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Ser. 3
v. 9
Jan.-June
1875

THE

AMERICAN JOURNAL

OF

SCIENCE AND ARTS.

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THIRD SERIES.

VOL. IX.–[WHOLE NUMBER, CIX.]

Nos. 49—54.

JANUARY TO JUNE, 1875.

WITH SEVEN PLATES.

NEW HAVEN: EDITORS.

1875.

MISSOURI BOTANICAL
GARDEN LIBRARY

PRINTED BY TUTTLE, MOREHOUSE & TAYLOR, 221 STATE ST.

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SCIENTIFIC INTELLIGENCE.

ERRATUM.—Page 48, 19 l. from foot, for 63″·1 read 64″·1.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. I.—*Results derived from an examination of the United States Weather Maps for* 1872 *and* 1873; by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. SECOND PAPER. With Plate I.

(Read before the National Academy of Sciences, Philadelphia, Nov. 3, 1874.)

Direction and velocity of the wind within areas of maximum pressure.

IN order to deduce from the weather maps the laws of the wind's motion within an area of maximum pressure, I proceeded in substantially the same manner as in the case of areas of low barometer, described in my first article, page 6 (see this Journal, July, 1874). I selected all those cases in which an area of maximum pressure, or high barometer, was so situated that the direction and velocity of the wind were given at a considerable number of stations for at least half of the entire area. Then placing a wire cross upon one of the weather maps over the center of an area of high barometer, with the wires pointing northeast and southwest, the area was divided into four quadrants, which are designated as the north, east, south and west quadrants. Then beginning with the west quadrant, I counted the number of stations at which the wind was reported from the north, also the number of observations from the northeast, the east, southeast, etc.; and in like manner for each of the four quadrants. The velocity of the wind for the stations of observation in the different quadrants was also noted. The same was done with each of the weather maps which furnished an example suited to this comparison. The total number of cases derived from the weather maps of two years (1872–3) was 188. All the observations made near the point of maximum pressure were rejected; generally all the stations included with the first isobar. Also no observations were employed beyond the isobar 30 00, and generally none beyond the isobar 30·10. I then found by addition the aggregate number of observations for each direction of the wind in the several quadrants, and from these numbers computed the wind's average direction for each quadrant. The average velocity of the wind for each quadrant was also determined. The following table shows the resulting velocities and directions, and I have added a line showing the angle which the wind's direction makes with a radius drawn from the point of greatest pressure.

For high barometer.

	West quadrant.	South quadrant.	East quadrant.	North quadrant.
Velocity of wind,	5·22 miles.	6·02 miles.	6·48 miles.	6·13 miles.
Direction of wind,	S. 63° 0′ E.	N. 29° 55′ E.	N. 36° 59′ W.	S. 59° 15′ W.
Angle with radius,	27° 0′	29° 55′	53° 1′	59° 15′

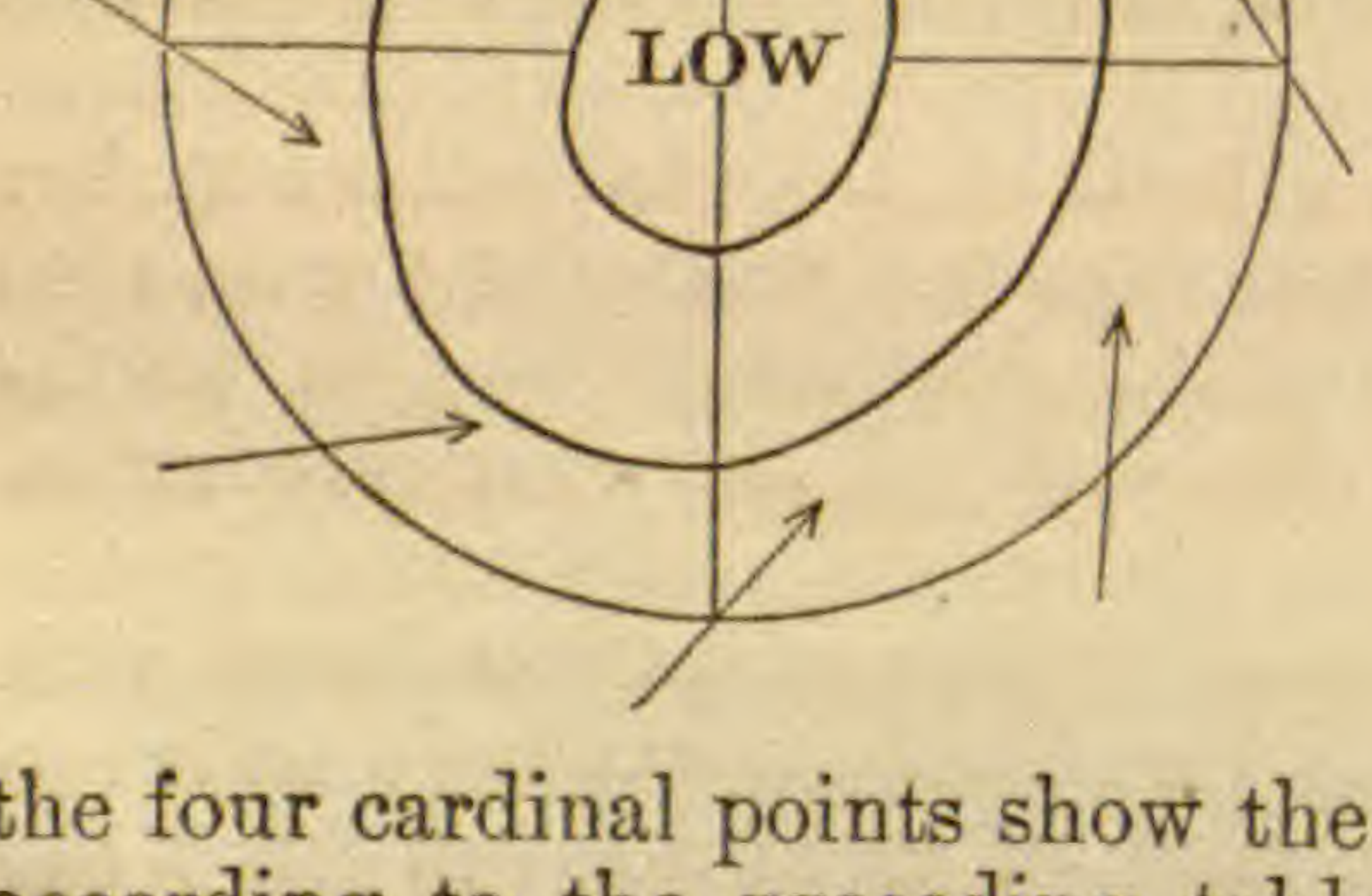
The importance of these results will be more apparent if we contrast them with the results obtained for areas of low barometer as given in my former article, pages 6–9. These results are as follows:

For low barometer.

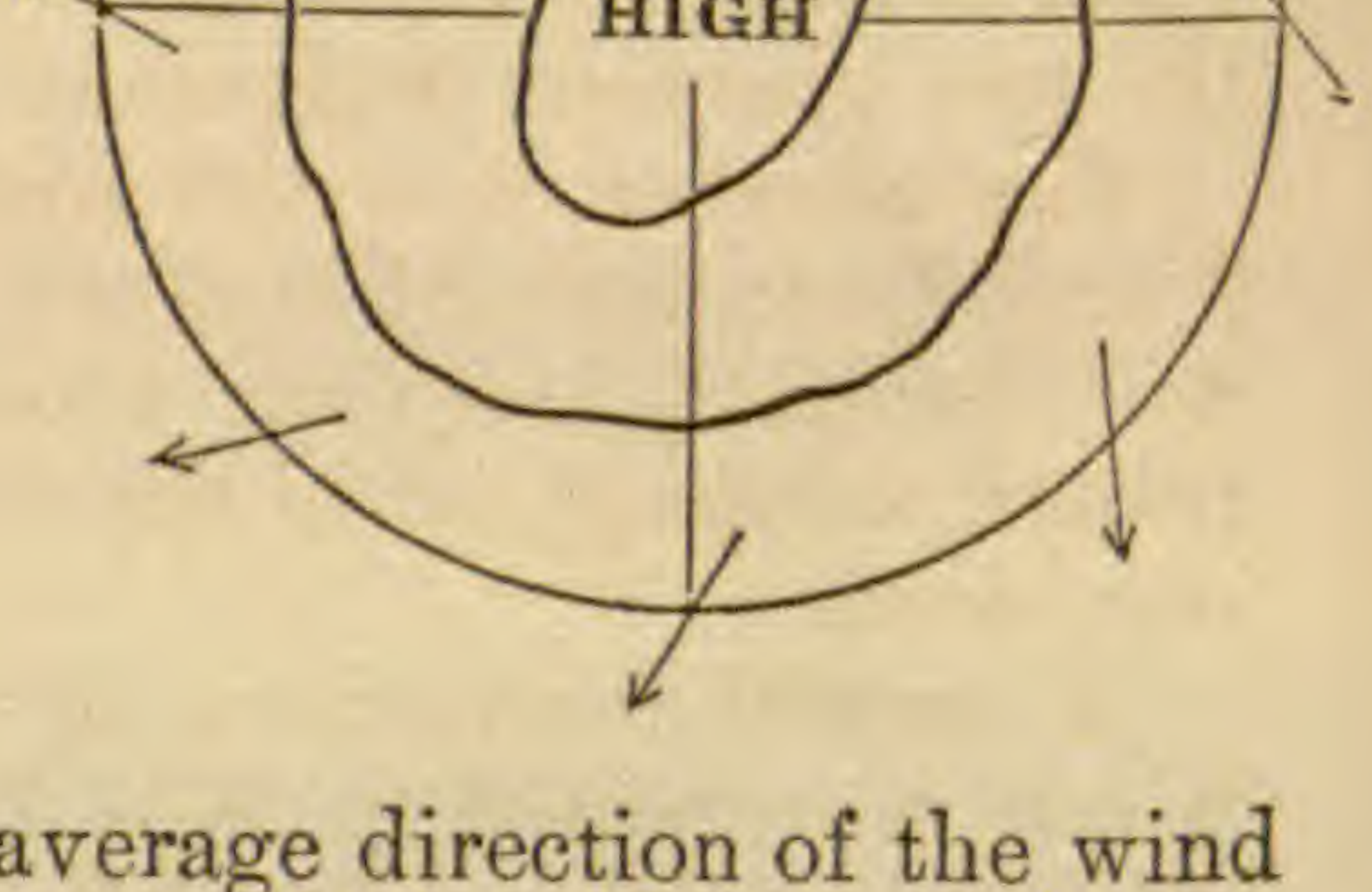
	West quadrant.	South quadrant.	East quadrant.	North quadrant.
Velocity of wind,	10·1 miles.	8·8 miles.	8·3 miles.	7·6 miles.
Direction of wind,	N. 58° 48′ W.	S. 40° 25′ W.	S. 32° 6′ E.	N. 42° 33′ E.
Angle with radius,	31° 12′	40° 25′	57° 54′	42° 33′

In order to exhibit these results palpably to the eye, I have constructed the two following figures, in which the arrows at

No. 1. For Low Barometer.



