. 576), approach Guillemin's mineral in composition, or lie between it and kaolinite.

In the subjoined table is given the composition of these minerals and the percentages required by Guillemin's formula, which is the one that has been deduced from Malaguti's analyses of kaolin, viz., $\ddot{\bar{A}}l\, \dddot{S}i\, 2\dot{H}$.

	$\dddot{S}i$	$\ddot{\bar{A}}l$	$\dot{H}$	Other substances.
Calculated, from Dumas' equivalents, -	39·30	44·98	15·71	
" by Guillemin,* - - -	40·75	43·89	15·36	
Pholerite, Fins, Guillemin, - - -	42·92	42·08	15·00	
" " " - - -	41·65	43·35	15·00	
" Naxos, J. L. Smith, - -	44·41	41·20	13·14	1·31
" Schemnitz, " - - -	42·45	42·81	12·92	
" Chemnitz, A. Knop, - -	39·34	45·90	14·76	
Steinmark, Georgstollen, Dumenil, - -	43·00	40·25	15·50	0·95
" Schlackenwald, Rammelsberg,	43·46	41·48	13·49	1·57
Tuesite, Scotland, Thompson, - - -	44·30	40·40	13·50	1·25
" " Richardson, - -	43·80	40·10	14·21	2·13

The correspondence between the calculation and the analytical results is not strikingly close. It is evident that most of the substances analyzed were not homogeneous, and future investigations must decide the yet open question, whether these pholerites are not really impure kaolinite.

It is to be desired that mineralogists having specimens of these pholerites in their possession, should take measures to decide this point by a study of their physical properties, and by instituting new analyses on material properly purified or shown by the microscope to be homogeneous.

New Haven, Conn., March, 1867.

* This calculation by Guillemin is erroneously given by several writers as a third analysis of pholerite from Rive-de-Gier. Guillemin mentions the occurrence of pholerite at Rive-de-Gier, but made no analysis of the substance from that locality.

ART. XL.—*Partzite—a new mineral;* by ALBERT ARENTS, Mining Engineer and Metallurgist.

THIS mineral was discovered early in the year 1865 in the Blind Spring mountains, situated in Mono county, California, and first denoted as a silver ore by Dr. A. F. W. Partz, for which reason I applied to it the above name.

It has hitherto never been found in crystals or of a crystalline structure, but always in amorphous masses generally without luster and rarely of a glistening appearance. Its fracture varies from conchoidal to even, and its color from yellowish-green to blackish-green and black—the lighter-colored portions containing the most silver. Oftentimes the mineral has considerable resemblance to the product obtained during the middle of the raking period in cupellation. The amount of silver it contains ranges between 4 and 12 per cent.

In the veins of the Blind Spring district the Partzite occurs in irregular deposits which are often nodular in shape, and occasionally occupy for a distance of many feet the whole width of the veins.

Its sp. gr. is 3·8; its H.=3–4. Before the blowpipe on platinum it is melted, but with difficulty, to a black slag; on charcoal, and especially by adding soda and pulverized charcoal, a metallic button is easily obtained which bears much resemblance to pure antimony. SO_3, ClH, and NO_5 decompose the mineral even in the cold, liberating oxyd of antimony and forming a copper-silver solution.

An analysis of the mineral shows the following composition:

		Relation of oxygen.		Relation of equivalents.		
SbO_3	= 47·65	7·47	7·47	$\frac{7·47}{24}$	= 0·311	= 1
CuO	= 32·11	6·47				
AgO	= 6·12	0·42				
PbO	= 2·01	0·14	=7·54	$\frac{7·54}{8}$	= 0·942	= 3
FeO	= 2·33	0·51				
HO	= 8·29	7·37	=7·37	$\frac{7·37}{8}$	= 0·921	= 3
	98·51					

From the above it will be seen that for 1 eq. of acid there are 3 eq. of bases and 3 eq. of water. We thus obtain the following formula: $(CuO, AgO, PbO, FeO)_3 SbO_3+3HO$.

Of arsenic but slight traces were detected which, however, in all probability were due to the presence of fine reticulations of a brilliant green color, by which the mineral is more or less interwoven.

The Partzite occurs together with argentiferous galena, in veins of a magnitude varying from nine inches to eight feet, and has already become the object of extensive mining operations.

ART. XLI.—*On Contributions to Paleontology, published by the Smithsonian Institution.**

AMONG the recent "Contributions to Knowledge" furnished to the scientific world by the Smithsonian Institution, is the series of publications on systematic Paleontology here enumerated. The importance of these articles demands an extended notice, and the principles followed in their preparation or compilation may be exposed with advantage to students.

Commencing with that which was earliest issued, and which is also the most important, we may congratulate naturalists on the appearance of the first part of Meek and Hayden's "Paleontology of the Upper Missouri." If fullness of detail, joined with conciseness of description and the elimination of characters that are not really pertinent to the group under consideration; if a rigorous comparison of such with related types; and if, finally, a careful revisal of the nomenclature and synonymy of all the groups and species discussed, entitle to a claim of excellence, then is the "Paleontology of the Upper Missouri" preëminently deserving of the fullest meed of praise. It will without question, in such respects, fall behind no work on Paleontology which has yet been published in this country, and is, indeed, the only one in which consistent attention has been paid to details. Mr. Meek, to whom the work is especially indebted for its systematic portion, has long stood among the first of American paleontologists, and these new labors fully sustain his title to this rank.

The part of this work issued carries us through the Silurian and Carboniferous ages, and for the subdivisions, the distribution of Professor Dana has been adopted. The faunas of the several *periods* are successively described, and of such the Potsdam, the Carboniferous and Permian, and the Jurassic are recognized. Subject to such subordination, the species are strictly arranged according to their zoölogical affinities, and under their respective branches, classes, orders, families and genera, and *their* subdivisions when such are recognized. Detailed descriptions are given of the families, subfamilies, and genera, and the genera of the former groups are also enumerated, and in all cases evidence is afforded of acquaintance with the most recent investigations. Not content with taking for granted the correctness of the accepted nomenclature, reference has been made to the history and

* 1. Paleontology of the Upper Missouri.—Invertebrates. By F. B. MEEK and F. V. HAYDEN, M.D. 4to. Washington, April, 1855. pp. 136, pl. 5.

2. Check List of the Invertebrate Fossils of North America.—Cretaceous and Jurassic. By F. B. MEEK. 8vo. Washington, April, 1864. pp. 40.

3. Check List id. of the Eocene and Oligocene. By T. A. CONRAD. 8vo. Washington, May, 1866. pp. 41.

4. Check List id. of the Miocene. By F. B. MEEK. 8vo. Washington, 1864. pp. 32.

original application of each name, and, in some cases, the nomenclature has been so modified that the first impulse of many paleontologists will be to dissent therefrom, but if the rules adopted—those recommended by both the British and American Associations for the Advancement of Science—are accepted, the correctness of such modifications must be admitted. In all cases, the typical species of the genera are enumerated immediately after the diagnoses of their respective genera. Would that such a plan had always been pursued by naturalists! None but the critical investigator of such questions can know how much uncertainty and how many disputes concerning points of nomenclature would have been thereby avoided, and he who, at this late day, and in face of the lessons of the past, still refuses to thus limit a newly established group, is deserving of reproach. If, for example, the simple precaution had been taken by the Messrs. Adams in the "Genera of Recent Mollusca," of specifying the types of their numerous new subdivisions, how much confusion would have been saved! As it is, we must be at a loss to know what types to apply their names to in many cases. Shall we take the first named species? It is only by accident of its position in an alphabetical arrangement that it is so placed, and it perhaps does not agree with the diagnosis, which often defines a very artificial group combining types dissimilar, and violently severed from their allies. Again, how are we to know what species are intended, when no synonymy is given and they are for the first time associated under new genera, by the specific parts of their names alone? As has been intimated, the applicability of the diagnosis is no criterion, and, in several cases, the species intended by the authors have been mistaken. It is a question whether we would not be justified in refusing recognition to names thus proposed, save as in courtesy.

Space will not permit notice of the numerous modifications, introduced in the limitation and allocation of the genera, and of the nomenclature. We may only recall that among Trilobites, several names proposed by Barrande and others, are replaced by prior ones of Corda; among the Brachiopods, several of Pander's and other names have been reëstablished, and the proper affinities of several genera, i. e., *Myalina* Koninck, *Aviculopecten* McCoy, and forms confounded with *Monotis*, have either been first demonstrated or confirmed by reference to their microscopical structure. Of new genera, may be enumerated *Chænomya** (Anatinidæ), *Grammatodon* (Arcidæ), *Camptonectes* Ag. (Pectinidæ), *Lioplacodes* (Viviparidæ) and *Macrophysa* (Lymnæidæ).

* It is suggested in a foot note that *Chænomya* might be identical with *Anthracomya* Salter, but that reference could not be had to the original description of that genus: the description of Salter's genus having since come to hand, proves, however, that the two are entirely distinct.

Of questions formerly doubtful and here apparently settled, that of the relations of the fossils, known under the names *Trigonellites* or *Aptychus,* is especially noticeable. These have been regarded as peculiar organisms, shells of Lamellibranchiates, remains of Fishes, the digestive apparatus of Gasteropods and Cephalopods, the valves of pedunculated Cirripeds, and supplementary appendages to the shell of Ammonites or their opercula, and all of these opinions have been more or less satisfactorily shown to be erroneous. Of late years, however, the belief in their pertinence to the Ammonitidæ had been gradually gaining ground. By our authors, it has been suggested that they represent the jaws of Ammonites. It is only surprising that this view had not been corroborated before, and especially after the jaws of *Nautilus* had been made known. Found often in intimate connection with Ammonitidæ and Goniatitidæ, what else could they be but the jaws? The examinations of *Nautilus* had demonstrated, that there was no such gizzard-like appendage, and no operculum, and in such respects had only confirmed what was *a priori* probable. Further it had been shown that *Nautilus* had jaws composed of an inner corneous, and external calcareous layer. The intimate relations of Nautilidæ with Goniatitidæ and Ammonitidæ being admitted, we might then expect to find analogous jaws in the latter, and it might be supposed that the search for such, would have soon culminated in the conclusion that *Trigonellites* represented them. The demonstration thereof could not, however, have been considered complete, till the discovery of the homologues of the upper as well as lower jaw of *Nautilus:* but both having now been found, and in opposition to each other, and in the aperture of the shell of *Scaphites Cheyennensis,* doubt will scarcely be entertained by any competent observer concerning their relations. Many paleontologists of late seem to have been prepared to assent to the opinion that *Aptychus* represented an operculum of *Ammonites,* and in figures it has been represented as fitting into and closing the apertures of Ammonitids with an admirable exactness,* but perhaps accuracy has, in such cases, been unintentionally somewhat

* The *Aptychus* has been represented with edges exactly applied to the walls of the chamber, but we are left to conjecture how it could be extended beyond the aperture of the adult which is much contracted by the inflection of the margin, as in *A. microstoma, A. Humphriesianus, A. Codomensis, A. Gervillii,* &c. In this dilemma, we would be obliged to assume that the "operculum" was variable in size, modified according to age, or present in some types and absent in otherwise very closely related ones—assumptions so bold that few, after due consideration, would be sufficiently brave to entertain the privilege of assuming that the duplication of the "*Aptychus*" was an adaptation to ensure its folding, for extrusion would even be denied to us, as the aperture is contracted from the distal as well as lateral margins.

sacrificed to effect. He who would adopt the theory that *Trigonellites* or *Aptychi* are the opercula of Ammonitidæ and Goniatitidæ, must first admit that the jaws of those animals have never been discovered, and in face of the fact, that almost countless species and innumerable specimens of many have been obtained, while the jaws of other Cephalopods, much less susceptible of preservation than those of living Tetrabranchiates, have been found: he must also necessarily assume that, notwithstanding the very close resemblance of the shells, the animals must have been fundamentally dissimilar, and finally, the anomaly is presented of a *double operculum increasing in opposite directions.* When, finally, it is remembered that the opposed portions of the Aptychoid, described by our authors, exhibit essentially the same relations as to size, &c., that the jaws of *Nautilus* do, and that, like those jaws, *Aptychus* has an internal corneous and external calcareous layer, more scarcely need be said. The difference of form, however, is very great.

Of necessity, some questions of affinity of species described are left undetermined on account of the condition of the fossils, and their solution must be deferred to the future. It is doubtless for this reason, and in order not to give a new name, that the *Valvata? scabrida*, whose affinities even with the family Valvatidæ are regarded as doubtful, is retained in that genus, and *Tropidina*, which it resembles in form, is for its accommodation subordinated to subgeneric rank under *Valvata.* Elsewise, the authors would have doubtless been influenced by the peculiar characteristics of the animal, especially its lingual dentition, and also of its shell, to elevate it to a generic rank, for in the family Viviparidæ, *Lioplacodes* is generically distinguished on slighter conchological differences than those apparent between *Valvata* and *Tropidina.* If we also demur to the retention of *Dentalium* under the Cyclobranchiata; to the extension of Pulmonifera to include the operculate Pulmonates; and to the elevated rank, which is retained for the Rostriferous Gasteropods, we record our chief grounds of difference, but would add in justice to the authors, that they have simply adopted the views regarding those groups generally prevalent.

It may be stated in conclusion that the part issued has 128 quarto pages of text (besides an index of seven pages) and five plates, and if it is added that sixty-six species are described and figured, some idea may be formed of the elaborate treatment to which they are subjected. The generalizations founded on the observations recorded may be expected to appear in the concluding part.

Reverting now to the "Check Lists" above enumerated, we have in them almost a complete catalogue of the invertebrate fossils occurring in the North American beds from the dawn of the Jurassic to the end of the Miocene Tertiary. The species found in the Jurassic and Cretaceous formations are arranged in a strictly zoological order under those respective heads,* the subordinate divisions of neither being recognized. The Tertiary, however, is subdivided into the Eocene, Oligocene, and Miocene, and the fossils of each epoch (except the Eocene) are arranged according to their structural affinities—or rather, we should say, as those have been interpreted. Of Jurassic species, 35 are enumerated; of Cretaceous, 885; of Eocene, 766; Oligocene, 105, and of Miocene, 775,—a total of 2566 species of extinct Invertebrates of the Secondary and Tertiary ages: to this number must be added previously undescribed species, whose geological or zoological relations were undeterminable, as well as numerous Cretaceous and Tertiary types since described. From this total are also excluded the species discovered in the Triassic beds. The compilation of such lists, unaccompanied even by references to the volumes in which the species are described, is a task of no slight magnitude, especially when all the species are subjected to a critical investigation respecting their affinities, and the care and conscientiousness with which that task has been done, and the knowledge and judgement which have been brought to bear upon it, will be obvious on the most superficial examination of the lists. That there are errors of judgement; that species may be found to have been enumerated several times and even under different genera; and that faults of other kinds may be hereafter detected,—is quite possible, but such failures are inseparable from compilations of this character, although made with the most rigorous care and by the best informed; one of the happy results of such lists is that these errors will sooner be detected and rectified, and that the recurrence of similar ones in the future will, in great measure, be prevented—surely a sufficient boon if none other were furnished! The imperfect condition in which many fossils are found, the inability to examine parts of the shell even which may furnish a good clue to their affinities, the necessity of trusting in the accuracy and interpretations of describers, who may be insufficiently educated, are all elements which must produce more or less error, and generations may elapse before they can be rectified. Under these circumstances, it may not be deemed singular, if views regarding some forms are suggested, differing from those expressed in the classifications of the lists noticed.

The species of the Jurassic, a formation chiefly developed in Dakota and Idaho, have been mostly described in the Paleontology of the Upper Missouri published since the list, and therein one new species—*Viviparus Gillii*—is added.

* This is the first attempt hitherto made, to group our Cretaceous and Jurassic Invertebrates, in accordance with their zoological affinities.

Of the more characteristic Cretaceous types, 111 species of Ammonitidæ, 40 of Inoceraminæ, 9 of *Venilia*, 8 of *Gryphæa*, 7 of *Neithea*, and 19 of *Rudista*, &c., are enumerated, and 13 new genera or subgenera are established for Cretaceous forms. Among observations on other types, is one especially deserving consideration from naturalists; "it is not probable that *any* of the species retained under the name *Fusus* in the foregoing list, belong to that genus" as properly restricted. Apparently few of the species indeed belong to the same family (Fasciolariidæ) with the true *Fusi* or *Coli*, some belonging rather to the Buccinidæ and others with the Cassidulidæ, &c. The mollusca possessing shells of a more or less subfusiform shape require a severe revision by one conversant with the anatomy of the including order; congeneric species have been widely separated from each other, while very diverse types have been combined under one genus, and from this defect the latest works have been by no means free.

The Eocene strata are grouped by Mr. Conrad under three sections—the "Lower and Medial Eocene (Shark River and Claiborne Groups)," the "Shell Bluff Group," represented by the upper part of the Claiborne Bluff, and on the Savannah river, and the "Upper Eocene, or Jackson Group," which derives its names from its development at Jackson, Miss., and which is also represented in the Carolinas, &c. By far the largest number of species is found in the Lower and Medial Eocene, and only five species have been obtained in the Shell Bluff Group: the three groups are believed to hold "few if any species in common." Of the so-called Oligocene species, all—105 in number—are found at Vicksburg, Miss.

Mr. Conrad has treated his subject with his accustomed ability, but occasionally we are led to wonder why certain combinations have been made,—under the Sycotypidæ, for example, the genus *Perissolax* is included, and the combinations of species under genera at least require explanation, before they can be understood. An ordinary observer would be able to discover no generic difference between the so-called *Ficopsis mammillatus* and the typical *Pyrulæ*.* After an examination of almost all the living species of the latter, the conclusion has been forced on us that the species in question is more nearly related to the *P. ficus* than several of the species that no one has pretended to at all isolate; yet it is not only generically separated by Mr. Conrad but united with species having, apparently, no close relation with it. The number of such inconsistencies, however, is not larger than might be expected in so long a list, and detracts little from

* The name *Pyrula* (Lam. 1799 type *Bulla ficus* L.) is provisionally adopted rather than *Sycotypus* or *Ficus*: *Sycotypus*, in the first place, is not congeneric with *Pyrula*, but was based on *Busycon canaliculatum* or *pyrum*, and Browne's names, not being binomial, can scarcely be adopted. *Ficus* is objectionable, as the name had previously been used in botany.

the merit of the work: there are indeed few who have exhibited in their labors such sagacity in the forming of the smaller groups, among Mollusca, and the appreciation of their affinities, as Mr. Conrad.

The Miocene, commencing along our eastern border at Maryland, extends southward to South Carolina, and on the western border, it is developed in California and Oregon, while in Dakota, fresh-water deposits have been referred to that period; it is not, however, by any means certain that these several deposits are synchronous.* In the east, the southern extension of the strata has been referred to the Pliocene, but it is traceable into the northern portion as a continuous formation throughout its extent. For the enumeration of the species of this formation we are indebted to Mr. Meek, but he has in most cases adopted the views of Mr. Conrad. Among the groups that require revision, as to their systematic relations, are the families "Buccinidæ" [=Nassidæ] and Muricidæ [=Muricidæ, Buccinidæ, &c]. In the Nassidæ, some incongruous forms are associated under *Tritia*, especially *T. altilis* and *Bulliopsis*; the latter group has congeners in the Vienna Basin, &c., which have been referred to the genus *Melanopsis*. But the consideration of such questions would transcend the limits of a review. Before closing, we would, however, refer to some praiseworthy features exhibited in the publications under notice.