No. 2. For High Barometer.



the four cardinal points show the average direction of the wind according to the preceding tables, and the four intermediate arrows show the direction at the corresponding points as interpolated from the first four numbers. The lengths of the arrows are proportioned to the velocity of the different winds.

From these diagrams it will be apparent that in each quadrant the direction of the wind for high barometer is nearly opposite to the direction in the same quadrant for low barometer, the differences in the several quadrants being as follows:

West quadrant.	South quadrant.	East quadrant.	North quadrant.
4° 12′	10° 30′	4° 53′	16° 42′

For high barometer the average angle which the winds make with radii drawn from the point of greatest pressure is 42° 18′; for low barometer the average angle which the winds make with radii drawn from the point of least pressure is 43° 1′. In each case, therefore, the wind's direction is almost exactly midway between a tangential and a radial movement, but approaching somewhat nearer to the latter.

In order to determine to what height above the level of the sea the law of movement shown in the preceding diagrams prevails, I discussed the observations made on the summit of Mt. Washington at an elevation of 6,285 feet above the level of the sea, in the same manner as I had already discussed the observations at the other stations, and obtained the following results:

For low barometer on Mt. Washington.

	West quadrant.	South quadrant.	East quadrant.	North quadrant.
Velocity of wind,	49 miles.	44 miles.	37 miles.	32 miles.
Direction of wind,	N. 55° 7′ W.	N. 76° 35′ W.	S. 53° 44′ W.	N. 20° 6′ E.
Height of barometer reduc. to sea-level,	29·54	29·60	29·76	29·76

For high barometer on Mt. Washington.

	West quadrant.	South quadrant.	East quadrant.	North quadrant.
Velocity of wind,	32 miles.	18 miles.	38 miles.	32 miles.
Direction of wind,	S. 14° 37′ E.	N. 4° 8′ W.	N. 54° 48′ W.	N. 57 52′ W.
Height of barometer reduc. to sea-level,	30·28	30·21	30·03	30·11

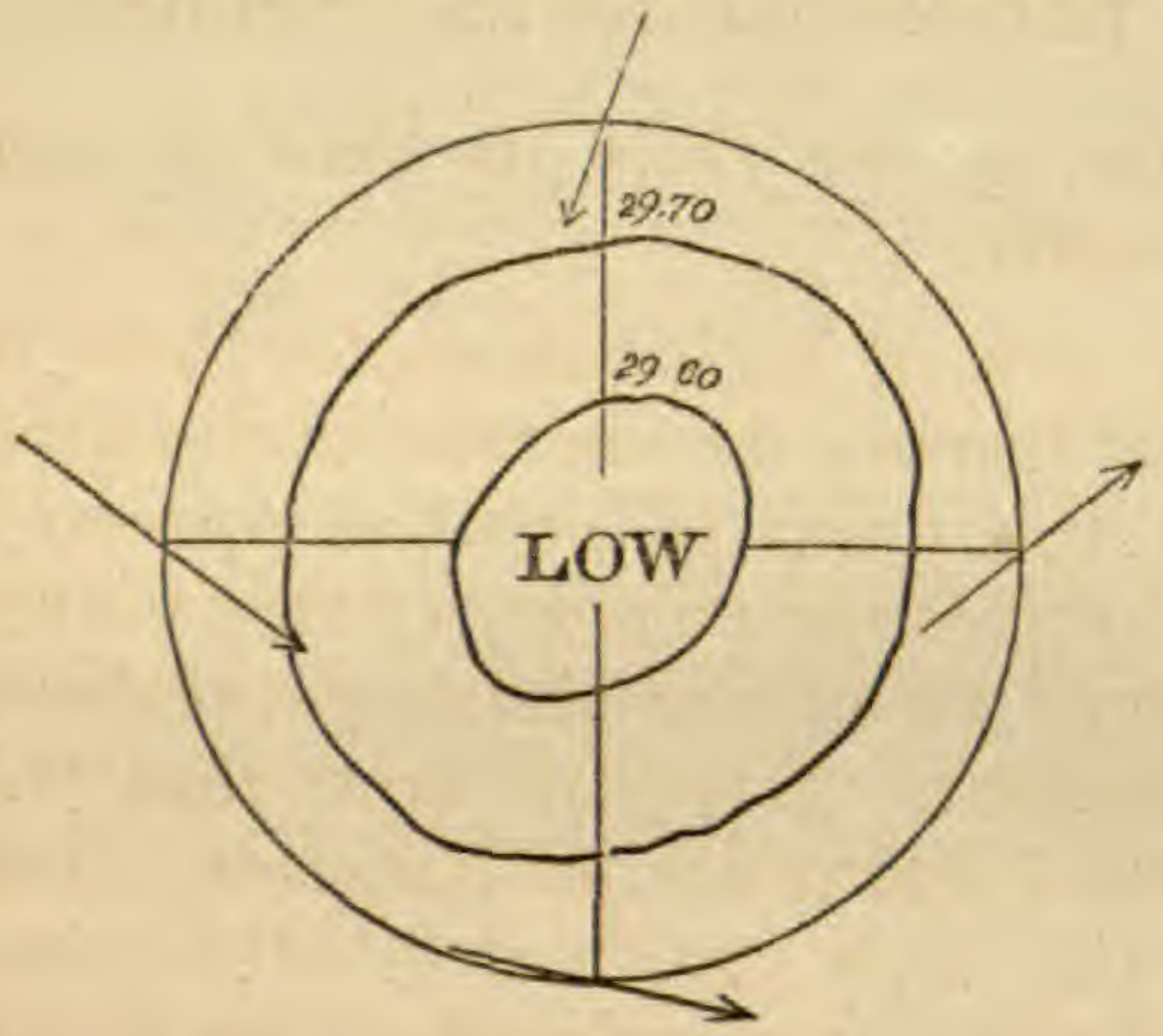
These results are graphically represented by the following diagrams, Nos. 3 and 4, in which, for convenience, the force of the wind is represented upon a scale only one-fourth as great as in the two previous diagrams.

The number of observations from which the results in Nos. 3 and 4 are derived is much less than for Nos. 1 and 2, and this will probably explain some anomalies which might be expected to disappear in the average of a greater number of observations.

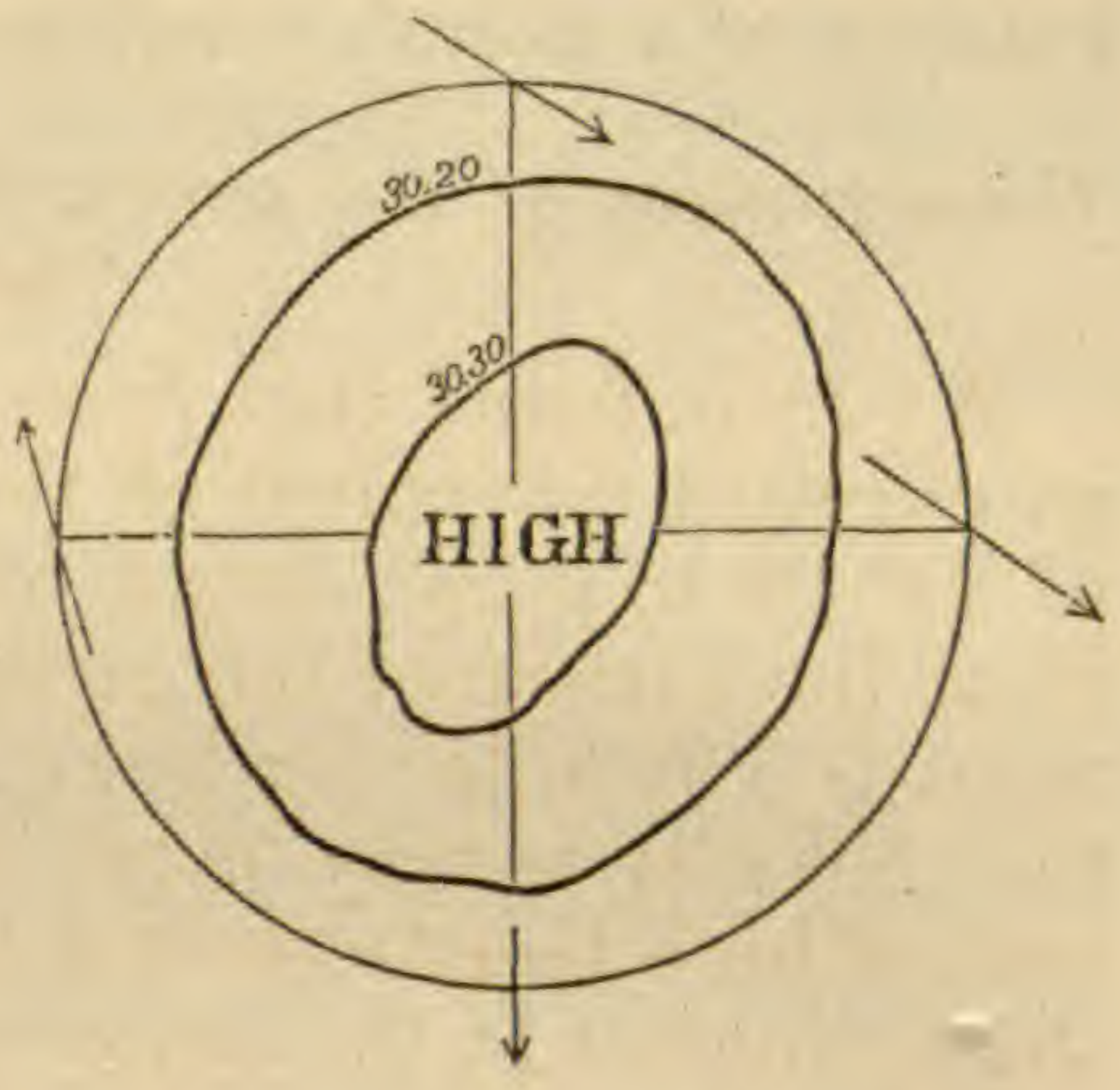
A careful comparison of these diagrams will show that the winds represented in Nos. 3 and 4 correspond pretty well with what might be expected from the winds represented in Nos. 1

and 2 struggling against an upper current from some N.W. quarter. The average direction of the wind on the summit of Mt. Washington in 1873 was from N. 76° W. If we regard this

No. 3. Low Barometer on Mt. W.



No. 4. High Barometer on Mt. W.



as the normal wind, and the winds shown in Nos. 1 and 2 to be disturbing forces tending to interfere with the normal wind, and we attempt to construct a triangle in which two of the sides shall represent these two forces, and the third shall represent the wind actually observed, we shall obtain a satisfactory construction in six out of the eight cases. In two cases the construction fails, viz., for low barometer in the west quadrant and for high barometer in the north quadrant, but a small change in the value of one of the angles would render the construction possible. These figures indicate that the average amount of the disturbing force is about equal to the normal force; in other words, the force of the winds shown in Nos. 1 and 2, at the height of 6,285 feet, is about equal to the force of the normal current which prevails at that elevation. It seems, therefore, reasonable to infer that at the height of 5,000 feet, the winds shown in Nos. 1 and 2 must generally be strong enough entirely to displace the normal current at that height.

It will be noticed that "for high barometer on Mt. Washington," the average height of the barometer was small, particularly for the east quadrant. But for the same dates, the average height at Burlington, Vt., was 30·35 inches, which suggests the idea that in those cases the reduction of the Mt. Washington observations to the level of the sea was too great.

A comparison of diagrams 1 and 2 cannot fail to suggest the idea that a high barometer must exert an important influence upon a neighboring low barometer. It will be noticed that when the high barometer is on the east side of the low barometer, both systems tend to impress nearly the same direction upon the wind at a point intermediate between them, and the same is true upon whichever side of the low barometer the high barometer is situated. It seems natural to conclude that the result must be an increased steadiness and force of the winds in question. How far this conclusion is confirmed by the observations, and what may be its effect upon the direction and velocity of a storm's progress, I propose to consider hereafter.

Consequences of the outward flow of air from an area of high barometer.

We have found that from an area of high barometer there is an outward movement of the air having an average inclination of 42° 18′ to a line drawn from the point of greatest pressure. Near the surface of the earth, the average velocity of this movement is 5·96 miles per hour, but as we ascend above the surface, this velocity is very much increased. Suppose now that the area of high barometer is a circle 1,500 miles in diameter; that the barometer at the center of this area stands at 30·50 inches, and that the average velocity of the entire column of air is 18 miles an hour, which is the mean between the velocities observed near the level of the sea and on the top of Mt. Washington. Assuming that the average inclination to the radius is 42° 18′, we find the resolved portion of the wind's motion in the direction of radius is 13·3 miles per hour. What must be the effect upon the height of the barometer resulting from this outward movement from the area of maximum pressure, the flow being supposed to extend to the height of 5,000 feet? In less than three hours the barometer would be reduced to thirty inches, if there were no counter movement in the upper regions of the atmosphere. Now we know that these areas of high barometer have considerable permanence. It is quite common for them to remain nearly stationary for 24 hours; frequently they continue thus nearly stationary and without much change for 48 hours; and cases sometimes occur in which the barometer remains above 30·25 inches for four or five successive days and even longer. Thus from Dec. 29, 1872, to Jan. 2, 1873, the barometer at New Haven was never below 30·30; from Nov. 29 to Dec. 3, 1873, the barometer was never below 30·35; and from Dec. 31, 1873, to Jan. 6, 1874, it was never below 30·25.

These facts appear to me to prove that areas of high barometer are maintained by a continued accession of air in the upper regions of the atmosphere, and this accession is probably derived from the air which ascends near the center of an area of low barometer. In my former article, page 10, I have shown that near the center of an area of low barometer there is a strong *upward* movement. The facts which I have now presented appear to me to demonstrate that near the center of an area of high barometer there is a *downward* movement, not generally violent, but steady and of long continuance. The result of such a downward movement must generally be a considerable fall of the thermometer at the surface of the earth. The atmosphere generally loses heat most rapidly at the top, in consequence of radiation into space, and it receives its heat chiefly at the bottom from the effect of the sun's rays upon the surface of the earth, so that at an elevation of a few miles a pound of air usually contains a less amount of heat than a pound of air near the earth's surface. Hence we conclude that within an area of high barometer the thermometer must generally stand below its mean height.

Monthly minima of temperature.

In order to test the preceding conclusion, I have taken the monthly minima of temperature as observed at New Haven for the years 1872, 3, and 4, and have compared them with the state of the barometer and such other circumstances as could be supposed to influence the result. These observations of temperature were all made with a self-registering thermometer. The precise hour of minimum is therefore unknown, but it occurred sometime during the night preceding the date given in column first. In the following table, column first shows the date of minimum temperature for each month; column second shows the lowest temperature recorded: column third shows the direction of the wind as recorded at the morning observation, which in summer was generally 6 A. M., and in winter about 7 A. M.; column fourth shows the degree of cloudiness at the same hour; column fifth shows the height of the barometer at New Haven; column sixth shows the position of the nearest center of high barometer as indicated by the U. S. weather maps; and column seventh shows the highest isobar represented on the map for the corresponding date.

Upon comparing these observations, we perceive that in all but five cases the sky at the date mentioned was cloudless, and in only two cases did the clouds cover as much as one-half of the sky. It is probable that in each of these cases, during a portion of the preceding night the sky had been entirely cloudless. We must conclude, then, that these monthly minima of temperature were in part the result of *radiation;* but this cause alone will not account for the very low temperature observed, for these observations were very much below the average temperature of the same months on cloudless nights. We find that in about two-thirds of the cases, New Haven was included within the area of a high barometer; that in several of the remaining cases an area of high barometer existed at the west and was rapidly approaching New Haven, although the barometer at the latter place had not yet risen above 30 inches; and that in the few remaining cases there was at no great distance from New Haven an area of *relatively high* barometer, although the actual height of the barometer did not much exceed 30 inches.

Lowest temperature for each month at New Haven, Conn., for the years 1872, 3, *and* 4.

Date of minimum.	Min'm temp.	Wind.	Cloudiness.	Barom. N. H.	Center of high barometer.	Highest isobar.
1872. Jan. 31	4°·4	N.W.	0	30·25	Nashville.	30·50
Feb. 23	6·7	N.	3	30·07	Norfolk, Va.	30·10
March 5	−1·2	N.W.	0	29·95	Chicago.	30·30
April 18	28·1	N.	0	29·97	Near Long Island.	30·00
May 1	39·2	S.E.	3	30·26	Near New York.	30·30
June 2	48·2	N.	0	30·01	Lake Huron.	30·10
July 25	56·0	W.	5	30·08	Gulf of Mexico.	30·20
Aug. 31	54·0	W.	0	29·70	Illinois.	30·10
Sept. 4	43·3	N.	0	30·05	Pittsburg, Pa.	30·10
Oct. 30	29·3	N.E.	0	30·57	Maine.	30·60
Nov. 30	10·3	W.S.W.	0	29·75	Georgia.	30·50
Dec. 28	−20·0	N.	0	30·10	Nashville.	30·60
1873. Jan. 30	−26·0	N.W.	0	30·25	Pennsylvania.	30·30
Feb. 24	−6·0	W.	0	29·77	Nashville.	30·30
March 5	8·5	N.W.	0	30·53	Knoxville.	30·70
April 1	31·8	W.	0	30·08	Chesapeake Bay.	30·10
May 4	33·2	N.	1	29·96	Louisville.	30·10
June 1	46·3	W.	0	30·35	Chesapeake Bay.	30·40
July 19	55·0	N.W.	5	29·94	Halifax.	30·20
Aug. 24	51·0	N.	0	30·06	Lake Huron.	30·40
Sept. 15	38·0	N.	0	30·27	Washington, D. C.	30·20
Oct. 30	29·4	N.	0	30·47	New York.	30·40
Nov. 29	15·5	W.	0	30·47	Wheeling, Va.	30·60
Dec. 31	10·0	W.	0	30·33	Wilmington, N. C.	30·60
1874. Jan. 17	3·6	W.	0	30·43	Lynchburg, Va.	30·50
Feb. 2	−1·4	N.N.E.	0	30·72	Quebec.	30·80
Mar. 24	12·2	N.N.W.	0	30·32	St. Louis.	30·70
April 5	14·8	W.	0	30·44	Baltimore.	30·40
May 12	32·7	N.	0	30·52	Long Island.	30·50
June 14	46·3	N.N.W.	0	30·26	Washington, D. C.	30·30
July 4	57·0	S.	0	30·05	Charleston, S. C.	30·10
Aug. 29	50·9	N.	0	30·06	Gulf of St. Lawrence.	30·10
Sept. 23	43·5	N.W.	0	30·28	Baltimore.	30·30
Oct. 15	32·0	N.	0	30·41	Virginia.	30·50
Nov. 14	19·1	N.	0	30·67	New York.	30·70

The preceding considerations appear to me to prove that the extremely low temperatures which occur at irregular intervals in every month of the year, but particularly in the winter months, are due mainly to the descent of cold air in the neighborhood of an area of high barometer; and this descent of the air results from the outward movement which generally takes place from the center of an area of high barometer.

Long continued periods of cold weather.

Sometimes we have a period of severe cold continuing ten days or even longer. The most remarkable cases of this kind within the last three years took place between Dec. 22, 1872, and Feb. 3, 1873. The following table shows the most important particulars respecting two periods of this description as observed at New Haven.

Date.	Max'm temp.	Min'm temp.	Barom. 7 A. M. N. H.	Wind. N. H.	Cl'diness.	Center of high barometer.	Highest isobar.	REMARKS.
1872.								
Dec. 21	34°·2	24°·7	30·16	N.N.W.	3	Nebraska.	30·70	Pleasant day.
22	17·5	11·3	30·12	N.N.W.	0	Kentucky.	30·60	1 in. of snow last night.
23	29·4	−0·9	30·11	S.W.	10	Georgia.	30·30	Snow ceased at 10 A.M. Amount, 3½ inches.
24	17·4	8·7	30·40	N.W.	10	Illinois.	30·70	Pleasant afternoon.
25	16·2	−1·5	30·53	N.	5	N. Hampshire.	30·60	Pleasant day.
26	8·8	−1·0	30·06	N.N.E.	10	Montreal.	30·20	Snowed all day till 9 P.M. Am't, 15 in.
27	14·4	4·8	29·72	N.	10	Nebraska.	30·70	Cloudy all day.
28	28·3	−11·7	30·12	N.	0	Tennessee.	30·60	Pleasant day.
29	27·3	6·2	30·34	N.W.	10	Georgia.	30·50	Cloudy all day.
30	24·3	0·2	30·53	N.N.W.	0	N. Carolina.	30·60	Pleasant day.
31	29·3	10·4	30·28	N N.E.	10	Georgia.	30·40	Snow till 4 P.M. Am't, 3 inches.
1873.								
Jan. 1	30·4	8·5	30·42	N.	0	Albany.	30·40	Fine.
2	20·6	3·3	30·45	N.	0	Maine.	30·50	Cloudy afternoon.
26	27·2	7·5	30·25	N.	10	Baltimore.	30·20	Slight snow in forenoon.
27	26·0	19·3	29·99	N.E.	10	Dacotah.	30·40	Snow all day. Am't, 6 in.
28	33·0	15·0	30·06	S.W.	0	Nebraska.	30·80	Fine.
29	12·2	0·0	30·35	N.W.	0	Indiana.	30·50	Fine.
30	20·4	−16·8	30·25	N.W.	0	Pennsylvania.	30·30	Fine.
31	34·2	6·3	30·15	N.W.	0	Dacotah.	30·50	Fine.
Feb. 1	33·8	9·7	30·10	N.W.	0	Nebraska.	30·70	Fine.
2	17·5	2·8	30·30	N.N.W.	0	Illinois.	30·60	Fine.
3	35·5	6·2	30·25	S.W.	4	Charleston.	30·30	Snow from 2½ P. M. to [evening.