One rarely seen in paleontological publications, and yet extremely desirable, is the indication by the authors of the supposed affinities of all the genera introduced by them into the system. This contrasts most favorably with the negligence in such respects by many paleontologists, who describe supposed new genera as if they were isolated organisms to which nothing in the earth, or the waters under the earth, or the heavens above, was like. Such descriptions, moreover, are loaded with characters partly family, ordinal, or even classical, and partly specific combinations, which evidently indicate that the authors had no clear idea of the relations of the forms introduced; nevertheless it were to be desired that knowledge and precision in this respect could be exacted. Akin to this is the custom, when hints are offered as to affinities, of comparing to, or considering the new forms as "connecting links" between representatives of widely different groups. Without referring to any known example our meaning may be illustrated by supposing a naturalist, in making known a new type of Litorinidæ, referring to *affinities* (not anal-

* It may be here remarked, that the fossils occurring in Oregon, and first referred to the Miocene by Mr. Conrad, are now considered by him to be of Eocene age, and enumerated in his list; they are also enumerated by Mr. Meek in his list of the Miocene species, and finally, Dr. Carpenter has identified almost all the species with living forms. It is more certain that Dr. Carpenter is wrong in almost all his identifications than that Mr. Conrad was not right in the first instance.

ogies) to the genera *Trochus*, *Bulimus* and *Phasianella:* such extreme cases are not rare in Paleontological literature, and, to say the least, are suggestive of a confusion of ideas which necessarily renders our confidence in the describers very limited. Let us hope that such errors will be more generally avoided hereafter, and that, with such bases as we have in the publications under review, worthy superstructures may be erected, and that the good examples set therein may be followed by at least our own countrymen. T. G.

ART. XLII.—*On the genus Elasmognathus;* by THEODORE GILL.

SINCE my communication on the new Tapiroid to which I have given the name *Elasmognathus Bairdii*, I have been enabled to examine skulls of four more specimens of the species, all essentially agreeing, but offering differences which perhaps indicate sexual variation. The more the skull is examined, the more does the great difference from the other *Tapiridæ* impress the observer; it resembles that of the Asiatic Tapir (*Rhinochœrus Malayanus*) rather than those of the American species (*Tapirus terrestris*, *T. pinchaque*), especially in the abbreviation of the cranial box, and apparently in the form of the maxillary bones behind, as well as of the nasal bones. The abbreviation of the cranial box is a very important peculiarity of the new type and contrasts strongly with the larger one (not only relatively but actually) of *Tapirus;* this abbreviation would seem to entail some of the differential characters, such as the lamellar form of the maxillary bones behind, &c., as the proportions in other respects are nearly similar. Among the genera of Ungulates, there are indeed no two nearly related genera which exhibit differential characters more strongly marked, or of greater value, than *Elasmognathus* and *Tapirus.* In the extent and form of the cranial box, the form and relations of the maxillary bones, the form of the nasal bones, and the *complete* osseous development of the nasal septum, those genera are widely different; and as those differences must be the coëfficients of peculiarities in the face and proboscis and of consequent modification of habits, and as they are supported by numerous minor differences, consistency in our systematic arrangements seems to require that the generic distinction of *Elasmognathus* should be recognized. Among the normal mammals, none except *Rhinoceros tichorhinus* has a nasal septum so completely ossified as *Elasmognathus.*

ART. XLIII.—*On the action of water upon "Carbohydrates" at an elevated temperature;* by O. LOEW.

IT is well known that the carbohydrates are not decomposed with separation of carbon, at a temperature of 170° C. Cane-sugar yields at 160° levulosan and glucose, at 180° caramelan, at 200° caramel, assamar and caramelin, and at about 250° it yields with total decomposition aldehyd, aceton, acetic acid, furfurol and carbon. But the decomposition takes place quite differently if water is present. While dried sugar yields only levulosan and glucose at 160°, it is perfectly decomposed on heating with water in sealed tubes at the same temperature.

This decomposition is accompanied with the formation of carbonic acid and separation of carbon. Very nearly half of the carbon contained in the sugar employed is thus separated. If the black mass contained in the tube, which has a strong acid reaction, is distilled with water and the distillate saturated with carbonate of lead, and evaporated, a salt is obtained giving all the characteristic reactions of formic acid. I obtained the following results on analysis:

0·5800 grm. gave 0·593 sulphate of lead, 0·728 grm. gave 0·210CO_2 and 0·046 water.

	Calculated.	Found.	
Pb	69·69	69·84	=Formiate of lead.
C	8·08	7·87	
H	0·66	0·69	

There is also formed in this reaction a small quantity of humic acid.

The specific action of the water in this decomposition seems to be that of an acid; for if sugar be heated with *alcohol* at the *same* temperature, in sealed tubes, it remains perfectly unchanged; not the smallest quantity of carbon is separated. Further I have found that sugar is not decomposed by heating it with a solution of baryta in heated tubes at 170° C. Beautiful needles of sugar-baryta only are formed.

Water has the same action upon other "carbohydrates." Starch, gum, or milk-sugar heated with water to 170° for about five hours, gives formic acid, carbon and carbonic acid; gum yields the most carbonic acid. There is also formed a peculiar acid, but little soluble in water, though easily in alcohol and ether. I propose to make this acid the object of further study.

ART. XLIV.—*Exploration of Kent's Cavern, Devonshire: Report of the Committee of the British Association, consisting of* Sir CHARLES LYELL, Bart., Professor PHILLIPS, Sir JOHN LUBBOCK, Bart., Mr. JOHN EVANS, Mr. EDWARD VIVIAN, and Mr. WILLIAM PENGELLY (Reporter).*

THE celebrated Kent's Cavern, or Kent's Hole, is about a mile due east from Torquay harbor. It is situated in a small, wooded, limestone hill on the western side of a valley which, about half a mile to the south, terminates on the northern shore of Torbay.

The hills which surround the district consist of limestone, greenstone, clay-slate, and a reddish grit or compact sandstone. The two last are traversed by veins of quartz; and, with the possible exception of the greenstone, they all belong to the Devonian system. Indeed the entire Torquay peninsula is exclusively made up of rocks of this age.

According to tradition, there were formerly four or five entrances to the cavern, of which two only were generally known, the others being merely narrow apertures or slits through which, until they were blocked up from within, the initiated were wont to enter clandestinely. The remaining two are about fifty feet apart, and occur in the face of one and the same low natural cliff, running nearly north and south, on the southeastern side of the hill. The northern entrance is in form a rude triangle, about six feet high and eight feet wide at the base. The southern is a natural and tolerably symmetrical arch, 9½ feet wide at the base, and six feet high. Its form is due partly to a gentle curvature of the strata—the apex of the opening being in the anticlinal axis—and partly to the actual removal, by natural causes, of portions of the limestone beds; the base of the opening, or chord of the arc, consists of undisturbed limestone; so that the entrance may be aptly compared to the mouth of an oven.

From the time of the researches and discoveries which, forty years ago, rendered the cavern famous, to the commencement of the exploration under the auspices of this Association, the southern entrance has been blocked up, the northern alone being used by visitors. The base of the latter is about 189 feet above the level of mean tide,† whilst that of the former is about four feet lower.

The cavern has been known from time immemorial. Even tradition fails to reach back to the date of its discovery. It did

* From the Report of the British Association for 1865.

† A "bench mark" of the Ordnance Survey in the road from Torquay to Ilsham farm, and which is at no great distance from the cavern, is, as Col. Sir H. James kindly informs me, 131·629 feet above the level of mean tide at Liverpool. By pocket aneroid, the base of the northern entrance of the cavern is 57·5 feet above this mark.—W. P.

not, however, attract the attention of scientific inquirers until September, 1824, when Mr. Northmore visited it with the double object, as he stated, "of discovering organic remains, and of ascertaining the existence of a temple of Mithras," and he declared himself "happy to say that he was successful in both objects." He was speedily followed by Mr. W. C. Trevilyan, who, according to the Rev. Mr. M'Enery, "was the first that obtained any results of value to science." Mr. M'Enery, whose name must be forever associated with the cavern, first visited it in the summer of 1825. He was at that time quite inexperienced in cavern researches; for he states that the party which had been induced to accompany was a large one, and that on entering the cavern he "was the last of the train, for he could not divest himself of certain undefinable sensations, it being his first visit to a scene of this nature." The visit was a memorable one; for, separating himself from his companions, and devoting himself to what he conjectured to be a favorable spot, he found several teeth and bones. He thus describes his feelings on the occasion:—"They were the first fossil teeth I had ever seen, and as I laid my hand on these relics of extinct races, and witnesses of an order of things which passed away with them, I shrank back involuntarily; though not insensible to the excitement attending new discoveries, I am not ashamed to own, that in the presence of these remains I felt more of awe than joy." He at once communicated his discovery to Dr. Buckland, and with great energy followed up his "good fortune" for several years. So far as can be ascertained from his memoranda, the date of his latest visit was August 14th, 1829.

Though he at one time intended to publish a narrative of his labors and discoveries, and had made arrangements for the requisite illustrations, the intention was unfortunately abandoned. After his decease, it was feared that his manuscripts had been destroyed or lost; but after experiencing a variety of fortune they passed into the hands of Mr. Vivian of Torquay, who from them compiled a Memoir which was published in 1859.*

In 1840, Mr. Godwin-Austen read a paper before the Geological Society of London, on the "Bone Caves of Devonshire," when he described the results of his investigations in Kent's Hole.

In 1846, the Torquay Natural History Society appointed a committee to conduct an exploration of a small portion of the cavern. Though their object was mainly to obtain specimens for the Society's Museum, very careful attention was given to the positions and associations of all the articles found. A paper embodying the results of this investigation was drawn up

* Cavern Researches. Simpkin, Marshall and Co., 1859.

by Mr. Vivian, a member of the committee, and read in 1847 before the Geological Society of London. A mention of this communication appeared in the 3d volume of the Quarterly Journal of the Society.

Though it may be doubted, perhaps, whether any of the foregoing explorations were conducted with that rigid observance of method which is now held to be necessary, all the explorers are unanimous in stating that they found flint "implements" mixed up with the remains of extinct animals.

In 1858, the results of the systematic and careful exploration of Brixham Cavern, on the opposite shore of Torbay, induced the scientific world to suspect that the alleged discoveries which, from time to time during a quarter of a century, had been reported from Kent's Hole, might, after all, be entitled to a place amongst the verities of science; and from that time various proposals for further investigations have been made. As is well known, these suggestions took a definite form at the last Meeting of this Association, when a liberal grant of money was made, and a committee was appointed for the purpose of further exploration. It is the object of this communication to state what up to this time the results have been, so far as they are at present determined.

The committee have great pleasure in stating that, in reply to their application for permission to make the proposed investigation, the proprietor, Sir L. Palk, Bart., M.P., assured them most promptly that it would "give him great pleasure to place every facility in their hands." He placed the cavern in their exclusive custody, and suggested the most satisfactory arrangement for the ultimate disposal of such objects of interest as might be found.

Though large portions of the deposits were broken up by Mr. M'Enery and his successors, there is still within the cavern a very considerable amount of virgin ground. The committee, however, were desirous of selecting an area in which not only were the deposits certainly intact, but which would not present any very great difficulties in working. After a visit of inspection it was decided to undertake the exploration of the large chamber into which the southern entrance immediately opens. The mode of investigation was laid down, trustworthy and intelligent workmen were engaged (Mr. Charles Keeping, brother of the well-known fossil collector, being the chief), and the work, consigned to the superintendence of the two resident members of the committee, Mr. Vivian and the Honorary Secretary, was commenced on March 28th of the present year.

Immediately outside the cave lay a considerable talus of earth and stones, the upper portion of which, at least, is believed to have been thrown out by Mr. M'Enery, who conducted his researches through the northern opening. It was necessary to cut through this mass, in order to reach and make available the entrance which the committee had selected for their operations. This material was very carefully examined, partly for the purpose of detecting any objects of interest which it might contain, and partly as an initiatory exercise for the workmen.

The cavern is in no part subject to any considerable amount of drip; and no portion of it is drier than the chamber selected for exploration. Since the commencement of the work unusually heavy rains have fallen in the district, but water has entered through the roof at very few points only, and in no instance in such an amount as to produce discomfort or inconvenience.

The following is the succession of deposits, in descending order, which the chamber contained.

1st. Huge blocks of limestone which had manifestly fallen from the roof. Many of them required blasting to effect their removal; and in several instances it was necessary to blast even the masses into which they were by this means divided. One of the blocks measured 11 feet long, 5½ broad, and 2½ thick; hence it contained upward of 100 cubic feet, and must have weighed fully seven tons. In some cases two or three of them lay one on another, and, in a few instances, were firmly cemented together by a separate cake of stalagmite between each pair; whilst others lay unconformably with considerable interspaces. Occasionally, what appeared to be a boss or dome of stalagmite proved to be a block, or two or three small blocks, of limestone invested on all sides with a stalagmitic sheet. Certain masses, lying at some distance from a drop, were without even a trace of stalagmite.

2d. Beneath these limestone blocks there was a layer of mould of an almost black color. It varied from a few inches to upward of a foot in depth.

3d. Underneath the black soil came a cake of stalagmitic breccia, made up of comparatively small fragments of limestone so very firmly cemented together with carbonate of lime as occasionally to require blasting. It was rarely less, but not unfrequently much more, than a foot thick. Everywhere it was firmly attached to the walls, and it occasionally extended completely across the chamber. Not unfrequently, however, the center of the chamber was altogether destitute of this breccia, in some instances, because there is no drip near the area, in others, because it was intercepted by an overlying limestone block.

4th. The breccia is succeeded by the ordinary reddish cave-loam, which contains a large number of limestone fragments, varying in dimensions from bits not larger than sixpences, to masses but little smaller than those which lay on the surface. They lie at all angles without anything like symmetrical arrangement. In fact the entire deposit is without any approach to stratification. Many of the stones are partially encrusted with calcareous matter, and not unfrequently loam, stones, and splinters of bones are cemented by the same substance into a very tough breccia. The presence of a calcareous drip is more or less traceable everywhere. Hitherto the cave-earth has been excavated to the depth of four feet only. How far it extends below this, or what may be beneath it, is at present unknown. Where it is not covered with the stalagmitic breccia, the black soil lies immediately on it; but the line of junction is everywhere sharply defined. In no instance do the two commingle.

Since the large masses of limestone occur at all levels in the cave-earth as well as everywhere above it, it is obvious that whatever may be the cause to which their fall is attributable, they cannot be referred to any one and the same period. They fell from time to time throughout the accumulation of the cave-earth, they continued to fall whilst the stalagmitic breccia was in process of formation, as well as during the introduction of the black mould, and they are amongst the most recent phenomena which the cavern presents. And even of those which lie on the surface, there is conclusive evidence that in some cases a considerable interval of time must have elapsed between the fall of two blocks lying one on the other—an interval sufficiently great for the formation of the cake of stalagmite between them, and which is sometimes fully six inches thick. There can be little doubt that some of them fell very recently, even when measured by human standards.

It is by no means easy to determine the cause which threw them down. To call in the aid of convulsion seems undesirable, since it would be necessary to do so very frequently. Moreover, it may be doubted whether anything short of a violent earthquake would be equal to the effect. Though the roof of the chamber is of very great span and entirely unsupported, and though it presents appearances which are not calculated to inspire confidence, the violent concussions produced by the frequent blastings already mentioned, blastings which not unfrequently throw masses of limestone, weighing upward of a ton, to a distance of several feet, have never brought down even a splinter.

The fall of the blocks has sometimes been attributed to changes of dimensions in the roof arising from changes of temperature; but the fact that the cavern temperature is all but constant throughout the year, seems fatal to this hypothesis.

The masses lying on the surface were a sufficient guarantee that the deposits beneath them remained intact. There can be no doubt that they are at once a proof and the cause of the undisturbed character of the soil they cover. A portion of the cavern so easily accessible as is this chamber, would not have been spared by Mr. M'Enery, but on account of some great difficulty or discouragement; and in fact he states that the fallen masses completely foiled him in his attempts to make explorations in it, excepting in one branch some distance south of the area selected by the committee. Their own characters, moreover, render it absolutely certain that the deposits have never been violated.

The following is the method of exploration which has been observed from the commencement, and which it is believed affords a simple and correct method of determining the exact position of every object which has been found.

1st. The black soil accessible between the masses of limestone on the surface was carefully examined and removed.

2d. The limestone blocks occupying the surface of the deposits were blasted and otherwise broken up, and taken out of the cavern.

3d. A line, termed the "datum line," is stretched horizontally from a fixed point at the entrance to another at the back of the chamber.

4th. Lines, one foot apart, are drawn at right angles to the datum line, and therefore parallel to one another, across the chamber so as to divide the surface of the deposit into belts termed "parallels."

5th. In each parallel the black mould which the limestone masses had covered is first examined and removed, and then the stalagmitic breccia, so as to lay bare the surface of the cave-earth.

6th. Horizontal lines, a foot apart, are then drawn from side to side across the vertical face of the section so as to divide the parallel into four layers or "levels," each a foot deep.

Finally, each level is divided into lengths, called "yards," each three feet long, and measured right and left from the datum line as an axis of abscissæ.

In fine, the cave-earth is excavated in vertical slices or parallels four feet high, one foot thick, and as long as the chamber is broad where this breadth does not exceed 30 feet. Each parallel is taken out in levels one foot high, and each level in horizontal prisms three feet long and a foot square in the section, so that each contains three cubic feet of material.

This material, after being carefully examined *in situ* by candlelight, is taken to the doorway and reëxamined by daylight, after which it is at once removed without the cavern. A box is appropriated to each yard exclusively, and in it are placed all the objects of interest which the prism yields. The boxes, each having a label containing the data necessary for defining the situation of its contents, are daily sent to the Honorary Secretary of the committee, by whom the specimens are at once cleaned and packed in fresh boxes. The labels are numbered and packed with the specimens to which they respectively belong, and a record of the day's work is entered in a diary.

The same method is followed in the examination of the black mould, and also of the stalagmitic breccia, with the single exception that in these cases the parallels are not divided into levels and yards.

With very rare exceptions the cavern has been visited daily by one, and frequently by both of the superintendents; and monthly reports of progress have been regularly forwarded to Sir Charles Lyell, the chairman of the committee.

Though it would be premature to attempt anything like an exhaustive list, it may be of interest to furnish a brief and general account of the objects which have been found.

Of the articles met with in the black mould, those occurring *between* the fallen masses of limestone have been kept distinct from such as have been detected *beneath* them. Such a division, however, is not rendered necessary by the characters of the objects themselves, and will not be attended to on the present occasion. In this category also may be placed the greater number of the specimens found in the talus outside the cavern. The collection is of a various miscellaneous nature. It consists of stones of various kinds, human industrial remains, charred wood, bones of various animals, marine and land shells, and the broken shells of hazel-nuts. It passes from the rabbit's nest lined with clean dry fur and containing a couple of fresh green ivy-leaves, and numberless fragments of wine and porter bottles flung away by parties who have visited the cavern mainly from a love of frolic, back to the age of bronze implements and of flint-flakes, and probably represents from fifteen hundred to two thousand years.

The stones are in most cases well rounded, and, at least, some of them are of marine origin, since they are distinctly lithodomized. They consist of limestone, quartz, red grit, greenstone, and flint; all except the last derivable from the rocks of the immediate district, and were probably obtained from the neighboring beaches, where also the flints were perhaps found; for though there is no flint *in situ* within five miles, it is a well-known fact that such pebbles are met with on existing beaches at much greater distances from any known accumulation of flints in place. The rounded stones are extremely numerous in the black mould, and were undoubtedly selected and taken to the cavern; but for what purpose it may not be easy to determine. There are also several pieces of hard greenish-grey grit of an elongated form, which were perhaps used as whetstones. Angular pieces of slate are also numerous. They are probably fragments of articles fashioned by man, as occasionally a piece is met with which is obviously a portion of a curvilineal plate. Such plates are mentioned by Mr. M'Enery, who supposes them to have been used as covers for earthenware vessels. The human industrial remains consist of articles in bronze and in bone, pottery, spindle-whorls, and flint-flakes. The bronze articles are a fibula, the bowl and part of the stem of a spoon, a spear head, a fragment of a socketed celt, two or three rings, one coil of a helical spring, a pin about $3\frac{3}{4}$ inches long, and an object resembling a horseshoe in form, but not more than an inch long. In this connection may be mentioned a lump of metal which, from its general appearance, would be termed copper ore, but from its interior, a small portion of which has been exposed accidentally, it is probably native copper, or a mass of metal which has been smelted. A similar mass mentioned by Mr. M'Enery, is said to have been analyzed "by Mr. Phillips and found to be pure virgin ore." Much of the pottery, excepting one small piece, undoubtedly Samian, is extremely coarse, and in most cases it is unglazed. A large number of fragments have been found, but nothing approaching a perfect vessel. They are generally ornamented, and from the different patterns, as well as from other facts, it may be concluded that they represent a considerable number of utensils. One piece probably formed part of a vessel in which things were burnt, as on its inner surface there is a firm admixture of clay and small bits of charcoal. Much of the pottery is without doubt of Roman age.