Column second shows the highest temperature and column third the lowest temperature observed at New Haven on each of the days named in column first; column fourth shows the height of the barometer, column fifth the direction of the wind, and column sixth the amount of cloudiness observed at New Haven at 7 A. M.; column seventh shows the position of the nearest center of high barometer, and column eighth the highest isobar drawn on the U. S. weather map for the corresponding date; column ninth shows some miscellaneous particulars recorded at New Haven.

It appears from the preceding table and from a comparison with the U. S. weather maps, that during the period above named there was an area of high barometer of unusual extent, which covered nearly the whole of the United States east of the Rocky Mountains and generally included New Haven. The only exceptions are near Dec. 27th and Jan. 27th. But at each of these dates an unusually high barometer prevailed at the same time at a great distance west, and its influence was felt not only at places where the pressure was above 30 inches, but also at places where the barometer had not yet reached the height of 30 inches. I conclude, therefore, that the severe cold which prevailed at this period throughout the United States east of the Rocky Mountains was mainly the result of cold air descending from the upper regions of the atmosphere under the influence of a high barometer.

The only other explanation of this phenomenon which I think can be plausibly urged, is that this cold was the result of a current of air sweeping along the surface of the earth from a very high northern latitude, and bringing with it the low temperature of the region from which it came. I admit that during the period in question northerly winds were unusually prevalent, but these were winds attending high barometer in accordance with the laws which have been already established. I admit also that when there is a general drift of the atmosphere from north to south over an extensive area it must bring with it a reduction of temperature, but I am satisfied that this cause alone will not account for the suddenness and magnitude of the depression in the present case. From the 21st to the 22d of December, the mean temperature at New Haven fell 15°, and it continued at about this point or even lower for nine successive days. Was there at this time a steady flow of air from the Arctic regions sufficient to account for this effect? I am unable to appeal to my weather maps for an answer to this question, for, unfortunately, on these days, the observations from most of the stations in the extreme northwest are wanting, and if it were otherwise, it might appear that the maps did not extend far enough northward to furnish all the information which was required. If our observations covered the whole area of North America, I have little doubt we should find that the depression of the thermometer below its mean height was greater in the United States than it was in the region north of us, as I have shown was the case in the storm of Dec. 20, 1836, of which the investigation was published in vol. xi of the Smithsonian Contributions to Knowledge.

Storm of Jan. 6–8, 1874.

In the absence of adequate observations from British North America, it may be more satisfactory to take an example of a storm in the southern part of the United States, in which case the weather maps will inform us of the condition of the atmosphere on the northern margin of the storm. For this purpose, I have selected the storm of Jan. 6–8, 1874, which came up from the Gulf of Mexico and crossed the United States in a direction about N. 30° E. The following table shows the observations of the thermometer at $7^{h}\ 35^{m}$ A. M., from Jan. 4 to

Jan. 9, 1874, at all the southern stations of the Signal Service and most of the northern stations. These observations were copied from the weather maps and forwarded to the chief sig-

Observations of the thermometer at 7^h 35^m *A. M., Jan.* 4–9, 1874.

	Mean Temp. Jan'y.	Thermom. at 7^h 35^m A. M.						Above or below mean temp.					
		Jan. 4.	Jan. 5.	Jan. 6.	Jan. 7.	Jan. 8.	Jan. 9.	Jan. 4.	Jan. 5.	Jan. 6.	Jan. 7.	Jan. 8.	Jan. 9.
Indianola,	55°	49°	35°	34°	38°	41°	52°	− 6°	−20°	−21°	−17°	−14°	− 3°
Galveston,	55	52	39	34	43	48	55	− 3	−16	−21	−12	− 7	0
Key West,	68	70	66	68	68	62	57	+ 2	− 2	0	0	− 6	−11
Punta Rassa,	62	68	64	62	63	50	44	+ 6	+ 2	0	+ 1	−12	−18
New Orleans,	55	65	50	38	35	38	58	+10	− 5	−17	−20	−17	+ 3
Mobile,	52	58	48	43	33	32	50	+ 6	− 4	− 9	−19	−20	− 2
Lake City,	55	59	64	64	45	30	30	+ 4	+ 9	+ 9	−10	−25	−25
Jacksonville,	56	57	62	65	55	38	35	+ 1	+ 6	+ 9	− 1	−18	−21
Shreveport,	47	42	30	39	36	40	43	− 5	−17	− 8	−11	− 7	− 4
Montgomery,	48	53	54	48	35	32	44	+ 5	+ 6	0	−13	−16	− 4
Savannah,	52	60	59	64	51	36	37	+ 8	+ 7	+12	− 1	−16	−15
Charleston,	50	58	61	59	55	36	37	+ 8	+11	+ 9	+ 5	−14	−13
Augusta,	47	60	63	64	43	33	31	+13	+16	+17	− 4	−14	−16
Wilmington,	47	58	61	64	58	40	39	+11	+14	+17	+11	− 7	− 8
Fort Gibson,	40	15	11	21	22	31	30	−25	−29	−19	−18	− 9	−10
Memphis,	40	58	24	31	29	35	52	+18	−16	− 9	−11	− 5	+12
Nashville,	37	61	28	35	28	26	42	+24	− 9	− 2	− 9	−11	+ 5
Knoxville,	35	38	38	43	33	29	31	+ 3	+ 3	+ 8	− 2	− 6	− 4
Louisville,	33	61	25	32	29	25	38	+28	− 8	− 1	− 4	− 8	+ 5
Cincinnati,	31	60	30	33	32	28	38	+29	− 1	+ 2	+ 1	− 3	+ 7
Norfolk,	37	57	61	43	64	42	36	+20	+24	+ 6	+27	+ 5	− 1
Lynchburg,	33	54	56	37	59	37	32	+21	+23	+ 4	+26	+ 4	− 1
St. Louis,	32	33	12	21	22	33	38	+ 1	−20	−11	−10	+ 1	+ 6
Washington,	34	60	53	35	65	43	41	+26	+19	+ 1	+31	+ 9	+ 7
Cape May,	33	46	48	43	50	43	38	+13	+15	+10	+17	+10	+ 5
Baltimore,	33	47	51	38	56	44	35	+14	+18	+ 5	+23	+11	+ 2
Keokuk,	27	13	8	11	16	28	30	−14	−19	−16	−11	+ 1	+ 3
Omaha,	20	− 2	9	16	22	27	30	−22	−11	− 4	+ 2	+ 7	+10
Pittsburgh,	29	65	30	35	41	33	35	+36	+ 1	+ 6	+12	+ 4	+ 6
Philadelphia,	32	52	48	36	57	45	35	+20	+16	+ 4	+25	+13	+ 3
New York,	30	48	47	35	53	47	33	+18	+17	+ 5	+23	+17	+ 3
Chicago,	26	35	15	17	25	27	34	+ 9	−11	− 9	− 1	+ 1	+ 8
Cleveland,	28	60	31	33	33	30	37	+32	+ 3	+ 5	+ 5	+ 2	+ 9
Buffalo,	27	57	27	26	32	34	33	+30	0	− 1	+ 5	+ 7	+ 6
Boston,	27	47	49	32	34	55	34	+20	+22	+ 5	+ 7	+28	+ 7
St. Paul,	14	− 3	6	17	12	21	23	−17	− 8	+ 3	− 2	+ 7	+ 9
Breckenridge,	10	−20	0	12	16	18	9	−30	−10	+ 2	+ 6	+ 8	− 1

nal officer at Washington, by whose direction they were compared with the official records, the errors were corrected and the omissions in the daily weather maps supplied. From Jan. 1st to Jan. 5th a storm traveled entirely across the continent from west to east, the center of the storm passing over Lake Superior. This storm was followed by unusually cold weather, as is shown in the observations of Jan. 4th at Breckenridge, St. Paul, Omaha, Fort Gibson, Keokuk, &c. On the 5th of January another and entirely distinct storm prevailed in the Gulf of Mexico; on the 6th it passed over Georgia; on the 7th it passed over Virginia, and on the 8th it passed north of Lake Ontario. This storm was followed by an unusual reduction of temperature in the southern States. Its effects were to some extent blended with those of the preceding storm, yet the effects of the latter can be distinctly traced, especially in the neighborhood of Florida. In the second column of the preceding table, I have given the mean temperature of January for each of the stations in column first; columns 3–8 show the observations of the thermometer at 7^h 35^m A. M.; and columns 9–14 show the differences between the observed temperatures and the mean temperature of January. The observations for January 8th are graphically represented on the accompanying chart, plate I, where the curve which passes through Mobile connects all those places where the depression of the thermometer was 20° below the mean; the curve which passes between Charleston and Savannah shows a depression of 15° below the mean; the curve passing near Nashville shows a depression of 10°; while the curve passing near Cincinnati connects those places having the mean temperature of January. Everywhere south of this line the temperature was below the mean; and everywhere north of this line the temperature was above the mean. It will be noticed from the table that on the 8th, in northern Florida, the depression of the thermometer was greater than it had been on either of the preceding days at Knoxville, Nashville, Cincinnati, Louisville and Memphis. This fact, together with the form of the isabnormal curves (convex toward the north), indicates that the cold did not come from the north or northwest, but must have descended from the upper regions of the atmosphere over the southern States.

There are other considerations of a more general nature which appear to me entirely conclusive with reference to the general principle which I have been trying to establish. The phenomenon in question is not peculiar to the United States, but prevails far to the north of us, even to the coldest regions which have ever been visited by man. It was found at Melville Island, lat. 75° N.; it was found at Van Rensselaer Harbor, lat. 78½° N.; it is found in the coldest parts of Siberia. At Melville Island, on the 26th of December, 1819, during a strong wind, the barometer fell to 29·10 inches; it soon began to rise, and in four days it rose to 30·75, the highest point attained during the year. During the same time the thermometer fell from $-5°$ to $-43°$; the lowest temperature observed during the year. At Van Reusselaer Harbor, on the 28th of December, 1853, during a severe gale, the barometer fell to 29·05, and in two days it rose to 30·50. The thermometer during the same time fell from +16° to −22°. At Jakutsk, in Siberia, lat. 62°, the mean temperature of January is −44° Fahr. But on the 21st of January, 1838, the thermometer fell to −76° F., or 32° below the mean temperature of the season. Now according to Dove's charts, there is no place on the earth's surface where the mean temperature of the coldest month is much below that of Jakutsk. What can cause such an extreme depression of the thermometer at the coldest point of the earth's surface? I think we are shut up to the conclusion that this unusual cold results from the descent of the upper atmosphere to the surface of the earth. If this is the true explanation of periods of unusual cold in Siberia, a similar phenomenon in the United States is doubtless to be explained in like manner.