The objects fashioned in bone are a comb, which in size and outline resembles a common shoe-lifter having teeth cut in the broad end; a spoon, neatly formed of a portion of a rib, and measuring about 6 inches long and $\frac{9}{10}$ths of an inch broad; a chisel about $2\frac{6}{10}$ths inches in length, and at its broad end $\frac{4}{10}$ths of an inch in width; a wedge, somewhat rudely fashioned out of a horn or antler; two small fragments which appear to be portions of combs, and one of which bears traces of ornamentation; and an article about 3 inches long, apparently the handle of some tool.

The spindle-whorls are formed of different materials, such as Devonian red grit, one of the harder varieties of Triassic sandstone (rocks abundant in the neighborhood), a somewhat coarse, greenish, schistose rock not found near the district, and Kimmeridge coal. They differ somewhat in dimensions and in workmanship; some being well finished, whilst others are so roughly made as to render it safer perhaps to call them simply "holed stones." With them may be mentioned a large bead, which appears to consist of amber or some analogous substance; and a small, holed, ellipsoidal fragment of limestone, which was perforated probably by some lithodomous mollusk.

The flint-flakes are four in number, two of dark and two of light or white flint, the latter being the best formed. The light color is more or less superficial, the center being of a dark gray.

The charred wood is very abundant. Some specimens are undistinguishable from prepared charcoal, whilst others are obviously nothing more than partially burnt sticks, some of them of considerable size.

Bones are extremely numerous. They are more or less discolored, and have lost a considerable portion of their weight.

It may be doubted whether the entire elements of any skeleton have been found lying together. Amongst them there are the relics of pig, deer, sheep, fox, wolf (?), bat, hare, rabbit, with smaller rodents, birds, and various kinds of fish. Some of them appear to have been exposed to the action of fire.

The land shells are principally various kinds of snail, the larger forms being the most prevalent. They occur in all stages of growth, and thus render it probable that they had established a colony in the cavern. Amongst the marine shells are the limpet, whelk, oyster, cockle, mussel, pecten, solen or razor-shell, and the internal shell of the cuttle-fish, *Sepia officinalis.* From the unrubbed condition of the last, it was probably not found cast ashore on the beach, but taken directly from the cephalopod to which it belonged.

The source of the shells of hazel-nuts is not far to seek. They were no doubt obtained from the wood in which the cavern is situated, and were perhaps carried in by small animals whose homes were under the fallen masses of limestone where the shells were found. Most of them are perforated at one end.

In passing below the black mould we first encounter the stalagmitic breccia. This the workmen carefully break into small fragments, in order to detect any articles of interest imbedded in it. The search, though not very productive, has not been quite fruitless. In the breccia have been found charred wood, marine and land shells, and bones of various animals, some of which perhaps are extinct.

Immediately beneath this cake we enter the red cave-loam, and at once find ourselves amongst the relics of several species of extinct animals. The only differences in the four successive levels in which, as already stated, the red loam is taken out are simply that the first or uppermost is the poorest, and the third, perhaps, the richest in osseous remains; and that the three lower levels contain a large amount of minutely comminuted bone, of which there are very few instances in the uppermost foot. In other respects the levels are the same—everywhere the same in the materials which form the staple of the deposit; in the occurrence of pebbles of various kinds of rock, which differ from those in the overlying black mould only in being less numerous; in the presence of bones in the same condition and representing the same species of animals; and in yielding "flint implements" of the same types. It will not be necessary, therefore, to describe each level separately or in detail.

The bones found below the stalagmite are heavier than those met with above it. This distinction is so well marked and so constant as to be characteristic. It would be easy to assign them to their respective deposits by their specific weights alone. Most of those from the red loam are but little discolored, indeed some of them are of chalk-like whiteness. A few, however, occur here and there which have undergone a considerable amount of discoloration, a consequence, probably, and also a proof of a greater degree of exposure before their inhumation. On most of the latter, certain lines and patches of lighter color not unfrequently present themselves, which may be likened to such as are sometimes left by mosses or lichens on objects of which they have grown.

A large number of bones, including jaws, teeth, and horns, are scored with teeth-marks, clearly the work of animals of different kinds. Some of the long bones are split longitudinally. Many appear to have been rolled, including most of those which have been gnawed; and in the case of the latter, it is tolerably obvious that the rolling was subsequent to the gnawing. Some of those found beneath the large masses of fallen limestone are in a crushed condition, and thus apparently attest the fact that the deposit on which they lay, and on which the blocks fell, was of compact nature, and capable of firm resistance.

The minutely comminuted bone already spoken of, is commonly found converted with loam and stones into a firm breccia. Not unfrequently, however, it occupies the hollow cavities of some of the larger bones. With it there sometimes occurs a cream-colored substance, which in a few instances has been met also in the form of small detached lumps having a low specific gravity. This, as well as some of the comminuted bone, has been supposed to be of fæcal origin.

In cleaning the bones it is frequently found to be impossible to remove entirely the earthy matter from them. They are at least partially invested with a thin film, which defies the brush and water. On drying, however, this matter commonly scales off, and proves to be a paste or paint composed of loam and carbonate of lime, the latter probably derived from drip from the roof.

Large portions of the osseous remains occur in the forms of fragments and mere splinters. The identifiable parts are chiefly teeth, which are extremely numerous. Amongst the Mammals represented, there are certainly the Cave-bear, Cave-lion, Cave-hyæna, Fox, Horse (probably more than one species), Ox, several species of Deer, the tichorhine Rhinoceros, and Mammoth. Remains of the Hyæna are probably the most abundant, after which come those of Rhinoceros and Horse. The relics of the Mammoths (both molars and tusks) are those of very young individuals.

It has already been hinted that "flint implements" occur everywhere in the cave-earth mixed up with the remains of extinct Mammals. Several of them were found in the presence of, and some of them by, the superintendents. Like the bones, they are at least abundant in the uppermost foot, and occur in greatest numbers in the lowest zones. Altogether, and without reckoning doubtful specimens and numerous chips, nearly thirty "implements" have been dug out. Though the designation of "flint" is given to all, some of them are perhaps of chert. Of the flints properly so called, some are of a dark, and others of a light-grey color, whilst a third kind are almost white, and have a porcellanous aspect. With the exception of three, they are all of the kinds known as flakes—flat on one side, and more or less carinated on the other. Some of them are fragments only, others were found broken in the deposit with the parts lying in contact, whilst others again are perfect. Some of the broken specimens of the white variety show that they are not of this color throughout their entire mass, but have a dark central axis or core. The flakes agree in character with those in the black overlying mould. The excepted three are of chert, and are worked on both sides. They were found in the second, third, and fourth levels; one in each. That from the second foot is about 4¾ inches long, and, where widest, 2½ broad. At one end it tapers to a point, and narrows to no more than ¾ of an inch at the other. In outline it is rudely a segment of a curvilineal figure, and is slightly falciform. The inner or concave margin is the cutting edge. Unfortunately the tip of the pointed end was broken off after exhumation. Those from the third and fourth levels are more highly wrought "implements." They are worked to an edge around the entire perimeter. In outline they are rather ovoid than elliptical, being narrower at one end than at the other. That from the third foot measures 4½ inches in length, and its greatest breadth and thickness are respectively 3¼ inches and ¾ of an inch. That found in the fourth zone, the lowest yet reached, is the most elaborately finished "implement" of the series. It is lighter in color and somewhat smaller than the preceding two, its dimensions being 3½ inches long, 2½ broad, and ¾ in thickness.

Without intending at present to enter on the consideration of all the bearings of the entire evidence produced, the committee feel at liberty to express their conviction that it is totally impossible to doubt either the human origin of the "implements," or their inosculation, in undisturbed soil, with the remains of the Mammoth, the Cave-bear, and their extinct contemporaries.

Nor are these the only indications of human existence found in the cave-earth. Several small pieces of burnt bone have been met with in the red loam, some of them loose and detached, others of small size and incorporated in the breccia composed of loam, stones, and comminuted bone.

Mention has been made already of the occurrence in the cave-earth of rounded stones not derivable from the limestone hill in which the cavern is situated. It seems probable that at least some of them were selected and taken there by man; though it may not be easy, perhaps, to determine in all cases for what purpose. But, waiving this point, there are two stones which must not be hastily dismissed. The first of them is $4\frac{3}{4}$ inches long, and something less than one inch square in the section. It is a mass of hard purplish-grey grit, and is undoubtedly a whetstone, or rather a portion of one. It was found in the first level of the cave-earth, in a small recess or cavity in the northern wall of the chamber, immediately beneath a projecting stratum of limestone *in situ*. In this cavity the stone stood with its longest axis vertical. The superintendents were inclined to the opinion that it had slipped through a hole into the cavity at a comparatively recent date; and they diligently set to work to find the means of its ingress. Here, however, they were completely foiled. There was no hole or passage, vertical or lateral, by which the cavity could have been entered. Not only, as has been said, was there a thick stratum of limestone *in situ* immediately over the recess, but over this again, as well as over the red loam, there was a thick compact mass of stalagmitic breccia, consisting of large and small pieces of limestone firmly cemented, and having a height of fully eight feet; the whole of which was removed before the cavity was disclosed or its existence suspected.

The second stone is a rude flattened spheroid, formed from a pebble of coarse, hard, red sandstone, and apparently used for breaking or crushing. Its diameters measure $2\frac{3}{4}$ and $1\frac{3}{4}$ inches. It was found in the second level of the red cave-earth, over which lay an enormous block of limestone, but no stalagmite.

In addition to the pleasure which always attends scientific discovery, the committee have had the gratification of confirming most of the statements of their predecessors. Any differences observable between the statements now made and those of the earlier investigators arise from defective, not conflicting evidence. For example, the committee have not yet been so fortunate as to find the remains of *Machairodus latidens*, mentioned and figured by Mr. M'Enery,* nor of *Hippotamus major*, alluded to by Prof. Owen† as occurring in the cavern; nor have they found anything in the least degree calculated to bring the statements alluded to into discredit. Again, so far as their researches have gone, the committee have not, like Mr. Godwin-Austen, found the bones of man mixed up, in undisturbed soil, with those of extinct animals;‡ it will be seen, however, that there is no *à priori* improbability in the statement of the distinguished geologist just mentioned; and the committee would remind such as may be disposed to attach importance to the fact that men's bones are not forthcoming as readily as their implements, that in the black mould, as well as in the red loam of the cavern, the only indication of man's existence are remnants of his handiwork. Pottery, implements and ornaments in bone, metal, and stone, the remnants of his fires, and the relics of his feasts are numerous, and betoken the lapse of at least two milleniums; but here, as well as in the older deposits below, the committee have met with no vestige of his osseous system.

In conclusion, the committee would observe that the value of their labors is not to be measured by the discoveries, or rather the rediscoveries, which they have made. They have not only disinterred a valuable body of fact, but with it a confirmation of the concurrent statements of M'Enery, Godwin-Austen, and the committee of the Torquay Natural History Society; and have thereby more than doubled the amount of trustworthy evidence which they have themselves produced.

Art. XLV.—*Additional Notice of the Cohahuila Meteoric Iron;* by Charles Upham Shepard.

Prof. F. Shepherd having put me in communication with Maj. E. M. Hamilton, in reference to the locality of Bonanza, New Mexico, I have derived from this persevering explorer several interesting particulars concerning these extraordinary masses that appear worthy of publicity.

Major Hamilton states that Bonanza is about thirty or forty miles north of Santa Rosa, but much farther to the west. Residents of the vicinity told him, it had only once before been visited by any traveller, and this was fifteen years ago, when an Englishman had been deputed thither in an official capacity, to determine whether the iron could be applied to any useful pur-

* Cavern Researches, p. 32, and plate F. (8vo edition).
† British Fossil Mammals and Birds, p. 410 (1846).
‡ Trans. Geol. Soc., Second Series, vol. vi; part 2, pp. 444 & 446.

pose. He reported it as having no value, for the reason that it would cost more to divide the masses, sufficiently to fit them for transportation, than the metal was worth.

Major Hamilton saw thirteen pieces, twelve of which had never been removed, and one small mass of about seventy-five pounds, that had been carried to the village of Santa Rosa. The area within which the twelve masses lie, is between one and two miles in diameter.

The largest mass projects two, or two and a half feet above the ground, and is some three feet long, and a little less in width. How far it is buried in the earth is unknown. Their surfaces are all smooth, without offering any projecting points. They are quite black and entirely free from rust. In shape, they are more or less spherical, and much resemble the time-worn boulders in the beds of rivers. Some of the smaller of them, are estimated to weigh between two and three thousand pounds.

Major Hamilton thinks it might be possible to cut off pieces of a few pounds weight, provided suitable tools for the purpose could be procured, though the operation would be attended with much difficulty.

The smaller masses might be transported across the Rio Grand into the United States, at an expense of fifteen hundred dollars each. The Mexican authorities would have no objections to their removal as they attach no value whatever to them.

Analysis.—The fragment analyzed by me, weighed 6·04 grm., and had a specific gravity of 7·825.

Its solution in hydrochloric acid, gave no indication of the presence of sulphur. The Rhabdite crystals, which in microscopic needle-points were quite abundant in the cold solution, gradually disappeared on the addition of nitric acid, leaving only a very minute quantity of a white granular powder, supposed to be silicate of magnesia. It amounted to only 0·001 per cent. The composition of the mass was,

Iron, - - - - - - - - -	97·900
Nickel, with traces of chromuim, cobalt, magnesium and phosphorus,	2·100

The phosphorus, as determined upon seven gram. of the peroxyd of iron precipitate, was less than eight parts in 10·000. No search was made for tin or copper.

As I have not yet been able to procure a polished slice of the iron, I can add nothing concerning the Widman figures. If they exist, they will be extremely fine, and probably resemble those of the Braunau iron.

Amherst, March 20, 1867.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the conversion of dynamical into electrical force without the aid of permanent magnetism.*—The magneto-electric machine of Mr. Wilde has been briefly described in a former notice. A modification of this apparatus which possesses much theoretic interest has been contrived by the brothers W. and C. W. Siemens, and at about the same time and independently by Wheatstone. In these machines the steel magnets of the generating or primary magneto-electric machine are replaced by electro-magnets. The electro-magnets are first charged by a galvanic battery or other rheomotor, the armature is then caused to rotate, and the battery is removed, when the magnetic action continues to accumulate without its aid. Instead of employing a battery the soft iron of the electro-magnet may be touched by a permanent magnet. In practice this is not necessary, as the residual magnetism of the iron is sufficient. In Wheatstone's apparatus the wires covering the electro-magnets and those surrounding the armature are connected, so that the current, which is made to move in one direction, acts upon the electro-magnet in such a manner as to increase its existing polarity. The force required to turn the armature then becomes vastly increased, as well as the intensity of induced current. In this case also the residual magnetism of the iron is the primary cause of the current which then goes on increasing up to a maximum, at the expense of course of a certain amount of work expended in producing rotation. When a cross wire is placed so as to divert a portion of the current from the electro-magnet a remarkable increase in the heating and magnetizing power of the current is observed. Wheatstone accounts for this increase by supposing that the current passing through the armature branch and cross wire experiences a much less resistance than if it had passed through the armature and electro-magnet branches, and though the electro-motive force is less, the resistance having been rendered less in a greater ratio, the resultant effect is greater. In conclusion Wheatstone points out the analogy between the augmentation of the power of a weak magnet by means of an inductive action produced by itself, and the accumulation of power shown in the electrical machines of Holtz and others, in which a very small quantity of electricity is made by a series of inductive actions to equal or exceed the effects of the most powerful machines of the ordinary construction. —*Proc. of the Royal Society*, xv, 367, 369. W. G.

2. *New applications of methods of reduction in organic chemistry.*—Berthelot has studied the action of iodhydric acid upon a variety of organic compounds, and has greatly extended our knowledge of the transformations produced by this valuable reagent, the introduction of which, it will be remembered, is due to himself. The experiments were conducted by introducing the organic matter to be operated on into a tube with a very concentrated solution of iodhydric acid, sealing the tube and heating to a temperature of 275° C. In this manner the iodid, bromid, and chlorid of ethylene yield hydruret of ethylene, haloid acid, and free iodine, the reaction in the case of the iodid being represented by the equation

$$C_4H_4I_2+2HI=C_4H_6+2I_2,$$

and in the case of the bromid of ethylene by the equation

$$C_4H_4Br_2+4HI=C_4H_6+2HBr+4I_2.$$

In like manner di-iodhydrate of acetylene, $C_4H_2(2HI)$, and iodid of ethyl, C_4H_5I, yield hydruret of ethylene and free iodine. Iodid of allyl yields hydruret of propylene, according to the equation

$$C_6H_5I+3HI=C_6H_8+2I_2.$$

Iodhydric acid acts even upon perchlorinated compounds; thus sesquichlorid of carbon, C_4Cl_6, reacts with it according to the equation

$$C_4Cl_6+12HI=C_4H_6+6HCl+6I_2.$$

All the hydrocarbons capable of uniting directly with iodhydric acid, as for instance all the ethylenes and acetenes, $C_{2n}H_{2n}$ and $C_{2n}H_{2n-2}$, first unite with iodhydric acid, and afterward by the action of an excess of the acid upon the new compound formed, yield a new hydrocarbon and free iodine.

Alcohols treated in the same manner yield first the iodids of the radicals and these then react with iodhydric acid in the manner explained above. Thus the first action of iodhydric acid upon common alcohol may be represented by the equation

$$C_4H_6O_2+4HI=C_4H_6+H_2O_2+2I_2,$$

iodid of ethyl being an intermediate product. In like manner glycerine yields hydruret of propylene.

Ethers derived from the oxacids are first decomposed with formation of an iodid of the radical and regeneration of the oxacid; the iodid and oxacid are then separately acted on by the excess of free iodhydric acid. Thus methyl-formic ether and iodhydric acid react according to the equation

$$C_2H_2(C_2H_2O_4)+2HI=C_2O_2+C_2H_4+H_2O_2+I_2.$$

Common aldehyd yields hydruret of ethylene mixed with hydrogen and probably with some marsh-gas. Acetone gives hydruret of propylene according to the equation

$$C_6H_6O_2+4HI=C_6H_8+H_2O_2+2I_2,$$

but the hydruret of propylene undergoes a partial decomposition, probably according to the equation

$$C_6H_8+H_2=C_4H_6+C_2H_4.$$

Organic acids treated with iodhydric acid are reduced to formenes containing the same quantity of carbon as the acid, provided that these are sufficiently stable to resist a temperature of 275° C. Thus acetic acid reacts according to the equation

$$C_4H_4O_4+6HI=C_4H_6+2H_2O_2+3I_2.$$

Succinic acid, like butyric acid, yields hydruret of butylene;

$$C_8H_6O_8+12HI=C_8H_{10}+4H_2O_2+6I_2.$$

The author remarks that the facts mentioned above furnish a general method of reproducing the fundamental hydrocarbon of each series by means of all the bodies in the series. Thus hydruret of ethylene, $C_4H_4(H_2)$, yields by replacement $C_4H_4(Cl_2)$, $C_4H_4(HI)$, $C_4H_4(H_2O_2)$, $C_4H_4(O_4)$, and $C_4H_2(O_4)(O_4)$, in each the substitution being by equal volumes. All these compounds, by the reducing action of iodhydric acid, reproduce the original hydrocarbon, C_4H_6.—*Bull. de la Société Chimique*, Janvier, 1867, p. 53. W. G.

3. *On the monatomic nitriles.*—The monatomic nitriles may be regarded as primary monamines, the three atoms of hydrogen in ammonia being replaced by one atom of a triatomic radical. L. Henry has shown that this view is supported by several new and interesting facts. Thus acetonitrile, $(\mathrm{C}_2H_3)'''N$, readily unites with dry bromhydric and iodhydric acids with production of intense heat. The resulting salts are solid crystalline white bodies, soluble in alcohol but insoluble in ether. They are rapidly decomposed by water or moist air, forming acetic acid and salts of ammonia. Benzonitrile gives analogous compounds. Sulphocyanic acid and sulphocyanid of ethyl may also be referred to the type of ammonia, like the corresponding cyanic acid and cyanid of ethyl. The sulphocyanids of ethyl and allyl combine readily with dry bromhydric and iodhydric acids, giving white crystalline bodies decomposed by water.—*Bull. de la Soc. Chim.*, Janvier, 1867, p. 85. W. G.

4. *On graphitoid boron.*—Wöhler has obtained the so-called graphitoid boron, discovered by Deville and himself, in sufficient quantity for analysis, and has found that the substance in question is not boron but a compound of boron and aluminum. The compound is always formed in preparing crystallized boron or by fusing aluminum in the vapor of chlorid of boron. The borid crystallizes in very thin pale copper-colored six-sided tables which, according to Prof. W. H. Miller, are monoclinic. It does not burn in the air but burns in chlorine with brilliancy, forming chlorid of aluminum and chlorid of boron. Two analyses led to the formula AlB_2.—*Ann. der Chemie und Pharm.*, cxli, 268. W. G.

5. *On the constitution of mellitic acid.*—Bæyer and Scheibler have found that mellitic acid is six-basic and has the constitution of benzol, in which six atoms of hydrogen are replaced by six of carbonyl, $\mathrm{C}\Theta_2H$, so that its formula is $\mathrm{C}_6(\mathrm{C}\Theta_2H)_6$. When heated with lime it is completely decomposed into carbonic acid and benzol. With sodium amalgam mellitic acid takes up six atoms of hydrogen and forms the six-basic acid, $\mathrm{C}_6H_6(\mathrm{C}\Theta_2H)_6$, which, when heated with sulphuric acid, yields a four-basic acid, $\mathrm{C}_6H_2(\mathrm{C}\Theta_2H)_4$. This can take up four atoms of hydrogen to form a new acid, which, when treated with sulphuric acid, again loses carbonic acid. The final product of these transformations is benzoic acid. The authors beg chemists who may possess a stock of mellite to supply them with material for their investigation.—*Ann. der Chemie und Pharm.*, cxli, 271. W. G.

6. *On the cyanic ethers.*—Gal has studied the action of chlorhydric and bromhydric acids upon cyanic ether. The dry ether absorbs chlorhydric acid gas, and by distillation a liquid is obtained which has a penetrating smell, fumes slightly in the air, and boils between 108° and 112° C. The author gives to this body the formula $C_4H_5O.C_2NO.HCl$, which may be referred to the type of chlorid of ammonium, and written

$N\left\{\begin{matrix}\overset{\shortparallel}{C_2}O_2\\ C_4H_5\\ H\end{matrix}\right\}Cl.$ Water decomposes this substance, forming chlorid of ethylammonium and carbonic acid, the reaction being expressed by the equation

$$C_4H_5O.C_2NO.HCl+2HO=C_4H_7N, HCl+2CO_2.$$

Bromhydric acid yields a similar compound boiling at 118°–122° C. Heated in sealed tubes at 100° both compounds yield cyanuric ether and free hydracid. The cyanic ether obtained by Cloëz by acting upon ethylate of sodium with chlorid of cyanogen, and which is a neutral liquid insoluble in water and not volatile, exhibits an entirely different behavior toward the hydracids. Chlorhydric acid converts it into cyanuric acid and chlorid of ethyl, the reaction being represented by the equation

$$3(C_2NO.C_4H_5O)+3HCl=C_6N_3O_3.3HO+3C_4H_5Cl.$$

Bromhydric acid acts in a similar manner. Gal is of opinion that the compound of Cloëz is the true cyanate of ethyl, $\left.\begin{matrix}C_4H_5\\C_2N\end{matrix}\right\}O_2$, while the cyanic ether of Wurtz is an ammonia, $N\left\{\begin{matrix}C_2O_2\\C_4H_5\end{matrix}\right.$. The author promises a further investigation of the subject. The connection of his results with those of L. Henry, mentioned above, will be obvious at a glance.—*Bull. de la Soc. Chim.*, Dec. 1866, p. 435. W. G.

7. *On the action of alcohols upon terchlorid of phosphorus.*—When absolute alcohol is poured drop by drop into an equivalent quantity of terchlorid of phosphorus a powerful reaction ensues, the principal product of which is a body having the formula $P(\text{Є}_2H_5\text{Ө})Cl_2$, or oxethylchlorid of phosphorus. This is a liquid boiling at 117° C., heavier than water, and decomposed by this into alcohol and phosphorous acid. Butylic and amylic alcohols give analogous bodies.—*Bull. de la Soc. Chim.*, Dec. 1866, p. 481. W. G.

8. *On the polymers of acetylene.*—Berthelot has studied the products of the action of heat upon acetylene, and has arrived at results of great interest and importance. When acetylene is heated to a temperature approaching that at which glass melts, it is gradually converted into a series of polymeric bodies, among which are benzol, styrol, reten, and fluorescing hydrocarbons. In one experiment Berthelot prepared pure acetylene by the direct combination of pure hydrogen and pure carbon, and then obtained from this acetylene benzol, which was thus formed by actual synthesis from its elements. The relation between the two substances is readily seen since $3C_4H_2=C_{12}H_6$; benzol is therefore triacetylene. Berthelot believes that a volatile hydrocarbon occurring among the products of the action of heat upon acetylene is diacetylene, $2C_4H_2=C_8H_4$. Styrol or tetracetylene, $4C_4H_2=C_{16}H_8$, forming about one-fifth of the entire product was easily recognized. Naphthalin forms another product, and probably is a product of the decomposition of pentacetylene, $C_{20}H_8=5C_4H_2-H_2$. The highest product yet examined is retene, which Berthelot regards as enneacetylene, $C_{36}H_{18}=9C_4H_2$.—*Ann. der Chem. und Pharm.*, cxli, 173. W. G.

9. *New method for the preparation of oxygen.*—When cuprous chlorid $\text{Є}u_2Cl_2$ is exposed to the air, it absorbs oxygen and is converted into cuprous oxy-dichlorid $\text{Є}u_2\text{Ө}Cl_2$. If this latter compound be heated to

about 400° C., it is decomposed into oxygen and cuprous chlorid, as before.

Upon this reaction Mallet founds a method for the commercial preparation of oxygen. The cuprous salt, mixed with sand or clay to prevent fusion, is placed in a retort, which can be rotated horizontally. It is readily oxydized by a current of air, passed over it for three or four hours. The heat necessary for the decomposition is no higher than that required for the preparation of oxygen from potassic chlorate. With this arrangement the loss of material is inappreciable. Each kilogram of cuprous chlorid yields 28 to 30 liters of oxygen.

A very simple modification of this method permits the preparation of chlorine gas with equal facility. If after oxydation chlorhydric acid gas be conducted over the cuprous oxy-dichlorid, the latter becomes cupric chlorid, €uCl_2. At a red heat, this salt decomposes into cuprous chlorid and chlorine.—*L'Institut*, 1867, p. 61.

10. *Apparatus for detecting differences of density in transparent media.*—Dr. A. Töpler has given a new method of observing certain important phenomena which escape attention by direct vision more or less completely. His pamphlet, "Beobachtungen nach einer neuen optischen Methode, Bonn, 1864," is not at hand; but from a very complete synopsis (with quarto plate) in Ergänzungsblätter zür Kenntniss der Gegenwart, Hildburghausen, 1866, i, 88, and from his article on the application of this method to microscopic observations, in Pogg. Ann., 1866, cxxvii, 556–580, we give the following:

s

A L M B T

f

Let A be a radiant; a good lamp surrounded with a brass cylinder. The latter has a circular opening, in front of which is placed a small vertical metallic screen with holes near its edge for the transmission of the light from A. This pencil of light falls upon a system of lenses, L, of at least two and a half to four feet focal length and of large diameter. The lenses, L, in the usual tube, together with the lamp, A, and screen, are supported on the same table; the screen can be moved in the axis of the lens, L, to change the divergence of the pencil. At a distance of from ten to twenty-five feet, L will give the image B of A. Here a small astronomical telescope, T, is so placed in the common axis that this image falls just on the front face of the objective; at this point is placed a metallic screen, *s*, having a straight, sharp edge; this screen can be moved by a screw, like the movable part in the slide of Bunsen's spectroscope. This is the "Schlieren"-apparatus, which hence may be put together in almost any philosophical cabinet.

If the lens, L, is perfect, the entire beam of light is concentrated in B; and in moving the screen, *s*, down, no change in the image, B, is observed until the screen reaches B, when the lens, L, *suddenly* disappears. But if L is not perfect, if it contains a flaw, *f* (i. e., *Schliere*), then this will refract light differently from the body of the lens; the rays from *f* will *not* collect in B; when *s* has nearly reached B, many of the rays from *f* (which otherwise would have reached the objective of T and thus the eye) are now cut off; hence *f appears dark on the bright ground* of the image of L. And when *s* is moved down so as completely to cut off the regular image B, many of the rays from *f* will yet reach the objective, so that *f now appears bright upon a dark ground.* As the distance LT is quite considerable (even twenty feet or more), and as the telescope may have considerable power, this method is *incredibly sensitive.* The object to be examined must of course be transparent; if it is the objective of a telescope, this serves as L; if a flame or the like, it is placed at M near L, between L and T.

Töpler has found that perfectly homogeneous glass is exceedingly rare; it has usually either filiform flaws (which are easily detected and but little injurious) or has flaws throughout its entire mass, appearing in this apparatus as if brushed over by a brush. These very injurious flaws hitherto were not discovered till the lens was almost worked out; by this apparatus they are easily detected in the glass.

The *flame* of a Bunsen burner (placed at M) shows besides the three well known parts visible to the unaided eye, two others: an exterior, large, very well defined cone (consisting of the heated products of combustion and of air) and a bright interior cone, resting on the tube as the base, having a sharp outline (consisting of the gas mixture before any combustion has taken place).

The *electric spark*, when produced by the induction coil and allowed to pass between the electrodes held at M, shows very interesting and instructive phenomena; of which, however, it would be very difficult to give a clear idea in a few words.

The *sound-wave in air* corresponding to each separate spark is, like the sound, a *single impulse;* it is beautifully visible as a *bright circle or ellipse* around the source of sound, moving regularly from the center outward. A succession of sparks in regular intervals gives moving circles of light. The spark from a Leyden jar gives a sharp sound, and one increasing circle of light one sound-wave. That this is a sound-wave, Töpler proved by trying in vain to blow it aside by a feeble current of air, and also by finding it to progress more rapidly in heated air. But more interesting yet is his experiment on the reflected sound-wave. Suspending a glass plate from the brass electrodes by means of corks, he saw in lines of light precisely the same phenomenon which we observed when circular waves of a liquid meet a plane wall: they are reflected as circles described from a point as far behind the obstacle as the origin of the wave is in front of the same. By having the electrodes either in the axis of the apparatus or at right angles to it, Töpler found that in the first case the lines were elliptical, in the latter circular: so that the wave is a surface of revolution around the electrodes as an axis.

It may well be said that by means of Töpler's apparatus we *see the sound;* in Chladni's and even in Kundt's experiments we only see the motion imparted by air to some other body, not the motion of the air itself. For the application of this method to the microscope, see Töpler's article in Pogg. Ann. G. H.

11. *On atomic heat and the specific gravity of gases.*—Gustav Schmidt, known by his theoretical labors on heat and the steam-engine,* has published an article on "*Atom-wärme*" (the specific heat of atoms, which we abbreviate as above); but only the appendix to the article, treating on the specific gravity of gases, seems to contain any addition to our knowledge.

* Theorie der Dampfmaschinen. Freiberg, 1861.

The atomic heat, w, of an element ($=gc$, where g is the atomic weight and c the specific heat of the substance), he endeavors to prove to be $w=an$, where a is a constant, the same for all the elements, and n the characteristic of the element. Therefore, if α represents the number of atoms in any compound, and if the atomic heat of the compound equals the *sum* of the atomic heat of the several atoms, it follows that

$$w=gc=\Sigma\alpha\,.\,an=a\Sigma\alpha n.$$

Schmidt makes a number of suppositions in regard to a and hence obtains different values of n. For *solids* he takes either $a=\frac{32}{30}=1{\cdot}0666$ or $a=0{\cdot}8$; for gases he adopts $a=0{\cdot}86$, and correspondingly for n.

n	Solids.		Gases.
	$a=1{\cdot}0666$	$a=0{\cdot}8$	$a=0{\cdot}86$
2	H, C, B, Si	C	H
3	P	H, B, Si	
4	F, O	....	O, C, N, S
5	N, S	O, P	Br, Cl
6	Cl, Br, I, and metals	F	P, Si
7		N, S	
8		Cl, Br, I, and metals	As, Sn, Ti

A glance at this table is enough to convince any one that this supposition cannot be correct. We need only to calculate the values $w=an$ from this table, and compare them with those used by Kopp, to see that the so-called "*characteristic*" is essentially characterized by having no character whatever.

We should not have referred to this memoir if we had not found the closing pages thereof to contain a most accurate theoretical determination of the *specific gravity* δ of all permanent gases, and of vapors above their boiling points (that of atmospheric air $=1$). If g be the *weight of a molecule* of equal volume with HCl or NH_4, he finds $\delta=0{\cdot}0346832\,g$, with a possible error in the coëfficient of less than one-fifth per cent, and *an actual error of less than one-fiftieth per cent.* To find this very important number he makes use of a relation from the mechanical theory of heat and the following quantities from experiments: pressure of atmosphere, specific gravity of air, coëfficient of expansion of air, and the percentage composition of the atmosphere with $O_2=32$ and $N_2=28$: all fundamental quantities determined by Regnault and others with most scrupulous care; by adopting the specific gravity of oxygen as determined by Regnault (1·10563) the atmosphere would contain 23·57 instead of 20·81 per cent of oxygen. This shows that the calculated density of oxygen (1·1099) is much more reliable than the observed one.

He finds furthermore, the *mechanical equivalent of heat* $k=422{\cdot}06$ meterkilograms (for kilogram-Centigrade) instead of Joule's, 423·54, $A=\frac{1}{k}$; the specific heat of aqueous vapor $=H_2\Theta$ 0·3822. As a further consequence from an empirical relation, $g(C'-C)=2$, (where C' specific heat by constant pressure, C rational specific heat) he finds finally the Gay-Lussac Mariotte's law expressible in $\frac{ApV}{T}=2$; or, *by heating a* *molecule of volume*, V, *of any gas under any constant pressure, p, at any temperature*, T ($T_0=\frac{1}{\alpha}=273°$ C. below 0° C.) *two calorics* (or units of heat) *are necessary to overcome the external work for each degree C. the temperature is raised.* The molecular weight and the unit of heat must of course refer to the same unit of weight.—*Sitzungsberichte*, Wien, 1865, lii, 417–452; *Corresp. Blatt d. naturf. Vereins*, Riga, 1864, xiv, 35–44; *L'Institut*, 1866, p. 191. G. H.

12. *Expansion of water below* 4° *C.*—Dr. WEIDNER has, by means of water thermometers (bulb a cylinder 11mm. diameter, 100mm. high, tube not less than 1mm.), determined this expansion with great care, starting in four independent series, with four different water-thermometers from the temperature of 4° C. to 0° C. and then to −9° or −10° C. From each series he calculates by a formula of form $V=1+at+bt^2+ct^3$ the expansion for each degree C., the volume at +4° C. being unity.

By comparing the four series I find a very close correspondence except for −4° C., where the first series deviates 37 millionths; on referring to the formula, the stated value, 513 millionths, is found to be 550·6, agreeing with the other three in the sixth decimal. Taking the mean from the four values given by Weidner we obtain the following volumes of water.

	Weidner.	Despretz.	Pierre.
+ 4° C.	1·000000	1·000000	1·000000
+ 3 "	14	8	5
+ 2 "	40	33	27
+ 1 "	80	73	63
0 "	137	127	118
− 1 "	210	214	214
− 2 "	302	308	317
− 3 "	415	422	430
− 4 "	550	562	556
− 5 "	709	699	700
− 6 "	893	918	865
− 7 "	1104	1135	1054
− 8 "	1344	1373	1271
− 9 "	1608	1631	1520
−10 "	1·001905		1803

Above zero Weidner's volumes are greater; but between 0° and −6° C. the three experimenters correspond well enough.—*Pogg. Ann.*, 1866, xxix, 300–308. G. H.

13. *Specific heat of soils.*—L. PFAUNDLER has determined the specific heat of seventeen soils with great care. The accuracy of the method with a modified Regnault's apparatus, was proved by determining the specific heat of water and of *Iceland spar.* The first showed the same increase as found by Regnault; the second gave, by ten independent determinations on the same piece, successively more and more subdivided, 0·20588, with a probable error of only 0·00006. This agrees with Regnault's results, 0·20694 (from eighteen determinations), and Kopp's, 0·206 (from four determinations), thus disproving that of Pape and Neumann (0·202). For *soils* he finds the specific heat between *one-fifth* and *one-half* (0·1923 and 0·5069); the most common value is 0·25 to 0·30.

Soils free from humus have the lowest specific heat, whether they consist of sand or lime; this might have been concluded from the fact that calcite and quartz have almost the same specific heat, viz., 0·20 and 0·19. The more rich a soil in humus, the higher is its specific heat. Thus peat was found to have 0·507, and a soil, very rich in humus, from Kaiserstein, gave 0·4143. Since water also must increase the specific heat of a soil, we may conclude that loamy soils also have a high specific heat.

So great a variation in so important a physical property of soils is of considerable importance to agriculture. A plant sensitive to changes in temperature may be unable to grow on soils of low specific heat, however excellent this soil might be in other respects.—*Pogg. Ann.*, 1866, cxxix, 102–135. G. H.

14. *The spectrum of the electrical brush and glow* has been observed by A. Schimkow. While the spectrum of the spark is affected by and produced in both nitrogen and oxygen, the *brush* discharge only gives *nitrogen* lines, and is not formed at all in pure oxygen; a trace of nitrogen entering the tube is sufficient to reproduce the light and its peculiar lines. The same is true in regard to the luminous glow observed when electricity is discharged between two points. At the same time the latter spectrum is still much fainter than that of the brush. It is characteristic of these lines that they especially occur in the most refrangible part of the spectrum. This seems due to the *much lower temperature* in the brush and glow discharge, as compared to the discharge in a spark. By introducing in the circuit of a coil a wet string four meters long, Schimkow made the nitrogen spectrum of a Geissler-tube appear precisely like the brush spectrum: the yellow lines had been weakened much more than the violet ones; at a low temperature, therefore, nitrogen seems especially to emit the most refrangible rays, harmonizing with the observation of von Waltenhofen, according to which the least refrangible rays are first extinguished when air is successively more and more rarefied. Thus the *brush* and *glow* are due to the luminosity of nitrogen at a temperature below that at which oxygen becomes luminous; and furthermore they consist principally of the more refrangible rays.—*Pogg. Ann.*, 1866, cxxix, 508–520; *L'Institut*, 1867, p. 55. G. H.