The *suddenness* of these changes of temperature is sometimes more remarkable than their magnitude. On the 21st of December, 1836, the thermometer at Albany fell 18° in one hour, from 11 A. M. to noon. Allowing for the usual diurnal change of temperature, this indicates an absolute change of temperature of 20° in one hour, being the effect of a severe storm then in progress. In summer, during a thunder shower, it is not unusual for the thermometer to fall 5° or even 10° in a few minutes. Now an examination of the weather maps will show that this phenomenon is local. There is no cold stream of air flowing down from the northern regions to produce this sudden change of temperature, but the effect takes place along the track of a storm, which generally follows nearly a parallel of latitude, with, however, a slight inclination northward, that is, from a warmer to a colder region. These sudden gusts of cold air are believed to descend from the upper regions of the atmosphere.

Connection between the velocity of the wind and the distance between the isobars in the neighborhood of a storm center.

In order to determine the connection between the velocity of the wind and the distance between the isobars, I ruled a large sheet of paper with 40 vertical columns, and placed at the head of the columns the numbers 0, 1, 2, 3, etc., to denote velocity of the wind. Each weather map was then examined for observations suited to the present object. In the selection of stations the following rules were adopted: 1. All the observations within the first isobar about a storm center were omitted. 2. No observations were employed beyond the isobar 29·90, and when any station within these limits seemed to be under the influence of another storm center that observation was rejected. All the observations made on Mt. Washington were rejected. For each station which satisfied the above conditions the perpendicular distance between the two adjacent isobars was measured, and the distance recorded under the corresponding velocity found at the top of one of the vertical columns. All the weather maps for 1872 and 3' were examined in this manner, and the distance between the isobars recorded. The following table shows the average results:

Relation between the velocity of the wind and the distance between the isobars.

Veloc. miles.	No. of Obs.	Mean distance	Av. distance	Dist. in miles.	Veloc. miles.	No. of Obs.	Mean distance	Av. distance	Dist. in miles.
0	69	·79	--	---	20	76	·63	·61	95
1	55	·90	--	---	21	9	·56	·62	97
2	81	·90	·86	134	22	23	·65	·62	97
3	53	·87	·86	134	23	13	·65	·62	97
4	176	·83	·84	131	24	40	·59	·62	97
5	111	·82	·82	128	25	13	·65	·61	95
6	168	·80	·80	125	26	5	·56	·59	92
7	80	·76	·79	123	27	5	·59	·58	90
8	230	·78	·78	122	28	20	·56	·54	85
9	65	·77	·76	119	29	4	·54	·54	85
10	129	·77	·75	117	30	15	·46	·52	81
11	56	·71	·74	115	31	4	·54	·50	78
12	262	·72	·73	114	32	7	·51	·48	75
13	34	·74	·69	109	33	0	--	·46	72
14	93	·70	·68	106	34	1	·44	·44	69
15	42	·60	·67	104	35	4	·39	--	--
16	122	·64	·64	100	36	4	·39	--	--
17	26	·65	·62	97	37	0	--	--	--
18	66	·60	·62	97	38	0	--	--	--
19	10	·60	·61	95	39	0	--	--	--

Column first shows the velocity of the wind in miles per hour; column second shows the number of observations corresponding to each velocity; and column third shows for each velocity the average distance between the isobars expressed in decimals of an inch. It will be noticed that the numbers in column second are very unequal; the number of observations for velocities 4, 8, 12, 16, 20, 24 and 28 being much greater than for the intermediate velocities. This shows that the velocities are not reliable within 1 or 2 miles, and this probably explains in part the irregularity of the numbers in column third. In order to smooth down these irregularities, I have taken the average of each sucessive five numbers in column third and set down the result in column fourth. The numbers in column fourth may, therefore, be regarded as exhibiting the results of the observations freed from some of the sources of error which affect individual observations. In column fifth, these distances are expressed in miles. This last column of numbers represents, therefore, the average distance between isobars (drawn at intervals of one-tenth of an inch) corresponding to the velocities given in column first. The average distance of the stations of observation from the center of low barometer is estimated at 350 miles. The numbers in column fifth are therefore regarded as representing for the United States the average distance between the isobars corresponding to the velocities in column first, at an average distance of 350 miles from a storm's center. We thus see that the average distance between the isobars is twice as great for the lowest velocity as it is for the highest velocity, so that the distance between the isobars affords some indication of the velocity of the wind, but the individual observations present so great anomalies that it is only the average velocity of the wind which can be safely inferred from the distance between the isobars. The great irregularities noticed in the individual observations are doubtless to be ascribed in part to the obstructions to the wind's motion arising from the inequalities of the earth's surface. Over a large expanse of water the distance between the isobars must afford a much more reliable indication of the force of the wind.

In preparing the materials for the preceding article, I have been assisted by Mr. Edward S. Cowles, a graduate of Yale College of the class of 1873.

ART. II.—*On some Points in the Geology of the Blue Ridge in Virginia*; by WM. M. FONTAINE.

PROFESSOR H. D. ROGERS, in the first volume of his Pennsylvania Reports, in giving a description of the strata lying along the lower Susquehanna, was at first positively of the opinion that this great body of slates is of Silurian age. He accordingly described this system as "altered primal upper slates." Since the publication of his first volume he announced the opinion that this section contained two, and perhaps more, series of unconformable strata, one of which is older than the Silurian, being perhaps equivalent to the Huronian of Canada.

This series of slates and quartzites passes south through Maryland into Virginia, where it attains great breadth and occupies the larger part of the State. It passes entirely across the State, having the Blue Ridge Mountains on its western border and the gold belt of this section on the east.

I had an opportunity, some time since, to examine in some details a part of the western portion of this belt, and propose to give in this paper a concise account of some of the geological features there seen. My detailed examination was confined to the Blue Ridge, and to the parallel chain running some twenty miles east of it. I also studied, with less minuteness, portions of the valley between them.

The Blue Ridge at Harper's Ferry is a single chain, but in passing southwest it expands, so as to embrace a portion of the silurian rocks on the west, and also a considerable area of the more altered rocks on the east, until in some parts it is formed of several parallel, short ranges, composed of slate of very different character and age. Thus, according to the locality examined, one would find the main chain composed of argillites of seemingly very ancient date, or of coarse syenites, or again of Silurian quartzites.

The lower chain on the east leaves the immediate vicinity of the Blue Ridge in Maryland, diverging more and more as it passes through Virginia, so as to embrace a belt of the country which widens to the south. This chain has a variety of names, according to the locality. In Maryland and Northern Virginia it is called "Catoctin," but farther southwest in Virginia, "Bull Run." It is then broken up into a number of isolated mountains for a considerable distance, reappearing as the "Southwest," and "Green Mountains," in Albemarle County. Near Lynchburg, Va., it is called "Buffalo Ridge;" and southwest of this place, it is again dispersed into isolated ridges and peaks. For the sake of convenience, I shall call this entire range by its more northerly name, "Catoctin."

The valley between these ranges presents its simplest topography to the north. It is there occupied mainly by isolated hills of considerable magnitude and by some connected chains of the same. Farther to the southwest, mountains both isolated and in short ranges appear in the central portions. Near Charlottesville, Albemarle County, these attain considerable dimensions and continue with increasing force to beyond Lynchburg, a distance of more than sixty miles. Near Lynchburg the valley obtains its maximum width of about twenty-five miles.

The most northerly portion of this belt examined by me was at "Point of Rocks," Maryland, and at "Harper's Ferry." In order to give some idea of the portions of the entire belt not examined by myself, I shall quote from Professor Wm. B. Rogers' Virginia Reports; all the more freely, as they unfortunately never have been published.

At Point of Rocks, on the Baltimore and Ohio Railroad, we have a splendid exposure of the rocks, both in the tunnel through the mountain and in the cuttings for the canal. The rocks composing the Catoctin Mountains here are, in their least altered condition, well defined argillites. This particular variety forms a very important feature in the geology of the northern part of the Blue Ridge. Its lithological features are so pronounced that it can be traced with ease as far as Rockfish Gap, west of Charlottesville, but with greatly diminished breadth there. Here in the north, it occupies almost the entire space of twelve miles between Point of Rocks and Harper's Ferry. It forms also the most of the Blue Ridge at the latter place. Throughout this entire distance this rock shows a high southeast dip (45°), and evidently lies in a series of closed folds. The following is the normal character as presented throughout the district: Texture, fine, amorphous, to sub micaceous; color, dark gray, sometimes greenish, from films of chlorite. Cleavage usually obscured by consolidation, but parallel to the bedding. It occurs in more or less massive layers, often cut by joints, and is usually harder and denser than ordinary roofing slate. At Point of Rocks the following modifications are seen:

Commencing at the east entrance of the tunnel, we have the normal slates dipping 45° southeast; more toward the center intense local metamorphism appears. Here we find both cleavage and bedding lost, and finally see a massive structureless rock, but little harder than the true slates and of sub-micaceous texture; the particles being confusedly mingled and forming a substance not unlike some igneous rocks. This central portion is of a deep green color, from the great development of chlorite. It often has nests of epidote, sparingly disseminated and associated with knots and irregular veins of quartz. The quartz is very abundant. Some triclinic feldspar occurs in seams; and specular iron in brilliant, disseminated scales. Pyrite is quite common. This central, highly altered portion, has plainly been sufficiently softened to be capable of motion like a fused mass. It has been thrust up along the plane of bedding to the northwest. This is shown by the disturbance produced in the enclosing strata next to it, and also by the crumpling and bending of the slates on the west side. At the west end of the tunnel, where we have the normal slates again, these are thrown into abrupt sigmoid flexures, indicating such a motion of the central mass.

I have little doubt but that this peculiar effect is due to the crushing of the beds in the center of a synclinal fold. But the existence of a closed synclinal alone will not account for the very general occurrence of such features, throughout so much of the northern Blue Ridge, and almost everywhere along the long ranges of the Catoctin. There must have been fractures and lines of weakness of great extent in the direction of these mountains; for we find in them true igneous rocks also, especially in the Blue Ridge.

The rocks occupying a belt of two and a half miles in width, on the west of the Catoctin, exhibit along one or two lines the same features of metamorphism that are to be seen at Point of Rocks, but on a smaller scale. In each case we find this increase of local change along certain belts to be marked by ranges of hills commanding the country around. The Catoctin

Mountains, these hills, and the Blue Ridge at Harper's Ferry, are each the result, in part, of such local changes producing elevation, but mainly of unequal erosion. The normal slates have been eroded to a much greater extent than the more highly metamorphosed rocks, and these latter have been left standing up in connected ridges.

The entire distance from Point of Rocks to Harper's Ferry, on the Maryland side, is apparently occupied by the argillites. Professor Wm. B. Rogers states, however, that on the Virginia side a narrow tongue of gneiss is found at the eastern base of "Short Hill," near the center of the tract. This is the northern termination of a triangular area of gneiss which passes through Virginia along the eastern base of the Blue Ridge. A narrow belt of steatite and serpentine is also found in Loudon County, along with elliptical bands of magnesian limestone, which sometimes assumes the aspect of true marble. These latter rocks also pass southwest through the State in the belt in question. Professor Rogers describes the curious occurrence of the limestones. They resemble huge flattened concretions, being entirely enclosed in hydromica or talc slates, and apparently pass into them by insensible gradations.