II. MINERALOGY AND GEOLOGY.

1. *Note on a new genus of fossil Crustacea;* by F. B. Meek.—In the last number of this Journal, p. 257, I mentioned having seen in "The Reader," a notice of a paper by Mr. Henry Woodward, read before the Geological Society of London, in which he proposed to establish a new genus *Prestwichia*, for the reception of some of the species generally referred to *Belinurus*, but differing from the types of that genus in having the body segments anchylosed. The abstract of Mr. Woodward's paper, mentioned by me, was unaccompanied by figures or diagnosis, and no particular species were cited, but the fact that our Illinois fossil has its body segments anchylosed, and agrees very nearly in its general appearance with a part of the species referred by English authors to *Belinurus*, led me to refer it to the new genus *Prestwichia*. Since that time, I have seen Mr. Woodward's interesting paper as published in the Quarterly Journal of the Geological Society, vol. xxiii, No. 89, p. 28, with ex-

cellent figures, both of the typical *Belinurus* and the new genus *Prestwichia.* From these figures and the accompanying remarks, it becomes evident that certain differences between the previously published figures of the type upon which the genus *Prestwichia* is founded and our Illinois fossil, and which were noticed by us in the remarks accompanying the description of the Illinois species as being probably of more than specific importance, if not due to some accidental imperfection of the specimens figured by Prestwich, really exist, and consequently forbid the reference of our species to this new genus. As it also differs upon quite as important characters from the genus *Belinurus*, as now restricted and clearly illustrated by Mr. Woodward, it becomes necessary to propose for its reception a third genus, holding a somewhat intermediate position between *Belinurus* and *Prestwichia.*

For this new genus I would propose the name *Euproops*, in allusion to the anterior position of its eyes. This form is at once distinguished from the restricted genus *Belinurus*, by its anchylosed abdominal segments, and the anterior position of its eyes, as well as by the more oval or subcircular outline of its abdomen. From *Prestwichia*, with which it more nearly agrees in general form, as well as in its anchylosed segments, it differs remarkably in having the area enclosed by its eye-ridge (glabella) comparatively small, and of a quadrangular form, with the eyes situated far forward at its anterior lateral angles. On comparing these characters of the central region of its head with the corresponding parts of *Prestwichia*, as illustrated by Mr. Woodward, it will be seen that the latter differs in having the glabella proportionately much larger, and transversely elliptic in outline, with the eyes widely separated and placed far back at its lateral extremities. It also has within this large elliptic area a smaller crown-shaped one not seen in *Euproops*, but corresponding in size and general appearance with that bearing the eyes at its anterior lateral angles in the latter type.

March 29th, 1867.

2. *Geological Survey of Illinois*, A. H. Worthen, Director. Volume II, *Paleontology*, xix, and 470 pp., royal 8vo, with 50 plates and 30 wood-cuts. Springfield, 1866. Published by authority of the Legislature of Illinois.—This important and beautifully illustrated work, consists, besides the Introduction, of three Sections, as follows:

Section I.—"Descriptions of new species of Vertebrates, mainly from the Subcarboniferous limestones and Coal Measures. By J. S. Newberry and A. H. Worthen.

"Remarks on the occurrence of Fossil Fishes in Illinois. By A. H. Worthen.

"Supplement to descriptions of Vertebrates, consisting of a description of a new genus, and species of Reptiles from the Coal-measures. By Prof. Edw. D. Cope.

Section II.—"Descriptions of Invertebrates from the Carboniferous system. By F. B. Meek and A. H. Worthen.

"Supplement to the descriptions of Invertebrates, consisting of the descriptions of Polyzoa from the Paleozoic rocks. By H. A. Prout, M.D.

Section III.—"Report on the Fossil Plants of Illinois. By Leo Lesquereux."

From the Introduction we learn that:

"The number of species of all kinds, illustrated and described, in the Report, is about 325, of which nearly 300 were discovered or first made known to science through the agency of the Illinois Geological Survey. Of these 325 species, 50 are plants, 156 invertebrate animals, and 119 vertebrates. Altogether they represent 115 genera, 25 of which have been established by parties connected with the survey. Of these genera 18 are plants, 67 invertebrates, and 30 vertebrates—the latter of which, with one exception (a *Batrachian*), being all fishes. Of the 115 genera represented, 81 are more or less fully characterized, and most of them illustrated in this volume."

From the cursory examination we have been enabled to make, we find many important additions to our knowledge of American Paleontology in this volume. At present we can only notice a few of them.

Mr. Worthen states that the fossil fishes abound in four horizons—usually limited to a single stratum, rarely more than a few inches in thickness. In the beds which form the base of the Carboniferous system in Illinois, these remains are comparatively rare; but in the upper strata they become exceedingly abundant. The lowest bed occurs in the upper part of the Burlington limestone. It is a stratum of brownish-gray rock, from four to six inches thick, in which the teeth and spines of fishes are imbedded in great numbers. It was first observed at Quincy, Illinois, but was afterwards identified on Honey creek in Henderson county and at Augusta in Iowa, nearly one hundred miles away from the first named locality. The second *fish bed* occurs fifty or sixty feet higher, in the series near the base of the quarry rock of the Keokuk group. The third, in ascending order, is found in the upper part of the Keokuk limestone. The fourth is situated at the junction of the lower limestone in the Chester group with the green shales above. All these beds belong to the Mountain limestone or Subcarboniferous period. In the Coal-measures, the remains of fishes again become more rare, in Illinois. "Of the 118 species, described and illustrated in this volume, 16 are from the Coal-measures, 17 from the Chester limestone, 18 from the St. Louis limestone, 49 from the Keokuk limestone, 14 from the Burlington limestone; 3 from the Kinderhook group, and 1 from Devonian Strata," (p. 16). This is the first memoir in which any large number of the paleozoic fishes of America have been described; and as the species are well figured it will constitute the foundation on which all subsequent investigations in this department must be conducted. Next follows an interesting description of a new fossil *Batrachian*, discovered by Mr. Joseph Even, near Morris, Grundy county, Illinois, in a bed near the base of the Coal-measures.

In Section II will be found a great deal of information bearing on the classification of the Crinoidea; especially as regards such genera as *Actinocrinus*, *Cyathocrinus* and *Poteriocrinus* the relations of which are here discussed at length. The new genus *Strotocrinus* (M. & W.) has the formula of *Actinocrinus* in the lower part of the body, but is distinguished by the remarkable structure of the upper portion, which is greatly expanded and forms a ten rayed horizontal disc, the plane of which is at right angles to the vertical axis. The interior of *S. regalis*, and some other species is provided with a peculiar, convoluted internal plate, resembling a shell of a *Bulla* or *Scophander*, placed with its longer axis so as to coincide with that of the body of the crinoid. This is illustrated by a wood-cut on p. 191.

The genus *Steganocrinus* has also the structure of *Actinocrinus* in the lower part, but with: "Rays, from the third primary radial pieces, forming greatly produced, free arm-like appendages, either bifurcating or simple, which are covered their entire length above by small plates, and provided on each side with a row of alternating true arms. Vault with a subcentral proboscis." These arm-like appendages are tubular, with the ambulacral orifices arranged along the sides,—opening out into the grooves of the true arms.

On page 220 there are some figures illustrating the wonderful structure of the vault of *Gilbertsocrinus*. It is there shown that this genus is identical with *Trematocrinus* (Hall), *Goniasteroidocrinus* (Lyon and Casseday), *Rhodocrinus* (Miller) pars, (as understood by some naturalists), and *Ollacrinus* (Cumberland). This latter name has priority over all others, but its author did not characterize the genus. The vault exhibits fine slender lobes, which are branched at their extremities. These have been mistaken lately for arms,* but M. and W. have shown that the true arms are situated in the re-entering angles between them. There are numerous important improvements in the classification of paleozoic genera of Echinodermata suggested in this work, which can only be understood by consulting the very instructive observations and figures.

An interesting fossil belonging to the *Xiphorura* is doubtfully placed in the genus *Bellinurus*, but Mr. Meek has informed us that he now considers it distinct from that genus and also from *Prestwichia* to which he afterwards thought it might be referable (this vol. ante, p. 257). As it will be noticed elsewhere in this Journal, we need not allude to it further here. We may be permitted, however, to remark on the affinities of the *Xiphorura* and the *Eurypterida* that the beautiful specimens of *Eurypterus* figured by Nieskowski in the "Archiv fur die Naturkunde Livland, &c.," 1859, have the six anterior segments of the body sculptured as in *Pterigotus*; but the posterior six are not so marked, unless indeed obscurely along the median line. These latter six have their posterior angles produced backward, to form short angular spines similar to those in the lateral margins of the abdomen of *Limulus*. If then we examine the inner surface of the cephalo-thorax of *Limulus*, we shall find there, indications of six or seven anchylosed segments, all with the scale-like sculpture of *Pterygotus*. These markings are not seen on the outside, and, though the character at first sight may not seem important, yet it will strongly impress many observers with the idea that we have buried, as it were, in the buckler of *Limulus* the anterior segments of *Eurypterus*. The species figured by Nieskowski is clearly not *E. remipes* as he supposes.

Mr. Lesquereux gives, p. 463, a table of the number of species of plants mentioned in his Report. The following are the general results:

* John Rofe, Esq., F.G.S., has figured (Geological Magazine, vol. ii. pl. 8) an English specimen with portions of these appendages which he maintains to be the remains of the arms. They are evidently, however, merely projecting lobes of the body, the formations of which are not yet understood.

1.	Whole number of species in Illinois, ...	120
2.	Number of new species in Illinois, ...	37
3.	Species found in Illinois not published before, ...	60
4.	Species in the catalogue not found in Illinois, ...	219
5.	Whole number in the catalogue, ...	280
6.	New species in the same, ...	146

This Report was drawn up in 1860; since then, other species have been collected, which will be described in future publications of the Survey.

The two volumes of the Geology of Illinois, which have been issued, establish for at least one Scientific Institution of that noble State, a very high character. The Paleontology is a first class work, equal to the best that has been published by any geological survey, and where the fossils are well worked out in a country, we may be sure that the physical structure is also correctly understood.

The principle, that every nation should contribute something toward the general advancement of knowledge (not merely by the dissemination of what was previously known, but by assisting in the discovery of those truths which, although existing in nature, have remained unknown to man from the beginning), is now recognized by all enlightened communities to be a sound one. The people of the State of Illinois have made an effort in that direction which, under the wise management of their able State geologist, has been highly successful, and creditable to all the parties concerned. E. B.

3. *On the occurrence of Eozoon in the Primary Rocks of Eastern Bavaria;* by Prof. Gumbel. (Ber. Ak. München, 1866; Q. J. Geol. Soc., xxii, 23.)—A new species of *Eozoon*, the *Eozoon Bavaricum*, has been discovered by Prof. Gümbel in a rock consisting of a granular aggregation of calcite, serpentine, and a white hornblendic mineral, supposed to be of Huronian or Cambrian age. The specimens examined were from near Wunseidel and Thiersheim, and between Hohenberg and the Steinberg, especially the last-named locality. It exhibits—(1.) A thin band almost entirely calcareous, and traversed by a network of straight lines, or, when treated with acid, divided by band-like ribs into irregular cell-like spaces, the calcite filling which is seen to be granular. (2.) Thicker calcareous portions abounding in tufts of fine tubes, exactly as in *Eozoon;* these tubes end at the serpentinous portions (3.), which have generally the same form as in the *Eozoon* from Steinhag before described, but are much smaller. In decalcified examples they may be seen to possess the same vaulted margins as *Eozoon;* their breadth averages ·1 mm. and the diameter of the tubes ·01 mm. Generally these serpentine bands pass into an adjoining portion (4.), of one-half the width, or less, made up of very much twisted lamellæ, consisting of serpentine or a whitish mineral, and possessing highly vaulted and deeply channelled outlines. Prof. Gümbel considers that on the whole these characters undoubtedly prove the affinity of this more recent and very much smaller form to the group *Eozoon;* but as the last-mentioned structure (4.) differs from what has been observed in *Eozoon Canadense*, he gives it the distinctive name of *Eozoon Bavaricum*. Prof. Gümbell makes out, with more or less probability, that the *Eozoon* occurs in the pargasite of Pargas, Finland, the Coccolite-limestone of New York, at Tunaberg, Boden in Saxony, and Hodrisch in Hungary.

4. *A Catalogue of Official Reports upon Geological Surveys of the United States and British Provinces.*—In arranging a set of American Geological Reports in the Library of Yale College, the following catalogue became necessary; and it is here published in the hope that it may be of service to geologists.[1]

PART II.—STATES AND TERRITORIES WEST OF THE MISSISSIPPI RIVER AND BRITISH PROVINCES.

MINNESOTA.

1866. *Henry H. Eames*, 1st Ann. Rep., Saint Paul, 8vo, 23 pp.
" *Charles Whittlesey*, Rep. on Mineral Regions, Cleveland, 8vo, 54 pp.

IOWA.

1858. *J. Hall* and *J. D. Whitney*, Final Rep., vol. I, Albany, 8vo, 724 pp., 29 pl., 2 sect., map.
1859. *J. Hall* and *J. D. Whitney*, Suppl., vol. I, Albany, 8vo, 4 pp.
1860. " " " 8vo, 94 pp., 3 plates.
1860. " " Ann. Rep., Des Moines, 8vo, 75 pp.
1861.* *J. Hall*, Prelim. Notice of New Crinoidea, Albany, 8vo, 18 pp.
1867. *C. A. White*, 1st Ann. Rep., Des Moines, 8vo, 4 pp.

IOWA, WISCONSIN AND ILLINOIS.

1844. *D. D. Owen*, Rep. to Treas. Dept., Washington, 8vo, 191 pp., 16 pl., 4 maps.

WISCONSIN AND IOWA.

1848. *D. D. Owen*, Rep. on Chippewa Land Dist., Washington, 8vo, 134 pp., 23 pl., 14 sect., maps.

WISCONSIN, IOWA AND MINNESOTA.

1852. *D. D. Owen*, Final Rep. (U. S.), Philadelphia, 4to, 638 pp., 27 pl., 16 sect., map.

MISSOURI.

1855. *G. C. Swallow*, 1st and 2d Ann. Rep., Jefferson City, 8vo, 207, and 238 pp., 32 pl., 5 maps.
1857.* *G. C. Swallow*, 3d Ann. Rep., —— "
1859.* " 4th " " Jefferson City, 8vo, 14 pp.
1861.* " 5th " " " " "
" " Geol. Rep. on S. W. Branch Pacific R. R., St. Louis, 8vo, 93 pp., map.

KANSAS.

1866. *Benj. F. Mudge*, 1st Ann. Rep., Lawrence, 8vo, 56 pp.
" *G. C. Swallow*, Prelim. Rep, Lawrence, 8vo, 198 pp.

ARKANSAS.

1858. *D. D. Owen*, 1st Rep., Little Rock, 8vo, 256 pp.
1860. " 2d " Philadelphia, 8vo, 433 pp.

[1] Of those Reports marked with an * one copy is needed at the Library of Yale College; and also one copy of any Report not included in the list: persons having them to dispose of are requested to notify the Librarian.

Louisiana.

1853. *Randolph B. Marcy*, Rep. to War Dept. on Red River of La., (Geology by E. Hitchcock and G. G. Shumard; Paleontology, by B. F. Shumard,) 8vo, 320 pp., 66 sect. and plates.

Texas.

1859. *B. F. Shumard*, 1st Ann. Rep., Austin, 12mo, 17 pp.

ROCKY MOUNTAIN REGION.

1809. *M. Lewis* and *W. Clark*, Expedition across American Continent in 1804–6, by order United States Government, Philadelphia, 8vo, 2 vols. (London, 4to, 1814, and 8vo, 3 vols. 1817), maps.

1810.* *Z. M. Pike*, Expedition in western Territories in 1805–7, by order U. S. Government, Philadelphia, 8vo, maps, (London, 4to, 1811).

1823.* *Stephen H. Long*, Expedition from Pittsburg to Rocky Mts., in 1819–20, (War Dept.) (Compiled by Edwin James,) Philadelphia, 8vo, 2 vols. 503, and 442 pp. Atlas, (London, 8vo, 3 vols. 1823).

1824.* *S. H. Long*, Exped. to source of St. Peters River, in 1823, (War Dept.) (Geology by Wm. H. Keating,) Philadelphia, 8vo, 2 vols., maps, (London, 8vo, 2 vols. 1825).

1835. *G. W. Featherstonhaugh*, Rep. on Elevated Country between Missouri and Red Rivers, Washington, 12mo, 97 pp.

1836. *G. W. Featherstonhaugh*, Rep. on Geol. Reconn., *via* Wisconsin, to Cotean de Prairie, Washington, 12mo, 168 pp.

1843. *I. N. Nicollet*, Rep. to illustrate Map of Hydrographical Basin of Mississippi River, Washington, 8vo, 170 pp.

1845. *John C. Fremont*, Exped. to Rocky Mts. in 1852–4, (War Dept.), (Paleontology by James Hall), Washington, 8vo, 693 pp.

1848. *W. H. Emory*, Exped. from Fort Leavenworth to California, (War Dept.), includes Reports of J. W. Albert, P. S. Cooke, and A. R. Johnson, (Paleontology by J. W. Bailey), Washington, 8vo, 614 pp., maps.

" *A. Wislizenus*, Rep. of tour to North Mexico in 1846–7, with Col. Doniphan's Expd., Washington, 8vo, 141 pp., maps.

1852. *Howard Stansbury*, Exped. to Great Salt Lake, (War Dept.), (Geology and Paleontology by James Hall,) Washington and Philadelphia, 8vo, 487 pp., maps.

1853. *L. Sitgreaves*, Exped. down Zuni and Colorado Rivers, (War Dept.), Washington, 8vo.

1856. *G. K. Warren*, Exped. to Rocky Mts. in 1855, (Geology by F. V. Hayden), Washington, 8vo.

1857. *W. H. Emory*, Rep. on U. S. and Mexican Boundary Survey, vol. I, (Geology by C. C. Parry, A. Schott, W. H. Emory, and James Hall; Paleontology by James Hall and T. A. Conrad), Washington, 4to, 21 plates.

1859. *W. H. Emory*, Rep. on U. S. and Mex. Boundary, vol. II, Botany and Zoology; no Geology, Washington, 4to, plates.

1855. *Rep. on Pacific Railroad Exploration*, (War Dept.), vol. I, (Geology by George Gibbs), Washington, 4to.

1855. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. II, (Geology by James Schiel and Wm. P. Blake; Paleontology by J. Schiel J. W. Bailey, and W. P. Blake), Washington, 4to, plates.
1856. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. III, (Geology, by W. P. Blake, and Jules Marcou; Paleontology by James Hall,) Washington, 4to, plates.
" *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. IV, Botany; no Geology, Washington, 4to, plates.
" *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. V, (Geology by W. P. Blake; Paleontology by L. Agassiz, T. A. Conrad, J. W. Bailey, and Geo. C. Schäffer,) Washington, 4to, plates.
1857. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. VI, (Geology by J. S. Newberry; Paleontology by T. A. Conrad), Washington, 4to, plates.
1857. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. VII, (Geology by Thos. Antisell; Paleontology by T. A. Conrad), Washington, 4to, plates.
1857. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. VIII, Zoology; no Geology, Washington, 4to, plates.
1858. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. IX, Zoology; no Geology, Washington, 4to, plates.
1859. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. X, Zoology; no Geology, Washington, 4to, plates.
1855. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. XI, Literature of Surveys, and maps; no Geology, Washington, 4to.
1860. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. XII, Parts I and II, Botany and Zoology; no Geology, Washington, 4to, plates.
1862. *F. V. Hayden*, Rep. on Geology of Upper Missouri Region, Philadelphia, 4to, 218 pp., map.
1865. *F. B. Meek* and *F. V. Hayden*, Rep. on Paleontology of the Upper Missouri, Part I, (Smithsonian Cont.) Washington, 4to, 135 pp., 5 plates.

PACIFIC COAST REGION.

Oregon and Northern California.

1848. *J. C. Fremont*, Rep. upon Upper California, Washington, 8vo.
1850. *James D. Dana*, Rep. on Geology of U. S. Explor. Exped., in 1838–42, New York, 4to. Atlas.
1850. *P. T. Tyson* and others, Reps. to War Dept., Washington, 8vo, 128 and 37 pp., 12 maps and sections.
1854. *Wm. P. Blake*, Rep. to War Dept., Washington, 8vo, 80 pp.

California.

1853. *John B. Trask*, 1st Ann. Rep. Geol. Sierra Nevada, ——?, 8vo, 31 pp.
1854. *J. B. Trask*, 2d Ann. Rep. Geol. Coast Mts. and part of S. Nevada, ——?, 8vo, 95 pp.
1855. *J. B. Trask*, 3d Ann. Rep. Geol. Coast Mts., Sacramento, 8vo, 93 pp.