Resuming our detailed investigations at the eastern base of the Blue Ridge on the Maryland side, at Harper's Ferry, we still find the argillites forming the principal rock, and here also inclosing a core of metamorphic matter, which seems to be entirely formed out of the slates. This rock does not correspond exactly with any described in lithology, and I am at a loss to name it in the absence of any analysis of the materials. As it appears to be largely present throughout the State along the eastern base of the Blue Ridge, preserving a pretty constant position about two and a half miles from the Silurian strata, it merits a detailed description. I think it is one of the rocks called by Professor Rogers "greenstone."

This rock is seen with its most pronounced features at the bridge-head on the Maryland side, forming the perpendicular rugged mass which gives to the pass its most striking features. It is a massive rock in structure, having all the features of an eruptive igneous material. The principal component is a greenish-gray, rather waxy-looking amorphous base, having a hardness of two and a half, and a somewhat greasy feel. Imbedded in this material occur rounded shot-like particles of quartz as large as a garden pea. They have various colors, pink, bluish, and white, the former predominating. The luster of the quartz is waxy. The nodules sometimes almost disappear and sometimes form the larger portion of the mass. The rock has evidently been in a state of partial liquidity, and been thrust up along the plane of dip to the northwest. It often contains enclosed fragments of argillites, sometimes little changed, and sometimes impregnated with chlorite, or with the mineral owenite, which is one of the metamorphic associates of this rock. Width about three hundred feet. Traced from the bridge-head eastward, it is seen to pass gradually into unequivocal argillite, the quartz particles diminishing, and the base assuming more and more the laminated, slaty structure of the argillites. This portion of the argillites seems to have been involved in the upheaval of the mass, for it is cut up by joints into angular masses, much penetrated by irregular nests and seams of quartz, and is without bedding. A little farther east, just outside of this, we find a curious modification of the metamorphic rock. It here appears in the form of dykes, which thrust off the slates in arches. This rock is almost entirely composed of quartz, with a little of the amorphous matter present, which gives the stone a green color. Both this modification and the normal rock form an exceedingly tough and durable material, which by its indestructible nature has preserved the mountain from erosion.

The above described rock, in weathered specimens especially, might be mistaken for a species of conglomerate; and I think has been so described by H. D. Rogers, in his account of the South Mountains of Adams County, Pa. From the resemblance of its base to a variety of *Pinite*, and for lack of a better name, I shall call it "pinite porphyry," although it is not a true igneous rock. Farther east we find argillites in heavy masses, penetrated with quartz, and leaning against the ridge with a dip of about 50° southeast.

To the west, up stream, for two miles to the east limit of the Silurian, we have normal argillites preserving a predominating southeast dip. Close to the pinite porphyry the slates are thrown into such abrupt flexures that they are rolled into cylindrical masses, which are penetrated by numerous quartz seams. More to the west several short rolls occur, all denoting a thrust to the west on the part of the metamorphic rock. The line of junction of the argillites with the Silurian is sharply marked, and no passage of one into the other occurs, although the southeast dip is preserved.

My next investigations were made along the line of the Chesapeake and Ohio Railroad near Charlottesville, and at Rockfish Gap, where this road crosses the Blue Ridge by a tunnel seven-eighths of a mile long, affording a splendid section of the strata. Before passing to this, a short description, derived in part from Rogers' Virginia Reports, must be given of the intervening country, for in this important modifications occur. They are as follows: The argillites diminish, and are confined to the immediate vicinity of the Blue Ridge. Quartzites of various natures appear along the eastern border, and form the Catoctin to the southwest. These rocks in the north are the micaceous, slaty quartzites which form the Bull Run Mountains. To the southwest they become coarser, and by the assumption of a greater or less amount of feldspar, form gneissoid quartzites, or conglomerates. A schistose, argillaceous variety also appears here, much impregnated with chlorite and epidote, from its vicinity to the metamorphic rock, similar to that at Point of Rocks. Igneous rocks (not described) occur in the Blue Ridge near Swift Run Gap. Commencing on the east of the Catoctin range, we have the following rocks: 1st, Limestones, 2d, quartzites, and 3d, epidosites. These are usually associated, and the second form the mass of the Catoctin. These mountains in this region are usually composed of quartzites, while the limestones occur to the east of them. In the valley we find that from east to west steatites, hydromica slates, mica* slates, mica schists, and gneiss appear in the order named, so as to usurp the space which more to the north was occupied by argillites. The amount of epidote produced by concentrated local metamorphism along the line of the Catoctin is so much increased, that the partially fused rock, according to Rogers, is now a true epidosite, and seems to have invaded the quartzites and impregnated them with epidote and chlorite, just like a true igneous rock. This change may be due partly to the fact that the argil lites, which seem to be the source of the epidotic and chloritic products, are more deeply buried in this region. There is reason to think that the quartzites and associated rocks overlie the argillites here; hence the disappearance of the latter rocks.

We have seen that at Harper's Ferry the metamorphic products are principally quartzose. The case is different to the southwest, along the Blue Ridge. For much of the distance occupied by these mountains in this intermediate space, but especially near Swift Run Gap, and through the counties of Green and Madison, we find the argillites forming the main mass of the mountains highly impregnated with epidote, chlorite, quartz and other metamorphic products. At the same time, impregnations of various compounds of copper are found at numerous points here. As I did not visit this region, I cannot speak more definitely of it. The increased variety of meta-

* I have in this article used the terms *mica slate* and *mica schist* to denote different rocks. The former has slaty cleavages, is thinly laminated and fragile, having an amorphous to sub-micaceous texture, with a composition almost wholly formed of micaceous matter. The *mica schists* are stronger, heavier-bedded rocks, with quartz and micaceous matter in about equal proportions, and both appearing in visible individual particles. It is noteworthy that in no case is either constituent developed into large individuals. Thus the schist here differs much from that of the region adjacent to the Richmond granite, where both quartz and mica form large particles and produce a rock much like the mica schist of New York Island.

morphic products is no doubt due to the presence of true igneous rocks in this region. Rogers mentions their existence, but does not describe them.

The Chesapeake and Ohio Railroad crosses the Catoctin Mountains (here called "Southwest") about two miles east of Charlottesville, at Shadwell, which is situated on the Rivanna River. The stream has cut a passage through the range, exposing the rocks in its bed. The structure here is essentially the same with that seen at Point of Rocks. A series of closed folds give a succession of southeast dips. The material composing the mountain, however, is no longer argillite, but a more massive argillaceous quartzite, of greenish color, from the great amount of chlorite and epidote developed in it. This mass, when more highly altered, resembles very closely a true igneous rock, and is the material called by Rogers "epidotic rock." In passing out of the region of argillites of the north into the quartzites of the more southern district, we note thus a change in the structure of the Catoctin with respect to the nature of the strata. We still find a metamorphic product like that at Point of Rocks, only here with much more epidote. This, however, does not form any portion of the higher ground, called mountains in this section, but lies a short distance west of it, acting as the disturber and metamorphoser of the quartzite, which usually composes the mountains. The latter rock generally dips away from the epidosites (as we may call them), or stands vertically, and by its superior hardness has resisted erosion better.

The railroad crosses the valley nearly at right angles to the strike. By following it we get a tolerably good exposure of the strata. Just west of Charlottesville the first of a series of ledges of syenite is crossed. This rock, which abounds throughout the central portion of the valley, as far as Lynchburg, distant sixty miles, will be described in the account of the strata at that place.

The succession of rocks mentioned above as met with in going from east to west, in the district to the northeast of Charlottesville, occurs here also. We find, however, more abundant quartzites, and these of gneissoid character, extending farther west of the Catoctin range into the central parts of the valley. These quartzites play an important part in the structure of the rugged mass of mountains, which, commencing to the southwest of Charlottesville, and occupying the center of the valley, extend as far as Lynchburg. They are called near Charlottesville "The Ragged Mountains." Formed of a capping of quartzite, disturbed by the syenites, they assume the character of short ranges confusedly arranged. Toward Lynchburg they are less largely composed of stratified rocks. Various coarse granites and syenites make up most of their mass, especially in the short ranges called "Tobacco Row" and "No Business Mountains," lying above Lynchburg on both sides of the James.

The predominant rock along the railroad is a mica slate, and schist of varying character, but is mainly slate with micaceous matter in excess. The dip is usually high to the southeast. This is, however, not rarely reversed by the influence of the syenites. Near the eastern foot of the Blue Ridge, a very coarse gneiss is found.

The railroad climbs the mountain to the height of about seven hundred feet, gradually passing inward over the east slope, so that the tunnel is cut through the center and crest of the range. The mountain proper in the vicinity of Rockfish Gap is composed of argillites, highly altered by local metamorphism. Some very interesting effects are to be seen in passing over the eastern slopes. The metamorphic agent seems to have acted more energetically in certain bands, making an acute angle with the general direction of the mountain. Along these bands the slates have lost their cleavage, and have become much impregnated with epidote, quartz and chlorite. These three minerals often form concretionary masses, four to five feet in diameter, in which they are confusedly mixed together. Such lines of increased metamorphic action are, I think, determined by crevices or breaks in the strata.

The Blue Ridge at this point is a single chain, composed of highly altered argillites, with a central mass of eruptive rocks. Commencing at the east entrance of the tunnel, which is seven-eighths of a mile long, we find the argillite in heavy beds, lying with a dip of about 50° to the southeast. These slates have a dark greenish-grey color, from the presence of films of chlorite. They continue in the tunnel for about eight hundred and fifty yards, when we come upon an eruptive igneous rock, which extends about one hundred yards. This is succeeded by argillites, which continue with the same southeast dip to the edge of the Silurian strata, which are found near the west entrance. The southeast dip continues into the Silurian beds, but its steepness increases.

A belt of argillite on each side of the eruptive rock occurs, highly altered by the influence of the latter. In these belts the slates lose their bedding and cleavage, resemble a compact mass of angular fragments, and become impregnated with various minerals. When not thus impregnated, the texture is crystalline, the color grey, and the rock becomes harder and denser. The altered belt on the west side is much wider than that on the east, being as much as one hundred and fifty yards. In these altered belts occur many interesting associations of minerals, which can be well studied in the great mass of material used in making the two approaches of the tunnel.

The eruptive rock is a species of syenite of moderately fine texture. It contains a ground mass of rather fine granular red feldspar, quartz, hornblende and magnetic iron. In this occur porphyritically larger crystalline grains of red feldspar and quartz. The slates sometimes form a peculiar rock, indicating a gradual passage from slate to syenite, owing to contact effects. These portions might sometimes be mistaken for conglomerates, since they present rounded nodules of red feldspar and quartz, which exactly resemble water-worn pebbles. They lie imbedded in slaty matter, but perfectly distinct from it. We thus see that the structure here is precisely the same with that at Harper's Ferry. The central mass, however, is true igneous syenite. In composition it resembles the coarse syenite occurring farther southwest, but it is much better crystallized.

Among the products of metamorphism to be seen in the altered slates we may mention the following: 1. Rocks so highly impregnated with epidote as to appear a mass of acicular crystals. 2. The formation of numerous concretions of the size of a buckshot, composed of a core of epidote, with an envelope of milk-white quartz. 3. Calc spar with the characteristic cleavage. 4. This is sometimes intimately associated with epidote and silky fibers of asbestos, the spar being colored green by finely-disseminated hornblendic matter. 5. Masses of carbonate of lime, having a fine saccharoid texture like alabaster, and much like enclosed and metamorphosed fragments of ordinary limestone. They are, however, impregnations. Interesting studies both of the association and paragenesis of metamorphic minerals may be obtained.

The contact of the Silurian with the argillite is beautifully exposed in the west entrance of the tunnel, and the great contrast of the two systems thus brought side by side is well shown.

[To be continued.]

ART. III.—*Projection of the Fraunhofer Lines of Diffraction and Prismatic Spectra on a Screen;* by Prof. JOHN C. DRAPER, College of the City of New York.

HAVING been engaged during the past year in making photographs of absorption spectra of organic bodies, in which a solar spectrum with Fraunhofer lines was formed by a diffraction grating, I have resorted to the following method of forming such solar spectra, a description of which may prove of interest to those who are experimenting in the same field.

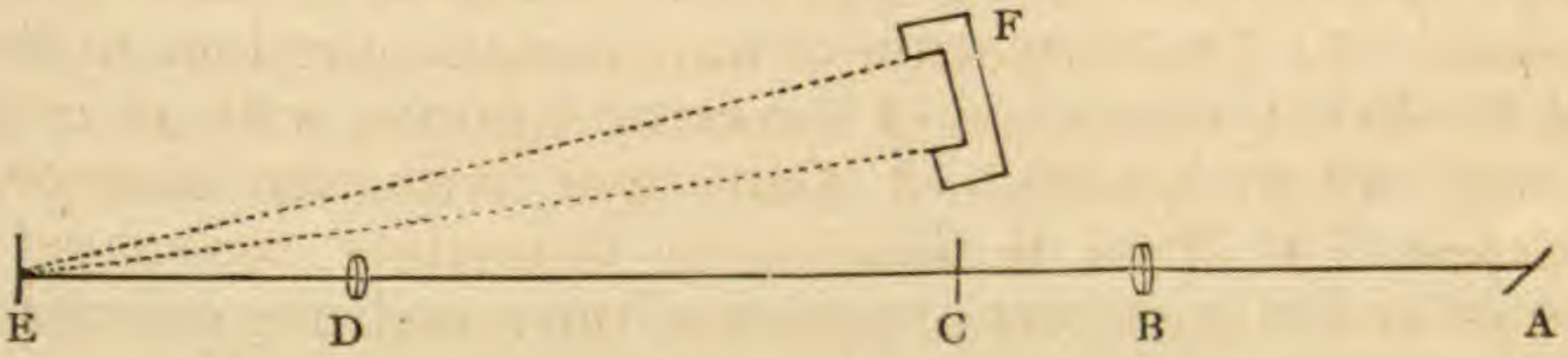
The grating generally used was made by Mr. L. M. Rutherfurd; it is ruled on speculum metal, 6,481 lines to the inch; it gives spectra by reflection. Other gratings on glass, now in my possession, give spectra by reflection and by transmission. The method answers equally well for both. It may be briefly stated as follows:

A beam of light is directed by the silvered plane mirror of a heliostat (A) into a darkened room.

It is received on an achromatic lens (B) ten centimeters in diameter; focal distance from posterior surface seventy centimeters.

A slit (C) is then placed within the focus of this lens, the distance being forty-eight centimeters from the lens (B).

After passing through the narrow slit, which is about one-tenth of a millimeter wide, the light is received upon a second achromatic lens (D), of the same diameter as the first, but with



a focal distance of one hundred and fifteen centimeters. The distance of this lens from the slit is one hundred and sixty-four centimeters, and the focussing of the lines of the spectrum on a paper screen or on the ground glass of the camera is accomplished by moving the lens (D) nearer to or farther from the slit (C), or by moving the camera or screen (F) itself.

The grating (E), mounted on a suitable stand, is placed at a distance of eighty centimeters from the second lens. All parts of the apparatus being carefully adjusted, so that A, B, C, D, E are on the same horizontal axis, the grating is then arranged on its vertical axis, to throw the center of its reflected image on the opening of the slit (C).

The lines of the grating being accurately parallel to the sides of the slit, a series of beautiful spectra are produced on each side of the slit, any or all of which may be received on suitably adjusted screens, one of which is represented at (F). In all of these spectra, if the slit has been very narrow, the prominent Fraunhofer, with numerous other lines, appear sharply defined.

Of the spectra described above, only the first, second and third orders on each side of the image of the slit are available for general use on account of the overlapping of those that follow. Of those that are available, I have preferred to use the second order, since in this the dispersion is much greater than in the first, and by the apparatus described above a spectrum of a length of more than thirty centimeters is obtained.

For the projection of the prismatic spectrum a prism is substituted in place of the grating, when a very fine spectrum is produced, the focus of the violet end of which is very much closer to the prism than that of the red end.

In the diffraction spectra, also, it is necessary to vary the angle at which the screen is placed to define sharply the lines at the extremities of each spectrum. In the spectra of the first order on each side, the screen is placed very nearly at right angles to a line drawn from the grating to (*b*), in the spectrum. As each order in succession is examined, the divergence from this angle is greater and greater, and at the same time the focal distance of the lines moves nearer to the grating.

The lenses I have employed were those of a very fine photographic combination; they give with the rest of the arrangement a spectrum in which the definition of the lines is perfect, and they are present by hundreds. Though the lenses are ten centimeters in diameter, only the central portion of each is used, a diaphragm with a circular aperture of five centimeters or less being placed in front of (B).

To form the absorbent spectra of any organic substance, a suitable solution of the same is poured into a cell with parallel sides. This is placed at any convenient point between A and B, care being taken that the faces of the cell are at right angles to the course of the ray A, B. The slit may in this case be opened wider, when each spectrum will show the characteristic absorbent bands of the substance employed, the position being indicated (and if required, recorded) by their relation to the lines of the solar spectrum in which they are produced.

When the calcium or electric light is to be used for lecture room demonstration of diffraction spectra, the lens (B) should have as short a focus and as large a diameter as possible. The grating may also be so arranged on its vertical axis as to throw its image at a right angle to the line B, E, to be there received on a screen. Though by this device the spectra on one side of the image of the grating are greatly elongated and those on the other compressed, it presents the advantage of enabling the audience to see all the spectra at once, and also the optical contrivances by which they are produced.

November 25, 1874.

ART. IV.—*Abstract of results from a new discussion of the secular change of the Magnetic Declination in the United States, and some adjacent places in North and Central America;* by CHARLES A. SCHOTT, Assistant U. S. Coast Survey.

(Read before the National Academy of Sciences, Nov. 4, 1874.)

[Communicated by permission of CARLILE P. PATTERSON, Superintendent U. S. Coast Survey.]*

THE present investigation incorporates the additional observations made or collected since 1859, and contains the improved results for the old stations as well as those for a number of new stations. The circular function adopted in the previous discussion to represent the secular change, continued to lead to satisfactory results, as might have been expected from its great adaptation to represent curves of a periodic character. Independent of the study of terrestrial magnetism, the necessity for the occasional reconstruction of the numerical expressions is sufficiently apparent from the demands of the Survey and the use which is made of them for the magnetic data given on our charts, viz: the magnetic declination (variation of compass) for a certain epoch, or date of publication, and its rate of change.

To briefly recapitulate the formulæ employed, let

$$D=\delta+r \sin(am+c)+r_1 \sin(\alpha_1 m+c_1)+ \ . \ . \ .$$

express the magnetic declination at any time t, positive when west, negative when east of north; also, let m = number of years (and fraction of a year) from the adopted epoch t, or $m=t-1850$.

$\alpha \ \ \alpha_1$ . . factors depending on the adopted periods,

$$p \ \ p_1 \ . \ . \text{ or } \alpha=\frac{360^\circ}{p} \ \ \alpha_1=\frac{360^\circ}{p_1} \ . \ . \ . \ .$$

The quantities δ, a constant representing a mean declination, $r \ r_1$ . . . . parameters, and $c \ c_1$ . . . . epochal constants of the periodic terms, are to be determined from the observations at any one place by the application of the method of least squares, in order to satisfy the condition that the sum of the squares of the residuals of the observed and computed declinations shall be a minimum ($\Sigma\Delta^2$=a minimum). For this purpose put $\delta=\delta_1+x$, where δ_1 = an assumed approximate value δ, and x a correction to it; also,

$$r \cos c=y \quad \text{and} \quad r \sin c=z,$$

then the conditional equations will take the form

$$0=\delta_1-D+x+\sin \alpha\, m\, .\, y+\cos \alpha\, m\, .\, z+ \ . \ . \ .$$

* The paper in full will be published in Coast Survey Report for 1874. It is an extension of the article which appeared in this Journal, vol. xxix, Art. XXIX, May, 1860.

which are to be treated in the usual manner. To determine the value of $\alpha\ \alpha_1$ three (or more, if necessary) assumptions are made, and those values which render $\Sigma\Delta^2$ a minimum are deduced, and finally adopted. In some cases, where certain observations were evidently less trustworthy than others, and which nevertheless could not be dispensed with on account of the small number of observations, or on account of their reference to desirable epochs, special weights were assigned; generally the observations received the weight unity, a few imperfect observations the weight one-half. Of observations evidently grossly in error, no notice was taken.

The second periodic term depending on $r_1\ \alpha_1\ c_1$ could only be established for a few places, owing to insufficiency in the number of observations and their want of the greater accuracy demanded for it.

The annual change v in the magnetic declination, positive when increasing west (or decreasing east), also the epoch of minimum west declination (or of maximum east declination), also its amount and the apparent probable error of an observation, are found as follows:

Differentiating the expression for D, we have

$$dD = r\alpha \cos(\alpha m + c)dm + r_1\alpha_1 \cos(\alpha_1 m + c_1)dm + \ldots$$

hence for any time t, and for minutes of arc,

$$v = 60 \sin 1^\circ[r\alpha \cos(\alpha m + c) + r_1\alpha_1 \cos(\alpha_1 m + c_1) + \ldots]$$

Maxima and minima are deduced from the equation

$$0 = r\alpha \cos(\alpha m + c) + r_1\alpha_1 \cos(\alpha_1 m + c_1) + \ldots$$

from which expression we can find m.

The apparent probable error e_0 of an observation is deduced from the differences Δ of the n observed and computed values by the formula

$$e_0 = \sqrt{\frac{0 \cdot 455\Sigma\Delta^2}{n - n_1}}$$

where n_1 equals the number of unknown quantities in the expression of D, which had to be found from the observations; when weights, w, are used, substitute $w\Delta^2$ for Δ^2. The greater part of this apparent probable error is due to the fact that the observations collected at any one station were not generally made at the same spot; it represents, consequently, local irregularities in the distribution of magnetism, as well as pure observing errors.