1856. *J. B. Trask*, 4th Ann. Rep. Northern and Southern Cal., Sacramento, 8vo, 66 pp.
1855. *W. P. Blake*, Rep. to Coast Survey on Geology of Cal., Washington, 22 pp., 4to.
1861. *Josiah D. Whitney*, Address to Legislat., on Survey, San Francisco, 12mo, 50 pp.
1862. *J. D. Whitney*, Letter to Governor (Rep. of Progress), San Francisco, 8vo, 7 pp.
1862.* *J. D. Whitney*, Address to Legislat., on Survey, San Francisco, 12mo, 33 pp.
1863. *J. D. Whitney*, 2nd Ann. Rep., San Francisco, 8vo, 12 pp.
1864. *J. D. Whitney*, Rep. Paleontology, vol. I, Philadelphia, 8vo, 243 pp., 32 pl. (Carboniferous and Jurassic Fossils by F. B. Meek; Triassic and Cretaceous, by W. M. Gabb.)
1865. *J. D. Whitney*, Rep. Geology, vol. I, Philadelphia, 8vo, 498 pp., 10 plates.
1866. *J. D. Whitney*, Rep. Paleontology, vol. II, part I, Philadelphia, 8vo, 38 pp. (Tertiary Invertebrate Fossils by W. M. Gabb.)
1866. *J. D. Whitney*, Letter to Governor on Survey, San Francisco, 8vo, 14 pp.

California and Arizona.

1861. *Joseph C. Ives*, Rep. on Colorado River, Washington, 4to, plates, (Geology and Paleontology by J. S. Newberry.)

BRITISH PROVINCES.

Newfoundland.

1839.* *J. B. Jukes*, Prelim. Rep. (Legislative Doc.), folio, St. Johns.
1842.* " General Rep. in Author's "Excursions in and about Newfoundland," London, 12mo, 2 vols. (Separate, with sections, London, 12mo, 160 pp. 1843.)

Nova Scotia.

1846.* *J. W. Dawson*, Rep. on Coal-fields of Caribou Cove, &c. (Legis. Doc.) Halifax, folio.
1860. *Joseph Howe, and Henry How*, Rep. on Discovery of Gold in Nova Scotia, (Legis. Doc.) Halifax, folio, 4 pp.
1861. *J. Howe*, Rep. on Gold-fields. (Legis. Doc.) Halifax, folio, 7 pp.
1862. *Henry Poole*, Rep. on Gold-fields, Western Section. (Appendix on Minerals, by H. How.) (Legis. Doc.) Halifax, folio, 25 pp.
1862. *J. Campbell*, Rep. on Gold-fields, Eastern Section. (Legis. Doc.) Halifax, folio, 8 pp.
1863. *J. Campbell*, Rep. on Gold-fields. (Legis. Doc.) Halifax, folio, 12 pp.
1864* *David Honeyman*, Rep. on Geol. Survey of Nova Scotia, and Cape Breton. (Appendix on Minerals by H. How.) (Legis. Doc.) Halifax, folio, 7 pp.
1865. *H. How*, Rep. on Minerals collected by D. Honeyman. (Legis. Doc.) Halifax, folio, 4 pp.

NEW BRUNSWICK.

1839. *Abraham Gesner*, 1st Ann. Rep., St. John, 8vo, 87 pp.
1840.* " " 2d " " " ——
1841.* " " 3d " " " 88 pp.
1842. " " 4th " " " 101 pp.
1843. " " Rep., with account of Public Lands, St. John, 8vo.
1850.* *J. Robb*, in Johnston's Agricultural Rep., Frederickton, 8vo, map.
1865. *L. W. Bailey*, Rep. on Southern N. Br., Frederickton, 8vo, 159 pp., map, section.
" *Henry Y. Hind*, Rep., especially on the Quebec Group, Frederickton, 8vo, 293 pp.

CANADA.

1845. *Wm. E. Logan*, 1st Rep. (for 1843), Montreal, 12mo, 159 pp.
1846.* " Rep. (for 1844,) " " 110 pp.
1847.* " " (for 1845), " " 125 pp.
" * " " (for 1846), " " 66 pp.
" * " 2 Repts. on Mining Region of Lake Superior, Montreal, 12mo, 31 pp.
1849.* *W. E. Logan*, Rep. (for 1847), Montreal? 12mo, 165 pp.
1849.* " Rep. on N. shore Lake Huron, Montreal, 12mo, 51 pp.
1850. " Rep. Progress for 1848, Toronto, 12mo, 65 pp.
" " " " 1849, " " 115 pp.
1852. " " " 1850, Quebec, " 54 pp.
" " " " 1851, " " 131 pp.
1854. " " " 1852, " " 179 pp.
1857. " " " 1853–6, Toronto, 12mo, 494 pp. Atlas, 4to, 22 pl.
1858. *W. E. Logan*, Rep. Progress for 1857, Toronto, 12mo, 240 pp.
1859. " " " 1858, Montreal, " 263 pp.
1863. " General Report, from 1843 to 1863, Montreal, 8vo, xxvii and 983 pp. Atlas.
1858. *E. Billings, J. W. Salter* and *T. R. Jones*, Decade III, Cystideæ, Asterideæ and Entomostraca, Montreal, 8vo, 102 pp., 11 pl.
1859. *J. W. Salter*, Decade I, L. Silurian fossils, Montreal, 8vo, 47 pp., 10 pl.
" *E. Billings*, Decade IV, L. Silurian Crinoideæ, Montreal, 8vo, 72 pp., 10 pl.
1865. *Jas. Hall*, Decade II, Graptolites of Quebec Group, Montreal, 8vo, 151 pp., 23 pl.
1865. *E. Billings*, Paleozoic fossils of Canada, Montreal, 8vo, 426 pp.
1866. " Catalogue Silurian Fossils of Anticosti, Montreal, 8vo, 93 pp.
1866. *W. E. Logan*, Rep. Progress from 1863 to 1866, Ottawa, 8vo, 322 pp.

BRITISH AMERICA.

1858. *Henry Y. Hind*, Rep. of Explor. between Lake Superior, and Red River, Toronto, 8vo, 425 pp., maps.
1860.* *H. Y. Hind*, Rep. on Assiniboine Exped. in 1858–9, Toronto, folio, maps.

1863.* *H. Y. Hind*, Rep. of Explor. in Labrador, London, 8vo, 2 vols., maps.

1860. *Oscar M. Lieber*, Rep. on Geology of Labrador, (U. S. Coast Survey), Washington, 4to, 7 pp.

ARCTIC REGIONS.

1819. *John Ross*, Voyage to Baffins' Bay, &c. (Appendix, on Geology, by John McCulloch), London, 8vo.

1822. *John Franklin*, Exped. to Polar Sea, 1819–22. (Appendix on Geology by John Richardson), London, 4to.

1828.* *W. E. Parry*, 3d Voyage of Discovery in 1827. (Appendix on Geology by Robt. Jameson), London.

1828. *J. Franklin*, 2d Expd. to Polar Sea in 1825–7. (Appendix on Geology, by J. Richardson; Paleontology, by R. Jameson), London, 4to.

1835. *J. Ross*, 2nd Voyage of Discovery in 1829–33. (Geology by Author,) London, 4to, 2 vols.

1836.* *G. Bach*, Arctic Land Exped. in 1833–5. (Appendix on Geology, by W. H. Fitton), London, 8vo.

1839. *F. W. Beechey*, Exped. to Pacific and Behren Strait. (Appendix on Geology, by Wm. Buckland), London, 4to.

1852.* *P. C. Sutherland*, Journal of Voyage in Baffin's Bay, in 1850–51. (Appendix on Geology, by J. W. Salter), London, 8vo, 2 vols., plates.

1855. *E. Belcher*, Exped. to Arctic in 1852–4. (Appendix on Geology, by J. W. Salter), London, 8vo, 2 vols.

ADDITIONS AND CORRECTIONS TO PART I.

MAINE.

For the last three Reports on this State read as follows:—

1839. *Ezekiel Holmes*, Explor. and Survey of Aroostook River Territory, Augusta, 12mo, 78 pp.

1862. *E. Holmes* and *Chas. H. Hitchcock*, 1st Ann. Rep., Nat. Hist. and Geol., Augusta, 8vo, 387 pp.

1863. *E. Holmes* and *C. H. Hitchcock*, 2nd Ann. Rep., Nat. Hist. and Geol., Augusta, 8vo, 447 pp.

NORTH CAROLINA.

1867. *W. C. Kerr*, Rep. Progress of Survey, Raleigh, 8vo, 56 pp.

FLORIDA.

1851. *Louis Agassiz*, Rep. on Florida Coral-reefs, (U. S. Coast Survey), Washington, 8vo, 15 pp.

ILLINOIS.

1867. *A. H. Worthen*, Rep. Paleontology, vol. II, Springfield, large 8vo, 474 pp. 50 plates. (Vertebrates by J. S. Newberry and A. H. Worthen; Invertebrates by F. B. Meek and A. H. Worthen; and Plants by Leo Lesquereux.)

5. *Note to Article on Kaolinite, etc.*, p. 361; by the authors.—When our article was just going to press, we received a letter from Prof. A. Knop, dated Carlsruhe, March 13th, directing our attention to his extremely interesting paper, *Beiträge zur Kenntniss der Steinkohlen-Formation und des Rothliegenden im erzgebirgischen Bassin, Neues Jahrbuch für Min.*, 1859, in which we find, p. 544, details of his investigation on the crystallography of the Schneckenstein "Kaolin." Prof. Knop has anticipated our observations on this substance in good part, as appears from the following quotation. "The crystals of the Kaolin from Schneckenstein have dimensions admitting of measurement under the microscope. They have an average length of about 0·021 mm., and a breadth of about 0·015 mm., and show, in part, the form of very sharply defined rhombic tables; in part, these are variously truncated on the angles connected by the macrodiagonal. Here and there the crystal-plates are aggregated to rhombic prisms and exhibit, on the assumption of rhombic crystallization, the combinations $\infty P \,.\, 0P$ and $\infty P \,.\, 0P \,.\, \infty \breve{P} \infty$. Repeated measurements gave constantly 118° for the obtuse angles of the planes."

The specimen from Schneckenstein kindly sent us by Prof. Knop, who first brought it to Wöhler's notice, perfectly resembles that received from Prof. Clark, as well as others adhering to topaz specimens from Schneckenstein in Prof. Brush's collection. These crystals are, however, too small for measurement by the means at our command. If the angle given by Prof. Knop be correct, we presume that more exact goniometry would prove the same true of the kaolinite from Summit Hill, the crystals of which, being six times larger in linear dimensions, we have measured without difficulty, though not with great precision. In our figures of the last named substance, drawn by the camera lucida, the angles vary one and in some cases two degrees; but they never fall below 118°, the opposite angles vary as much as those contiguous to each other, and they all point to 120° as the mean.

Prof. Knop has also favored us with a portion of the kaolin from Zeisigwald before referred to. The plates average ·0002 inch in breadth, and are finer than those of some plastic clays we have examined. Under an $\frac{1}{8}$ in. objective we have detected short bundles of plates, but in a cursory examination did not discover plates with a definite angular outline.

As regards pholerite, we learn from Prof. Knop's paper, that the mineral from Niederrabenstein, described by him, is not a homogeneous substance, but in the sample analyzed contained 7·91 per cent of quartz and other impurities, insoluble in concentrated sulphuric acid. The analysis quoted in our table is that of the portion soluble in sulphuric acid.

The substance itself, known as *Thonstein* or *Felsittuff*, was of close texture, easily cut by the knife and appeared when "magnified 330 diameters as a mass of fine crystalline colorless scales, which were of themselves only in part well defined or aggregated in parallel position to small thick packets."

This description agrees with what we have given of various clays, and leads to one of two conclusions, viz., either the substance is impure kaolinite, or, if pholerite, the latter has an appearance and prismatic crystallization closely similar to kaolinite.

In his analysis, Prof. Knop decomposed the substance by hot concentrated sulphuric acid, evaporated off the excess of this acid, warmed with chlorhydric acid, and dissolved in distilled water. From the undissolved residue silica was extracted by solution of caustic soda. There is one point in this method that is open to objection and might introduce a serious error in the results. In evaporating off the excess of sulphuric acid which requires a high temperature, the heat may easily rise at the close of the operation to a degree at which silica decomposes sulphate of alumina, and on subsequent treatment with chlorhydric acid, soluble silica would pass into the liquid and be included in the alumina precipitate, unless special precautions were taken. For this reason we do not regard the single analysis as conclusive of the existence of pholerite.

It is further to be observed that the pure kaolinite of Zeisigwald occurs in the same neighborhood and in cavities in a similar "thonstein."

The Naxos pholerite analyzed by Prof. J. L. Smith is described as associated with emerylite. But for the great care which Prof. Smith is known to employ in the selection of pure material, we might suppose he analyzed a mixture of kaolinite and emerylite. In fact, if we assume the 1·21 per cent of lime in his analysis to belong to emerylite, and calculate the corresponding quantities of silica, alumina and water, according to the theoretical composition of this substance as given in his paper, we obtain, after deducting these quantities from the per-centages in "pholerite," proportions of silica, alumina and water that represent kaolinite quite closely.

	Supposed pholerite.	Emerylite, calc. from lime.		Residue.	Residue calc. on 100. (kaolinite?)
$\ddot{S}i$,	44·41	2·93	=	41·48	45·57
$\ddot{\bar{A}}l$,	41·20	4·42	=	36·78	40·40
$\dot{C}a$,	1·21	1·21			
$\dot{H}$,	13·14	0·38	=	12·76	14·01
	99·96	8·94	=	91·02	99·98

We do not regard such calculations as conclusive, but their indications are worthy of being followed up. S. W. J. and J. M. B.

6. *On a new specimen of Telerpeton Elginense;* by Prof. T. H. Huxley, LL.D., F.R.S., V.P.G.S.—The specimen which was described in this paper had been broken into five pieces, exhibiting hollow casts of most of the bones of *Telerpeton Elginense.* It is the property of Mr. James Grant of Lossiemouth, and came from the reptiliferous beds of that locality, along with some highly interesting fragments of *Stagonolepis* and *Hyperodapedon.* The casts described by the author consisted of impressions of the bones of the skull, together with the lower jaw, and the teeth; of most of the vertebræ and ribs; of the greater portions of the pelvic and scapular arches; and of representatives of most of the bones of the fore and hind limbs; and it was stated that the characters of all these portions of the skeleton indicated decidedly Lacertilian affinities.

In describing these remains Professor Huxley discussed especially the biconcave character of the vertebræ; the mode of implantation of the teeth, which he believed to be acrodont, and not thecodont; and the anomalous structure of the fifth digit of the hind foot, which presents only two phalanges (a proximal and a terminal), a structure which differs from that of all known Lacertilian reptiles, whether recent or fossil. His researches had led him to conclude that the animal is one of the Reptilia, and is devoid of the slightest indication of affinity with the Amphibia. In all its characters it is decidedly Saurian, and accords with the sub-order *Kionocrania* of the true Lacertilia; but the author had not been able to make sure that it possesses a columella. He also remarked that the possession by *Telerpeton Elginense* of vertebræ with concave articular faces does not interfere with this view, as although most recent Lacertilia have concavo-convex vertebræ, biconcave vertebræ much more deeply excavated than those of *T. Elginense* are met with among the existing geckos.

Professor Huxley in conclusion drew attention to the interesting fact that *Telerpeton* presents not a single character approximating it toward the type of the Permian *Protorosauria*, or the Triassic *Rhynchosaurus*, and other probably Triassic African and Asiatic allies of that genus, or to the Mesozoic Dinosauria; and that whether the age of the deposit in which it occurs be Triassic or Devonian, *Telerpeton* is a striking example of a *persistent type* of animal organization.—*Geol. Mag.*, iv, 78.

7. *Note on Tultalite;* by F. Pisani. (From a letter to J. D. Dana, dated Paris, Dec. 6, 1866.)—*Taltalite* of Domeyko,* recently described by Mr. David Forbes,† comes from a copper mine of Señor Moreno near Taltal, in the desert of Atacama, where it is associated with atacamite and copper glance. It occurs in large masses, fibrous, silky in luster, brownish-black in color, and has a dark gray powder. Domeyko obtained

Si	Al	Fe	Mg	Ca	Cu	Cl	H	
20·8	16·2	11·3	0·8	2·4	44·5	0·7	2·25	= 98·95

affording the oxygen ratio for the bases and silica 21·83 : 11·08.

On a close examination of the mineral I have found that it is only a mixture of fibrous tourmaline and oxyd of copper. Treated with chlorhydric acid, it leaves a residue which contains boracic acid, and has the reactions of tourmaline; and the solution includes all the copper with but very little iron, no cobalt or manganese, and traces of lime. Besides, if from Domeyko's results we take all the oxyd of copper which the acid takes up, we obtain for the remainder—

Si 38·7 Al 30·1 Fe 21·2 Mg 1·49 Cu 4·41 H 4·1 = 100.

These numbers agree with those of a very ferriferous tourmaline, excepting the absence of boracic acid which Domeyko did not detect. I have in my collection a specimen of blackish-brown fibrous tourmaline from Chili, which is free from oxyd of copper. What has been called *taltalite* is similar, excepting the accidental mixture of oxyd of copper.

8. *On the punctate shell structure of Syringothyris;* by F. B. Meek. (From a letter to one of the editors, dated Washington, April 18th, 1867.)—I write a brief note to inform you that I have recently examined Prof. Winchell's types of his genus *Syringothyris*, which he was so kind as to loan me, and that I find them all, with the exception of two silicified specimens (showing no structure), *distinctly punctate.* It is probable that Prof. Winchell had happened to examine chippings from specimens not in a condition to show the punctures. I have likewise ascertained, since the publication of my former paper on this subject, that *Spirifer propinquus* Hall, and *S. Hannibalensis* Swallow, both nearly

* Domeyko's Mineralogy, 2d edit., p. 139, 1860. † Phil. Mag., [4], xxv, 111.

like *S. cuspidatus*, have a clearly punctate structure, and hence probably belong to the group *Syringothyris*.

I have also just read a letter from Mr. Davidson, written to Mr. Worthen, in which he quotes, from a letter to him from Dr. Carpenter, a paragraph giving the results of his examinations of specimens of *Syringothyris*, and of the same Irish shell examined by me (and at one time supposed to be *Spirifer cuspidatus*). These chippings were sent over by Mr. Worthen at Mr. Davidson's request some little time back. Dr. Carpenter says he finds the *Syringothyris* (that from Floyd Co., Indiana, I suppose) *distinctly punctate*, the punctures being as I stated, small and scattering. The chippings from the Irish specimen, sent over to Mr. Worthen with the name *S. cuspidatus* attached, Dr. Carpenter also found to be punctured, though the punctures are not so clearly seen as in the other. Chippings of *S. subcuspidatus* Hall, sent by Mr. Worthen, he says are not in a condition to show the structure.

At the time of writing, Dr. Carpenter had evidently not received a package of chippings I had sent him, containing specimens of *S. subcuspidatus* showing the punctures clearly. He says these examinations of the structure of *Syringothyris* confirm its generic or subgeneric differentiation established upon other characters, and that the Irish specimen he believes belongs to this group. He is still confident, however, that the *true S. cuspidatus* is not a punctate shell, which you will remember I had not supposed to be the case. I never doubted or questioned the accuracy of Dr. Carpenter's conclusions on that point; and there is no microscopist living in whose results I have more confidence than in his.*

9. *Geological Researches in China, Mongolia, and Japan during the years* 1862 *to* 1863; by Raphael Pumpelly. 144 pp., 4to, with 9 plates. Washington City. Published by the Smithsonian Institution, being No. 202 of the Smithsonian Contributions to Knowledge.—In vol. xli of this Journal, Mr. Pumpelly gave a very brief notice of the principal results to which he had arrived after his explorations in China and Japan. The volume issued contains a full account of his very interesting observations. It treats of the General Outlines of Eastern Asia; its general geology, with an account of his special explorations in China and Japan; the structure of the Southern edge of the Great Table-Land, and of Northern Shansi and Chihli; the Sinian system of elevation; the Yellow Stone and its delta and changes of course; and the Mineral Productions of China; and gives, in an Appendix, Dr. Newberry's descriptions of the Fossil Plants of the Coal rocks, with plates; J. A. Macdonald's analyses of Chinese and Japanese Coals; and the results of Mr. A. M. Edwards's microscopic examination of some Japanese infusorial earths and other deposits of China and Mongolia.

The Sinian system of elevation is the "extensive N.E. and S.W. system of upheaval, which is traceable through nearly all Eastern Asia, and to which this portion of the continent owes its most salient features." It is stated

* In a paper on certain types of the Spiriferidæ published in the Proceedings of the American Philosophical Society for 1866, and presented to that Society in May of 1866, Mr. J. Hall presents facts confirming my observations, communicated in a paper read before the Philad. Acad. Nat. Sci., in Dec. 1865, and published Feb. 1866, in which the presence of a punctate structure in shells of this type, and its coincidence with the internal tube of *Syringothyris*, were first announced. He, however, makes no allusion to my investigations, of which he certainly was not ignorant.

to be extensively apparent in the courses of the mountains, the strike of the strata, and the hydrography. It characterizes the trend of the metamorphic rocks over the plateau from Mongolia from the Great Wall to Siberia; and a map shows that it belongs to all Eastern Siberia, the Yablonvi, Altan-Kingan, and Stanovoi Mts., with their intermediate ridges, conforming to it. The period of the uplift is placed before that of the Coal-measures (Mesozoic). Mr. Pumpelly remarks that striking analogies are observed to exist between the Sinians and our own Appalachians, as to structure, strike, and dip; and that as the elevation of the Appalachians determined the outline of Eastern America, so the Sinian revolution fixed the eastern boundary of the great Asiatic continent.

10. *Nuove Osservazioni Geologiche sulle Rocce Anthracitifere delle Alpi;* del Commendatori ANGELO SISMONDA, Prof. di Min. nella Regia Universita di Torino. 26 pp., 4to, with colored maps. Turin, 1866.—Prof. Sismonda, in this paper, treats of the age of certain stratified rocks occurring among the metamorphic of the Alps of Savoy, which contain anthracite and plants of the Carboniferous age along with remains of animals of Liassic and Oolitic age. Sismonda concludes that there are three consecutive groups of these rocks; a lower, which is Liassic in its mollusks; a middle, with Liassic and Oolitic fossils; and above this a quartzose conglomerate and sandstone with anthracite, and supposed to be of the age of the Oxfordian clay. The Carboniferous plants are found both in the lower and upper.

11. *Ueber ein Æquivalent der takonischen Schiefer Nordamerika's in Deutschland und dessen geologische Stellung;* von Dr. H. B. GEINITZ und Dr. K. Th. LIEBE, Professoren in Dresden und Gera. 52 pp., 4to, with 8 lithographic plates and several wood-cuts.—The plates of this memoir contain figures of different Annelids and Fucoids from the slates near Wurzbach, which bear much resemblance to those that occur in rocks *called* Taconic in North America.

12. *Note on the genus Palæaster and other Fossil Starfishes,* with descriptions of some new species; by JAMES HALL. 24 pp., 8vo. From the Twentieth Report on the State Cabinet of Natural History. Published (to page 21) in advance of Report, Nov. and Dec., 1866.

13. *Descriptions of some new species of Crinoidea and other fossils* from the Lower Silurian strata of the age of the Hudson River Group and Trenton limestone; by JAMES HALL. Printed, in advance, from the Report on the State Cabinet for 1866, and issued Nov. 1866.

III. BOTANY AND ZOOLOGY.

1. *Catalogus Plantarum Cubensium, exhibens Collectionem Wrightianum aliasque minores ex Insula Cuba missas quas recensuit* A. GRISEBACH, Professor Göttingensis. pp. 301, 8vo. Leipsic, 1866. (Engelmann.) —Although printed a year ago (the preface bears the date of April, 1866), the derangements incident to the short war which last summer wrought such changes in Germany, in some way delayed until recently the publication of this little volume. It is now to be had of B. Westermann & Co., 440 Broadway, New York; and it is indispensable to those botanists who possess any part of Mr. Wright's rich Cuban collections of botanical specimens, which are cited by the numbers under which they were distributed. A goodly number of clerical or typographical errors (beyond those

indicated on pp. 287, 288), as also errors in the distribution, call for correction. It is to be hoped that Mr Wright will some day print a revised list in the order of their numbers. Meanwhile the writer of this notice will furnish to any possessors of these specimens who apply for them such corrections as he has been able to make in his own copy. As might have been expected the flora of Cuba proves to be very rich. This Catalogue contains—

Dicotyledons,	2350,	of which	781	are peculiar	to the	Island.
Monocotyledons,	634	"	148	"	"	"
Vascular Cryptogamia,	279	"	10	"	"	"
Total,	3263	"	939	"	"	"

And Mr. Wright's more recent explorations, which are still in progress, will largely increase the number. If Hayti could now be equally explored, the flora of the West Indies could be written with some approach to perfection.

Characters of the new species only (and these are very many) are given in this volume. The diagnoses of the new *Euphorbiaceæ* are, however, unfortunately omitted, having been published by anticipation, in the Nachrichten of the Göttingen Royal Society of Science. Now that we have, thanks to Professor Grisebach's studies, so good a foundation for Cuban botany, we may hope that our indefatigable explorer may crown his prolonged and laborious researches by a general revision of the flora of the island. A. G.

2. *Flora Australiensis*, Vol. III. *Myrtaceæ* to *Compositæ*, 1866.—This great work makes rapid progress in Mr. Bentham's able hands. The present volume comprises the largest and most difficult Australian order, the *Myrtaceæ*, and the usually paramount order *Compositæ*, these two filling a little more than three quarters of the 680 pages of this volume, which also contains the *Umbelliferæ* and the *Rubiaceæ*, usually of no small size. A. G.

3. *The Geographical Distribution of Mammals;* by Andrew Murray. 420 pp., 4to, with 105 chromo-lithographic maps. London, 1866. (Day & Son.)—This beautiful volume treats those subjects *in extenso* which are merely glanced at in the physical atlases of Johnston and others, including the distribution of fossil species according to their geological position, and discussions of the views of Agassiz and Darwin, without adopting either in full. The work extends to forty-three chapters, with an extended appendix and numerous cuts illustrating animal peculiarities.

Geological questions are discussed and maps given of the 100-fathom line of soundings; the effect of a depression of the land 600 feet; Tertiary and Quaternary formations; localities of glacial action; rising and falling of land of the present period; and the sargasso seas. The maps of mammal distribution then commence with the human race, chapter vii, p. 56, but two branches of which are acknowledged, the black and white, the latter including all except the negroes and Australians, with their affinities.

The completeness of the work may be judged from the extent to which groups and genera are located. Maps 7–10 are devoted to the distribution of monkeys; 13, to the lion; 14, to the tiger; 17, fossil hyenas; 18, existing hyenas; 26, bears; 29, hippopotamus (living and fossil);

30, swine; 34, goats; 35, sheep; 46, rhinoceros (living and extinct); 47, mastodons and elephants in Lower Miocene; 48, in Upper Miocene; 49, in Pliocene; and 50, existing elephants.

The appendix (pp. 312–412) is devoted to the classification of mammals proposed by different authors; a synonymic list of the species and their localities, distinguishing the extinct species; and mammals of special districts, as Spitzbergen, Nova Zembla, Greenland, Iceland, Sweden, France, Sahara, Japan, &c. North America is given under eight districts exclusive of Mexico.

A work of so much value, published in a style which precludes a return for the outlay, should have a place in the libraries of all who wish to encourage research in the cognate fields upon which the learned author is understood to be engaged. S. S. H.

4. *Observations on the Genus Unio, together with Descriptions of new species in the Family Unionidæ, and Descriptions of new species of the Melanidæ, Limneidæ, Paludinæ, and Helicidæ;* by Isaac Lea, LL.D. 146 pp., 4to, with 24 plates. Philadelphia. (Read before the Academy of Natural Sciences of Philadelphia, and published in their Journal.)—This volume is the eleventh in Dr. Lea's series on the Unionidæ. Like the preceding, it contains very large additions to the number of species, and is beautifully and generously illustrated. The introduction states that the number of new species of Unionidæ here described is 180, and of the other groups mentioned above, 118. The former are mainly from the Southern States, a few from Western Asia, and Lake Nyassa in Central Africa. The univalves are mostly of the U. States, but some are from Central America and Asia.

5. *An Inquiry into the Zoological relations of the first discovered traces of Fossil Neuropterous Insects in North America: with Remarks on the difference of structure in the wings of living Neuroptera;* by S. H. Scudder. 20 pp., 4to. From Vol. I of the Mem. of the Bost. Soc. Nat. Hist., Jan. 1865.—The paper discusses the characters of the fossil insects from the coal rocks of Illinois, described in vol. xxxvii of this Journal, with results of great interest to science.

6. *On the Osteology and Myology of Colymbus torquatus;* by Elliott Coues, A.M., M.D., Brevet Capt. and Assist. Surgeon, U.S. Army. 42 pp., 4to. From vol. I of the Mem. of the Bost. Soc. Nat. Hist., Nov. 1866.

7. *Notes on the Zygænidæ of Cuba;* by A. R. Grote. 18 and 38 pp., 8vo, with plates. From the Proceedings of the Entomological Society of Philadelphia, Part I, July, 1866, and Part II, Jan., 1867.

IV. ASTRONOMY.

1. *On the Obscuration of the Lunar Crater "Linné;"* by W. B. Birt, Esq.—The interesting phenomenon of a change in the appearance of the crater "Linné" was communicated to me by Herr Schmidt, the Director of the Observatory at Athens, an extract from whose letter is as follows:

"For some time past I find that a lunar crater situated in the plain of the *Mare Serenitatis* has been invisible. It is the crater which Mädler named Linné, and is in the fourth section of Lohrmann, under the sign A. I have known this crater since 1841, and even at the full it has not been difficult to see. In October and November, 1866, at its epoch of maximum visibility, i. e., about the time of the rising of the sun on its horizon, this deep crater, whose diameter is 5·6 English miles, had completely disappeared, and in its place there was only a little whitish luminous cloud. Be so kind as to make some observations on this locality."

The earliest information respecting the crater I received from Mr. Buckingham, who favored me with a copy of a photograph taken by him on November 18, 1866. On this photograph the place of "Linné" is visible, but faint. I have during the last lunation received records of observations from the following gentlemen: Doctors Mann and Tietjen, and Messrs. Talmage, Webb, Slack, Grover, and Jones. On the 13th, when the terminator passed over the east boundary of the *Mare Serenitatis*, the place of "Linné" was seen by Messrs. Webb and Talmage; Mr. Webb's aperture 9¼-inch silvered glass reflector, and Mr. Talmage's 10-inch refractor of Mr. Barclay at Leyton. Mr. Webb described the appearance as an ill-defined whitishness on the site of "Linné." Mr. Talmage recorded "a dark circular cloud." The exact position of these appearances was carefully ascertained afterward and found to agree with the place of "Linné." Doctor Mann and myself at Leyton were prevented by a thin veil of cirrus seeing the "cloud" recorded by Mr. Talmage. With smaller apertures both Mr. Grover and myself were unable to detect the slightest trace of "Linné," while the small crater "Linné B" of Beer and Mädler, and also Bessel, were very distinct *with the shadows within them.* On the following evening, December 14th, observations were made by Messrs. Webb, Slack, Grover, and Birt. A white spot was seen in the position of "Linné." Mr. Webb described it as the most conspicuous object on the east half of the *Mare Serenitatis.* Mr. Slack saw a whitish spot not remarkably bright, but could see no trace of a crater. Mr. Grover recorded "a tolerably defined roundish whitish speck," but he could not see the interior or margin of the crater, and "in this respect the spot showed very different from Bessel and other craters which were well seen." My own observations perfectly agree with the above. I estimated the light at 3°. On the 15th the spot was brighter, and I obtained the measures recorded below. On the 16th Messrs. Jones and Grover described the appearance as a white spot not over bright.

On the 20th Professor Foërster and Dr. Tietjen observed "Linné" with the Berlin refractor. The following is the translation of the letter which I received from Dr. Tietjen, dated Berlin, 21 December, 1866:

"On viewing the moon last night about 13^h M.T. Berlin with our refractor, in order to convince ourselves of the disappearance of the crater 'Linné,' Professor Foërster and myself perceived that crater very distinctly. If, therefore, an obscuration has taken place, on which certainly no doubt can exist, as it is affirmed by so competent an authority as Herr Schmidt of Athens, it has evidently now ceased."

Although Dr. Tietjen considers that the obscuration *has ceased*, it does not appear that either he or Professor Foërster *has seen into* the crater.

The whole of the observations are so accordant among themselves, and the measures appended so clearly indicate the white spot to be larger than the crater "Linné," as to leave no doubt that a change of some kind has taken place; and this conclusion appears to be supported by previous records which are here appended:

Date.	Authority.	Brightness.
1653,	Riccioli,	°
1788, Nov. 5,	Schröter,	0·5
1823, May 28,	Lohrmann,	7·0+
1831, Dec. 12, 13,	Beer and Mädler,	6·0
1858, Feb. 22,	De la Rue,	5·0
1865, Oct. 4,	"	5·0
	Rutherfurd,	6·0
1866, Nov. 18,	Buckingham,	2·0

The last four determinations of brightness are from photographs. There is some uncertainty in determining this element on the prints. Schröter, in plate IX of his Selenophotographische Fragmente, gives a large dark spot in the place of "Linné;" and the Rev. T. W. Webb informs me that "Linné" is not to be found on Russell's globe or maps, 1797, from which it may be inferred that the crater has previously been obscured.

The following measures were made during the last lunation:

Date. 1866.	Dionysius.	Linné.	Mag.	Miles.	Brightness.
Dec. 15	14″·70	11″·61	0·79	10·9	4°
18	14·13	7·07	0·50	6·9	5·5
19	13·95	7·32	0·52	7·2	5
21	13·32	6·75	0·51	7·0	4

The numbers in column 4 headed "Mag." are obtained by dividing the measures of "Linné" by the measures of the standard spot "Dionysius." The normal magnitude of "Linné" is 0·40 ("Dionysius" being unity) as determined by two independent methods. The numbers in column 5 headed "Miles" are not absolute, but only relative as compared with "Dionysius," by means of the numbers in column 4. "Dionysius," according to Lohrmann, is 13·8 English miles, and "Linné," according to Schmidt, 5·6 English miles in diameter. During the lunation no trace of the *crater* was seen.—*Monthly Notices Roy. Astr. Soc.*, Jan. 11, 1867.

2. *Shooting Stars seen in Colorado.*—The Denver News gives the following numbers of meteors seen at that place (N. lat. 39° 40′, W. long. 105°) in intervals of five minutes at different times on the morning of Nov. 14th, 1866. The number of observers is not stated.

Time	Meteors	Time	Meteors	Time	Meteors
At 12h 0m,	5 meteors.	At 1h 25m,	5 meteors.	At 3h 30m,	5 meteors.
12 20	3 "	2 0	5 "	4 0	12 "
12 30	7 "	2 30	14 "	5 15	10 "
12 45	9 "	2 45	11 "		
1 0	4 "	3 0	21 "	Total in 65m,	101 "

3. *Astronomical and Meteorological Observations made at the United States Naval Observatory during the year* 1864. Captain J. M. Gilliss, U.S.N., Superintendent. 524 pp., 4to. Published by authority of the Hon. Secretary of the Navy. Washington, 1866.—This important volume contains the following tables: (1.) Observations with the Meridian Transit Instrument; (2.) ib. with the Mural Circle; (3.) ib. with the Equatorial; (4.) Mean right ascensions, for 1860·0 of stars observed with the Transit; (5.) Mean declination, obs. with the Mural Circle; (6.) Right ascensions, declinations, and semi-diameters of the Sun, Moon, and Planets; (7.) Constants for the reduction of fixed stars; (8.) Catalogue of stars observed in 1864; (9.) Meteorological observations.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Additional Gifts to Science from George Peabody, Esq.*—Since the notice of Mr. Peabody's recent donations to science, which appeared in the January number of this Journal, this gentleman has given about $2,000,000 for the promotion of education in the South and Southwest. This munificent gift was accompanied by the following letter to the Trustees of the fund:—

To Hon. Robert C. Winthrop, of Massachusetts; Hon. Hamilton Fish, of New York; Right Rev. Charles P. McIlvaine, of Ohio; General U. S. Grant, of the United States Army; Admiral David G. Farragut, of the United States Navy; Hon. William C. Rives, of Virginia; Hon. John H. Clifford, of Massachusetts; Hon. William Aiken, of South Carolina; William M. Evarts, Esq., of New York; Hon. William A. Graham, of North Carolina; Charles Macalester, of Pennsylvania; George W. Riggs, Esq., of Washington; Samuel Wetmore, Esq., of New York; Edward A. Bradford, Esq., of Louisiana; George N. Eaton, Esq., of Maryland; and George Peabody Russell, Esq., of Massachusetts.

Gentlemen: I beg to address you on a subject which occupied my mind long before I left England, and in regard to which, one at least of you (the Hon. Mr. Winthrop, the distinguished and valued friend to whom I am so much indebted for cordial sympathy, careful consideration, and wise counsel in this matter) will remember that I consulted him immediately upon my arrival in May last.

I refer to the educational needs of those portions of our beloved and common country which have suffered from the destructive ravages, and the not less disastrous consequences of civil war.

With my advancing years my attachment to my native land has but become more devoted. My hope and faith in its successful and glorious future have grown brighter and stronger, and now, looking forward beyond my stay on earth, as may be permitted to one who has passed the limit of three score and ten years, I see our country united and prosperous, emerging from the clouds which still surround her, taking a higher rank among the nations, and becoming richer and more powerful than ever before.

But to make her prosperity more than superficial, her moral and intellectual development should keep pace with her material growth; and in those portions of our nation to which I have referred, the urgent and pressing physical needs of an almost impoverished people must for some years preclude them from making, by unaided effort, such advances in education, and such progress in the diffusion of knowledge among all classes, as every lover of his country must earnestly desire.

I feel most deeply, therefore, that it is the duty and privilege of the more favored and wealthy portions of our nation to assist those who are less fortunate; and, with the wish to discharge so far as I may be able my own responsibility in this matter, as well as to gratify my desire to aid those to whom I am bound by so many ties of attachment and regard, I give to you, gentlemen, most of whom have been my personal and especial friends, the sum of one million of dollars, to be by you and your successors held in trust, and the income thereof used and applied in your discretion for the promotion and encouragement of the intellectual, moral, or industrial education among the young of the more destitute portions of the Southern and Southwestern States of our Union; my purpose being that the benefits intended shall be distributed among the entire population, without other distinction than their needs and the opportunities of usefulness to them.

Besides the income thus derived, I give to you permission to use from the principal sum, within the next two years, an amount not exceeding forty per cent.

In addition to this gift I place in your hands bonds of the State of Mississippi, issued to the Planter's Bank, and commonly known as Planter's Bank Bonds, amounting, with interest, to about eleven hundred thousand dollars, the amount realized by you from which is to be added to and used for the purposes of this trust. * * * * * * *

The details and organization of the trust I leave with you, only requesting that Mr. Winthrop may be Chairman, and Governor Fish and Bishop McIlvaine Vice-Chairmen of your body; and I give to you power to make all necessary by-laws and regulations, to obtain an act of incorporation, if any shall be found expedient, to provide for the expenses of the trustees and of any agents appointed by them, and generally, to do all such acts as may be necessary for carrying out the provisions of this trust.

All vacancies occurring in your number by death, resignation, or otherwise, shall be filled by your election, as soon as conveniently may be, and having in view an equality of representation so far as regards the Northern and Southern States.

I furthermore give to you the power, in case two-thirds of the trustees shall at any time, after the lapse of 30 years, deem it expedient, to close this trust, and of the funds which at that time shall be in the hands of yourselves or your successors, to distribute not less than two-thirds among such educational or literary institutions, or for such educational purposes as they may determine, in the States for whose benefit the income is now appointed to be used. The remainder may be distributed by the trustees for educational or literary purposes wherever they may deem it expedient.

In making this gift I am aware that the fund derived from it can but aid the States which I wish to benefit in their own exertions to diffuse the blessings of education and morality. But if this endowment shall encourage those now anxious for the light of knowledge, and stimulate to new efforts the many good and noble men who cherish the high purpose of placing our great country foremost, not only in power, but in the intelligence and virtue of her citizens, it will have accomplished all that I can hope.

With reverent recognition of the need of the blessing of Almighty God upon this gift, and with the fervent prayer that, under his guidance, your counsels may be directed for the highest good of present and future generations in our beloved country, I am, gentlemen, with great respect, your humble servant, George Peabody.

Washington, Feb. 7, 1867.

More recently Mr. Peabody has given $140,000 to the Essex Institute in Salem, Mass., for the promotion of the Natural and Physical Sciences in his native county. Of this sum $100,000 is to be kept as a permanent fund, and the income to be devoted to various branches of science. The remainder of the gift will be chiefly expended on the Museum of Natural History. Mr. Peabody's letter to his Trustees announcing this donation was as follows:—

Salem, Feb. 26, 1867.

To Francis Peabody, Esq., Prof. Asa Gray, Wm. C. Endicott, Esq., Geo. Peabody Russell, Esq., Prof. O. C. Marsh, Henry Wheatland, A. C. Goodell, Jr., James R. Nichols, and Henry C. Perkins, Esqs.

Gentlemen: As you will perceive by the inclosed instrument of Trust, I wish to place in the hands of yourselves and your successors, the sum of one hundred and forty thousand dollars, for the promotion of Science and Useful Knowledge in the County of Essex.

Of this, my native county, I have always been justly proud, in common with all her sons, remembering her ancient reputation, her many illustrious statesmen, jurists and men of science; her distinguished record from the earliest days of our country's history, and the distinction so long retained by her, as eminent in the education and morality of her citizens.

I am desirous of assisting to perpetuate her good name through future generations, and of aiding through her means in the diffusion of science and knowledge; and, after consultation with some of her most eminent and worthy citizens, and encouraged by the success which has already attended the efforts and researches of the distinguished Scientific Association of which your Chairman is President, and with which most of you are connected, I am led to hope that this gift may be instrumental in attaining the desired end.

I therefore transmit to you the inclosed instrument, and a check for the amount therein named ($140,000), with the hope that this Trust, as administered by you and your successors, may tend to advancement in intelligence and virtue, not only in our good old county of Essex, but in our Commonwealth, and in our common country.

I am, with great respect, your humble servant,

(Signed) George Peabody.

Mr. Peabody has, moreover, recently given $20,000 to the Massachusetts Historical Society, and $15,000 each to Newburyport, Mass., and Georgetown, D. C., to found free public libraries in those cities.

These various gifts increase the amount of Mr. Peabody's recent benefactions to science and education in this country to nearly four millions dollars,—a truly noble and unparalleled record of private munificence.

2. *Ascent of Mount Hood, Oregon;* by the Rev. H. K. Hines.*—In September of 1864, in company with three gentlemen of Vancouver, I first attempted to reach the summit of Mount Hood. On reaching an altitude about 800 feet below the summit, a dense cloud came sweeping against the north side of the mountain, and, drifting rapidly over it, instantly enveloped us in its folds. The air changed suddenly to a fierce cold. The driving snow filled the air so entirely that a cliff of rocks 300 feet high, standing not more than fifty feet from us, was invisible.

* From the Proceedings of the Royal Geographical Society, March 23, 1867.

To go up or to go down, was, for the time, alike impossible. One of my companions was chilled nearly to insensibility, but we struggled against the tempest for hours, unwilling to be defeated in our purpose to reach the summit.

On the morning of the 24th of July, 1866, in company with three gentlemen of the city of Portland, Oregon, I set out full of determination to stand upon the summit, if energy and endurance could accomplish the feat. Our rendezvous was at the house of a Canadian, who, fourteen years before, had erected a cabin at the place where the emigrant road leaves the mountains and enters the valley of the Willamette. From this place the track enters the mountains along the gorge through which flows a dashing river about 300 feet in width, wh ch r ses beneath the glaciers of Mount Hood. Up this stream we travelled for 30 miles, when, leaving the gorge, the way makes a *détour* to the south to gain the summit ridge. Here is the celebrated "Laurel Hill." For three or four miles the ascent is continuous, and in many places very steep.

Reaching the top of Laurel Hill we were on the general summit of the range: a comparative level of perhaps 10 miles in width, whose general character is that of a swamp or marsh. On this plateau is a dense and grand growth of fir, cedar (*Thuja gigantea*, Nutt.), pine and kindred evergreens, with an almost impenetrable undergrowth of laurel (*Rhododendron maximum*, Hook). Straggling rays of sunlight only here and there find way through the dense foliage to the damp ground. Passing over this level we crossed several bold clear streams, coursing down from the direction of Mount Hood, and then, turning to the left, we took an old Indian trail leading in the direction of the mountain. After a ride of an hour and a half up a continuous and steep ascent, we came to an opening of scattered trees which sweeps around the south side of the mountain. It was about five o'clock when we emerged from the forest, and stood confronting the wonderful body of rock and snow which springs up from the elevation.

We selected a place for our camp on a beautiful grassy ridge between one of the main affluents of the Deschutes river and one of the Clackamas, and which nearly constitutes the dividing ridge of the mountain. Having erected here a hut of boughs and gathered fuel for a large fire during the night, we spread our blankets on the ground and slept well until the morning. We picketed our horses in this place. At seven o'clock of Thursday we were ready for the ascent. For the first mile and a half the ascent was very gradual and easy, over a bed of volcanic rock, decayed and intermixed with ashes. Huge rocks stood here and there, and occasionally a stunted juniper found a precarious foothold; some beautiful variegated mosses were also seen clinging to little knolls of sand. We soon reached the foot of a broad snow-field, which sweeps around the south side of the mountain several miles in length, and extending upward to the immediate summit. The first part of this ascent is comparatively easy, being smooth, and only in places so steep as to render the footsteps uncertain. Near the upper edge of this field of snow, the deep gorges, from which flow affluents of the streams Deschutes on the right, and Sandy river on the left, approach each other and seem to cut down into the very foundation of the mountain. The waters were rushing from beneath the glaciers, which at their upper extremity were rent and broken into fissures and caverns of unknown depths.

The present summit of the mountain is evidently what was long since the northern rim of an immense crater, which could not have been less than three miles in diameter. The southern wall of the crater has fallen completely away, and the crater itself become filled with rock and ashes overlaid with the accumulated snows of ages, through the rents and chasms of which now escape smoke, steam and gases from the pent-up fires below. The fires are yet so near that many of the rocks which project upward are so hot that the naked hand cannot be held upon them. Just at the southwest foot of the circular wall, now constituting the summit, and at a distance of near 2000 feet from its extreme height, is now the main opening of the crater. From this a column of steam and smoke is continually issuing, at times rising and floating away on the wind, at other times rolling heavily down the mountain. Into this crater we descended, as far as it was possible to go without ropes or a ladder. The descent was stopped by a perpendicular precipice of ice 60 or 70 feet high, resting below on a bed of broken rock and ashes so hot as immediately to convert the water, which dripped continually from the icy roof 100 feet above, into steam. The air was hot and stifling.

At this point the real peril of the ascent begins. It leads out and up the inner wall of what was once the crater, and near 1000 feet of it is extremely steep. The whole distance is an ice-field, the upper limit of a great glacier which is crushing and grinding its slow journey down the mountain far to the right. About 700 feet from the summit a *crevasse*, varying from 5 to 50 feet in width, and of unknown depth, cuts clear across the glacier from wall to wall. There is no evading it. The summit cannot be reached without crossing it. Steadily and deliberately poising myself on my staff, I sprang over the chasm at the most favorable place I could select, landing safely on the declivity 2 or 3 feet above it, and then with the staff assisted the others to cross. The last movement of 15 feet had considerably changed the prospect of the ascent. True, the crevasse was passed, but we were thrown directly below a wall of ice and rocks 500 feet high, down which masses, detached by the heat of the sun, were plunging with fearful velocity. To avoid them it was necessary to skirt the crevasse on the upper side for a distance, and then turn diagonally up the remaining steep. It was only 700 feet high, but it was two hours' sinewy tug to climb it. The hot sun blazed against the wall of ice within two feet of our faces, and the perspiration streamed from our brows, but on nearing the summit the weariness seemed to vanish, and with a feeling of triumph we bounded upon the pinnacle of the highest mountain in North America.

The summit was reached at about the center of the circular wall which constitutes the extreme altitude, and it was so sharp that it was impossible to stand erect upon it. Its northern face is an escarpment several thousand feet high. I could only lie down on the southern slope, and, holding firmly to the rocks, look down the awful depth. A few rods to the west was a point 40 or 50 feet higher, to the summit of which we crawled, and then discovered that 40 or 50 rods to the east was a point still higher, the highest of the mountain. We crawled back along the sharp escarpment, and in a few minutes stood erect on the highest pinnacle. This we found to be 17,640 feet high, the thermometer standing at 180°, about 40 feet below the summit, when the water boiled—giving 32 degrees of depression. This estimate makes Mount Hood higher than any summit of Europe or North America.

The view from the summit was magnificent. From south to north the whole line of the Cascade Range is at once under the eye, from Diamond Peak to Ranier, a distance of not less than 400 miles. Within that distance are Mounts St. Helen's, Baker, Jefferson, and the Three Sisters; making, with Mount Hood, eight snowy peaks. Eastward the Blue Mountains are in view, and lying between us and them are the broad plains watered by the Deschutes, John Day's, and Umatilla rivers. On the west the piny crests of the coast range cut clear against the sky, with the Willamette valley sleeping in quiet beauty lying at their feet. The broad silver belt of the Columbia winds through the evergreen valley toward the ocean. Within these limits is every variety of mountain and valley, lake and prairie, bold beetling precipices and graceful rounded summits blending and melting away into each other. It was with reluctance that at length we took the first step down the declivity.

The descent to the great crevasse, though much more rapidly accomplished, was quite as perilous as the ascent from it. We were now approaching the gorge, and a mis-step might precipitate us into unfathomed depths. Less than half an hour was sufficient to retrace the weary climbing of two hours, and standing for a moment on the upper edge of the chasm, I bounded over it where it was 8 feet wide. The impetus of the leap sent me sliding a long distance down the icy steep below.

In two hours and a half from the summit we were in our camp. * * *

3. *Meeting of the National Academy of Sciences in January,* 1867.—At the meeting of the National Academy held in the capitol at Washington in January last, commencing with the 23d of the month, the following papers were presented:

(1.) Report on the galvanic action from the association of zinc and iron by a Committee of the Academy.

(2.) Report on the deterioration and means of improving Greytown Harbor, Nicaragua, by a Committee of the Academy.

(3.) Report on proving and gauging spirits subject to duties, by a Committee of the Academy.

(4.) On some of the phenomena presented by the planet Venus when near to her inferior conjunction, by S. Alexander.

(5.) On the longitude between Europe and America and the velocity of galvanic signals in the Atlantic Cable, by B. A. Gould.

(6.) On the principles of the classification of fishes, by L. Agassiz.

(7.) Recent observations on the Glacial Phenomena of the Basin of the Great Lakes, by J. S. Newberry.

4. *Library and Geological specimens of Prof. H. D. Rogers.*—At a meeting of the Massachusetts Institute of Technology last December, the scientific library and the collection of geological specimens of the late Prof. Henry D. Rogers of the University of Glasgow, were presented to the Institute.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *A Manual of Inorganic Chemistry arranged to facilitate the experimental demonstration of the Facts and Principles of the Science;* by Charles W. Eliot, Professor of Analytical Chemistry and Metallurgy, and Frank H. Storer, Professor of General and Industrial Chemistry in the Massachusetts Institute of Technology. Boston. Printed for the authors. 1867.—We have received advance sheets of a good portion of this work, which will be completed in June. A careful examination of the 420 pages before us leads us to believe that the book will greatly contribute to extend the study of chemistry in this country. There are comparatively few students who can easily master chemistry under the system of teaching that now prevails. It is, on the one hand, impossible to make rapid progress in the acquisition of the facts of the science without a knowledge of principles; and on the other hand, principles cannot take a firm hold in the mind except as demonstrated by facts. The true method of teaching chemistry is in imitation of the process by which the science has been created, and this is primarily one of experiment and induction.

The beginner may naturally and easily put himself in the condition of an inquirer, but it is only by efforts that would exhaust and dishearten most young learners who have not naturally a special fondness for the science, that he can regard the subject from the standpoint of the sage. In the book under notice, the authors open with a brief introduction of four pages, in which the objects and scope of chemistry are concisely defined. Then they enter at once upon the consideration of the science itself, not by laying down a tedious series of general propositions or by toiling over notations, nomenclatures, and classifications, but by an account of common phenomena which are analyzed after the natural method. A few simple experiments open the way to the study of air and of its elements, of water and its ingredients. Following these, the compounds of these elements with each other, viz., the oxyds of nitrogen and ammonia, are discussed. By means of simple experiments the facts of definite combination by weight and volume are brought out, and following these demonstrations, on page 27, the discussion of atoms and molecules is introduced. In similar manner notation, typical and dualistic formulæ, dissociation, homologous series, and the most important considerations of chemical physics are introduced in their appropriate places.

The work is admirably adapted for the present transition state of the science. While not rejecting the established modes of expression in which the literature of chemistry is chiefly to be found, it presents, in our opinion, fully as much of the newer views as are appropriate to an elementary work. The student who has mastered this treatise is fitted thereby to study with profit and zest the writings of Wurtz, Kekule, Odling, Hofmann, and Frankland.

The adaptation to experimental teaching meets a want which has been pressingly felt, and should ensure the establishment of new working laboratories in our higher schools, as well as the practical drilling of a much larger number of students in those now in operation. The experiments, more than 200 in number, are all well described and easy of execution with a comparatively small outlay for materials. They are intended to be repeated by the students themselves under proper direction, and this mode of instruction which engages and disciplines the perceptive faculties and unfolds the methods of investigation is one which is more and more coming to be regarded as essential to a successful system of education.

The book is not only excellently adapted for the instruction of beginners, but, as far as its size admits, reflects very satisfactorily the present state of the science. It is entirely free from the puerilities, the blunders, and the contradictions which are so prominent in the majority of our elementary text-books. S. W. J.

2. *Traité des Matières Colorantes, comprenant leurs applications à la Teinture et à l'Impression, et des notices sur les fibres Textiles, les Epaississants, et les Mordants;* publié sous les auspices de la Société Industrielle de Mulhouse et avec le concours de son Comité de Chimie. Par M. P. Schutzenberger, Docteur, &c. Paris. (Victor Masson et Fils.) 2 vols. 8vo, avec figures et échantillons intercalés dans le texte.—Though many books have been published on dyeing and printing, there has long been a want of some sound, comprehensive work representing the present state of knowledge respecting these arts. The great work of Persoz, Traité de l'Impression des Tissus, may still be considered as the only full, standard treatise on the subject, but its publication dates so far back that it would require at least a whole volume of *addenda* to bring it forward to the present date. The last twenty years have added something to our knowledge of natural dyes, while most of the numerous artificial colors have been discovered within this period. Many changes have been made in the mixtures used in printing, and new plans have come into use for the subsequent operations. Thus the "aging box" is now made to shorten materially the time required for "aging" goods printed in the "madder style." The aniline colors have made an immense addition to the resources of the dyer and printer. Yet the world has been growing all the while, and these colors have found room for themselves without wholly displacing other things. As gunpowder still holds its own in spite of the extravagant prophecies about gun-cotton, so the enthusiastic hopes of some noted chemists respecting artificial dyes are very far from being realized. It is likely to be a long time before the coal mines of England will supply all the world with all needed dyes. Indigo, cochineal, and madder have lost little of their importance, the colors derived from lichens are still in use, and even carthamus has something more than a historic value.

What is lacking in the older works on dyestuffs is, in a great measure, supplied by the treatise now before us. The author says of the part which he has assigned to himself:—"Le but principal de cet ouvrage est donc la description des matières tinctoriales au point de vue de leurs propriétés chimiques, de leur préparation, et des moyens de determiner leur pureté et leur richesse." He writes not as a compiler making a book out of an indigested mass of clippings from other books, but as one who is himself an investigator, as one who has something fresh to say and knows how to say it in proper compass. In fact he comes up to our expectations of one living at a great industrial center and having the opportunities, the qualifications, and the rare assistance thus set forth in the preface :—" Onze années passées à Mulhouse comme professeur de chimie pure et appliquée, et comme directeur d'un laboratoire d'enseignment pratique, n'ont permis de réunir les éléments de ce traité. La Société Industrielle, toujours prête à fixer son attention sur tout ce qui est réellement utile, a bien voulu s'interesser au projet de ce travail, et m'offrir le concours effectif de ses lumières. La plupart des articles du premier volume et une partie de ceux du second ont été lus et discutés en séance du Comité de chimie."

We rejoice that it is no longer necessary to plead total ignorance when asked to recommend good, live books on tinctorial science and art. The technological student and the enlightened practical man may here find a really standard, recent work on the subject. It is true that the scientific novice might desire more, and more particular information on some points. Thus the so-called arseniate, silicate, and stannate of soda figure largely in practical printing, and yet one may search books long and almost in vain to find any tolerable account of their actual composition and mode of manufacture. If we examine the articles in the market that work best, we find that the arseniate is not the salt known to chemists by that name, but an anhydrous arseniate neutral to litmus and containing three equivalents of soda to two equivalents of arsenic acid; that the silicate is not the normal salt, but an indefinite waterglass combining one equivalent of soda with from two to three equivalents of silica; that the stannate contains a considerable excess of caustic alkali. For want of accurate knowledge on this last matter, a large establishment that we know of formerly lost several thousand dollars a year by persevering in a vicious mode of manufacturing the stannate, whereby only one-half of the tin used was obtained in solution.

Mr. Schutzenberger passes by the more common chemicals even more hastily than many other writers. But it is some compensation that he thereby gains the more room for other interesting and somewhat novel matter. He dwells much more fully than usual on the fact that such substances as hematin, quercitrin, and brazilin exist in nature as easily soluble glucosids, and not as the disengaged products always described in the books as very slightly soluble in cold water; and so the student will no longer be puzzled to understand why a decoction of logwood or Lima wood may be concentrated to a high degree without depositing the coloring matter. Though each one may find more conciseness on some points than he could have desired, we think on the whole the work will prove to all uncommonly full and satisfactory. J. M. O.

3. *Descriptive Astronomy;* by GEORGE F. CHAMBERS, F.R.A.S. (Clarendon Press Series). Macmillan & Co., London, 1867. 8vo, pp. xl, and 816.—The aim of the writer, who is an amateur astronomer, was to prepare a work that at one and the same time should be attractive to the general reader, serviceable to the student, and handy for purposes of reference to the professional astronomer. Especial pains were taken to present the latest information on all branches of the science.

The work is profusely illustrated, and thus is made quite attractive for popular reading. Notwithstanding the great difficulty of representing such delicate objects as comets and nebulæ by wood-cuts, the artists and publishers have succeeded remarkably well. The author does not encroach upon the domain of physical and practical astronomy by the use of formulas, as he seems to have most carefully avoided them. For a large class of readers the work would be thus no doubt much more desirable. This is made up to the professional astronomer by the multitude of tables, references, constants, &c., with which the book is crowded. Every person who owns or uses a telescope should have this work. We would call special attention to the chapters on comets, clusters and nebulæ, and celestial photography, and also to the catalogue of celestial objects available for small telescopes. Being prepared by a practical astronomer, he has in general given just that information which is convenient in the observatory. The three chapters on Meteoric Astronomy are, however, unworthy of a place in the book.

4. *Études et Lectures sur l'Astronomie*, par CAMILLE FLAMMARION. Tome I. 18mo, pp. 262. Paris, 1867. (Gauthier-Villars.)—This is a collection of several very interesting articles, written originally for the Cosmos and the Revue Contemporaine, giving the recent progress of astronomical science. The principal subjects are, the Nature and Physical Constitution of the Sun, the Minor Planets, Comets, Eclipses, Terrestrial Magnetism, Shooting Stars, the Nebula and Cosmogony. At the end of the volume is a celestial chart giving the apparent paths of the planets during the year 1867, a device which we heartily commend to almanac makers.

5. *Weights and Measures according to the Decimal System, with tables of conversion for Commercial and Scientific uses*; by B. F. CRAIG, M.D. 48 pp., 16mo. New York, 1867. (D. Van Nostrand.)—A convenient and handsomely printed little manual intended to aid in converting the common weights and measures into those of the French or decimal system and vice versa. The values are given up to 9 multiples, first of the different English weights and measures, with the corresponding values in the decimal system; and then of the decimal weights and measures with the corresponding values in the English weights and measures.

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