The principal uncertainty in the investigation arises partly from the large observing errors in the older observations, made with ordinary compasses or with rude instruments generally, and partly, since the introduction of the refined instruments, the theodolite and magnetometer, from the circumstance that the various observations for the same nominal locality were taken at different spots, involving changes of local deflections of the magnet. From the extended use of iron and the growth of cities, it is difficult to select and preserve in such places a suitable locality for use at future times. Accurate investigations of the secular change can only be made at permanent observatories, or in localities not liable to disturbing influences.

In applying a periodic function to the investigation of the secular change, it is *not implied* that the phenomenon is necessarily of a periodic character, or must exhibit more than a single *complete* period; the aim is to represent by such a function the changes in the direction of the magnetic resultant, as far as observed.

The collection of the material is given first, the stations being arranged in geographical order, beginning in the northeast, passing to the south and west, and ending in the northwest.* For each locality the observed declinations are given in chronological order, together with such notes and references, respecting observer, place, publication, etc., as could be found. The stations here given are the only ones at present suitable for a discussion of the secular change, but their number is constantly increasing by the accumulation of new facts. [The collection referred to is here omitted.]

The following table contains the empirical expressions for the magnetic declinations derived from the collected observations by the process explained above, for various localities, together with their latitudes and longitudes. Total number of stations, 43, and of observations, about 417.

TABLE I.

Locality.	Latitude	Longitude	Expression of Magnetic Declination.
	° ′	° ′	
Halifax, N. S.	44 39·6	63 35·3	$D = +15°.94 + 4°.42 \sin(1·0\ m + 49°.2)$
Quebec, Can.	46 48·4	71 14·5	$D = +12·67 + 3·84 \sin(1·65m + 43·6)$
York Factory, Hud. Bay.	57 00·	92 26·	$D = +\ 5·08 + 14·12 \sin(1·6\ m - 79·4)$
Portland, Me.	43 38·8	70 16·6	$D = +10·72 + 2·68 \sin(1·33m + 24·1)$
Burlington, Vt.	44 28·2	73 12·3	$D = +11·16 + 3·76 \sin(1·30m - 26·3)$
			$+ 0·18 \sin(7·2m + 138)$
Rutland, Vt.	43 36·5	72 55·5	$D = +\ 9·76 + 3·64 \sin(1·6\ m - 19·6)$
Portsmouth, N. H.	43 04·8	70 43·0	$D = +10·29 + 2·56 \sin(1·37m + 5·9)$
Newburyport, Mass.	42 48·4	70 49·0	$D = +\ 9·63 + 2·63 \sin(1·4\ m + 13·2)$
Salem, Mass.	42 31·9	70 52·5	$D = +10·22 + 4·04 \sin(1·55m - 6·1)$
Boston, Mass.	42 21·5	71 03·8	$D = +\ 9.46 + 2·83 \sin(1·3\ m + 4·6)$
Cambridge, Mass.	42 22·9	71 07·7	$D = +\ 9·58 + 2·69 \sin(1·3\ m + 7·0)$
			$+ 0·18 \sin(2·2m + 44)$

* This approximates to an arrangement proceeding from the greatest western to the greatest eastern declinations.

TABLE I—*continued.*

Locality.	Latitude	Longitude	Expression of Magnetic Declination.
	° ′	° ′	° ° °
Nantucket, Mass.	41 17·0	70 06·0	D = + 8·94 + 2·45 sin (1·35*m* + 13·8)
Providence, R. I.	41 49·5	71 24·1	D = + 9·10 + 2·99 sin (1·45*m* − 3·4) + 0·19 sin (7·2*m* + 116)
Hartford, Conn.	41 46·	72 40·8	D = + 8·06 + 2·90 sin (1·25*m* − 26·4)
New Haven, Conn.	41 18·5	72 55·7	D = + 7·83 + 3·16 sin (1·4 *m* − 21·6)
Albany, N. Y.	42 39·2	73 45·8	D = + 8·22 + 3·05 sin (1·44*m* − 9·7)
Oxford, N. Y.	42 26·5	75 40·5	D = + 6·19 + 3·24 sin (1·35*m* − 18·9)
Buffalo, N. Y.	42 52·8	78 53·5	D = + 3·40 + 3·41 sin (1·4 *m* − 23·3)
Erie, Pa.	42 07·8	80 05·4	D = + 1·27 + 2·00 sin (1·4 *m* − 10·5)
Cleveland, O.	41 30·3	81 42·0	D = − 0·34 + 1·89 sin (1·4 *m* + 6·0)
Detroit, Mich.	42 20·0	83 03·0	D = − 0·96 + 2·22 sin (1·5 *m* − 15·7)
New York City.	40 42·7	74 00·4	D = + 6·43 + 2·29 sin (1·6 *m* − 5·5) + 0·14 sin (6·3*m* + 64)
Hatboro, Pa.	40 12·	75 07·	D = + 5·23 + 3·28 sin (1·54*m* − 13·2) + 0·22 sin (4·1*m* + 157)
Philadelphia, Pa.	39 56·9	75 09·0	D = + 5·42 + 3·35 sin (1·55*m* − 22·9)
Washington, D. C.	38 53·3	77 00·6	D = + 1·79 + 1·90 sin (1·5 *m* + 5·9)
Cape Henry, Va.	36 55·5	76 00·5	D = + 2·95 + 2·95 sin (1·55*m* − 35·3)
Charleston, S. C.	32 46·6	79 55·8	D = − 2·75 + 2·38 sin (1·6 *m* + 15·2)
Savannah, Ga.	32 04·9	81 05·5	D = − 2·54 + 2·32 sin (1·5 *m* − 28·6)
Key West, Fla.	24 33·5	81 48·5	D = − 4·75 + 2·54 sin (1·4 *m* − 16·4)
Havana, Cuba.	23 08·	82 22·	D = − 4·82 + 1·44 sin (1·3 *m* − 38·2)
Kingston, Jamaica.	17 55·	76 50·	D = − 4·69 + 1·95 sin (1·2 *m* + 16·0)
New Orleans, La.	29 57·2	90 03·9	D = − 5·68 + 2·52 sin (1·4 *m* − 63·8)
Vera Cruz, Mex.	19 12·	96 09·	D = − 3·77 + 5·89 sin (1·1 *m* − 60·5)
Mexico, Mex.	19 25·9	99 06·0	D = − 4·30 + 4·59 sin (1·1 *m* − 76·5)
Acapulco, Mex.	16 50·5	99 52·3	D = − 3·97 + 4·96 sin (1·05*m* − 76·7)
Panama, New Granada.	8 55·	79 30·	D = − 6·28 + 1·57 sin (1·2 *m* − 13·9)
San Blas, Mex.	21 32·6	105 15·7	D = − 5·60 + 3·37 sin (1·0 *m* − 87·7)
San Diego, Cal.	32 42·1	117 14·3	D = − 12·54 + 1·64 sin (1·2 *m* − 180·0)
Monterey, Cal.	36 36·2	121 53·6	D = − 12·82 + 3·54 sin (1·0 *m* − 142·9)
San Francisco, Cal.	37 47·5	122 27·2	D = − 13·50 + 3·10 sin (1·0 *m* − 132·7)
C. Disappointment, W. T.	46 16·7	124 02·0	D = − 20·72 + 2·81 sin (1·2 *m* − 188·8)
Sitka, Alaska.	57 02·9	135 20·	D = − 29·08 − 0·010*m* + 0·00098m^2
Unalaska Island, Alaska.	53 52·6	166 31·5	D = − 20·05 + 0·024*m* + 0·00080m^2

In the second table are exhibited, for each locality discussed, the observed and computed declinations (by preceding formulæ), expressed in degrees and fractions of a degree.

TABLE II.

Year.	Obsd.	Compd.	Year.	Obsd.	Compd.	Year.	Obsd.	Compd.
Halifax. N. S.			Quebec, Can.			York Factory.		
1756·5	+12°·83	+12°·85	1649·5	+16°·0	+16°·34	1725·5	+19°·0	+19°·04
1775·5	13·58	14·05	1686·5	15·5	15·44	1787·5	+5·0	+4·93
1798·5	16·50	15·76	1810·5	11·0	11·25	1819·7	−6·00	−6·06
1818·0	17·47	17·25	1814·5	11·83	11·67	1843·5	−9·42	−9·05
1821·7	17·60	17·52	1831·5	13·62	13·54	1857·6	−7·62	−7·95
1852·5	18·17	19·41	1834·5	14·23	13·86			
1853·0	18·85	19·44	1842·5	14·20	14·66			
1860·5	19·92	19·76	1858·8	15·57	15·93			
1866·3	+21·09	+19·97	1859·5	16·28	15·97			
			1860·8	+16·47	+16·04			

TABLE II—*continued.*

Year.	Obsd.	Compd.
Portland, Me.		
1763·5	+7°·75	+8°·05
1775·5	8·50	8·14
1845·4	11·47	11·55
1851·6	11·69	11·91
1859·5	12·33	12·33
1863·5	12·47	12·52
1864·8	12·73	12·58
1865·5	12·71	12·61
1866·1	12·72	12·64
1873·7	+12·89	+12·94
Burlington, Vt.		
1793·5	+7·63	+7·63
1818·5	7·50	7·51
1822·5	7·70	7·69
1826·5	7·60	7·94
1830·5	8·17	8·21
1831·5	8·25	8·29
1832·5	8·42	8·37
1834·5	8·83	8·52
1837·5	8·75	8·75
1845·5	9·37	9·33
1855·7	9·95	9·94
1873·8	+11·32	+11·32
Rutland, Vt.		
1789·3	+7·05	+6·51
1810·4	6·07	6·14
1811·7	6·02	6·16
1859·6	9·82	9·49
1873·8	+10·67	+10·91
Portsmouth, N. H.		
1771·5	+7·77	+7·78
1775·5	7·75	7·74
1850·7	10·50	10·60
1859·5	+11·25	+11·12
Newburyport, Mass.		
1775·5	+6·75	+7·00
1781·5	7·30	7·02
1850·7	10·09	10·28
1859·5	+10·97	+10·81
Salem, Mass.		
1781·6	+6·90	+6·47
1805·8	5·95	6·32
1810·5	6·09	6·49
1849·6	10·24	9·75
1855·6	+10·83	+10·40

Year.	Obsd.	Compd.
Boston, Mass.		
1700·5	+10°·00	+9°·95
1708·5	9·00	9·45
1741·5	7·50	7·52
1776·0	7·67	6·62
1782·5	7·00	6·64
1793·5	6·50	6·82
1807·5	6·08	7·28
1839·5	9·10	9·03
1846·7	9·52	9·49
1855·6	10·23	10·05
1872·7	+11·25	+11·01
Cambridge, Mass.		
1708·5	+9·0	+9·30
1742·5	8·0	7·70
1757·5	7·33	7·28
1761·5	7·23	7·17
1763·5	7·00	7·13
1780·5	7·03	6·90
1782·5	6·75	6·89
1783·5	6·87	6·90
1788·5	6·63	6·93
1810·5	7·50	7·52
1835·5	8·85	9·02
1837·5	9·15	9·15
1840·4	9·30	9·36
1842·2	9·57	9·49
1844·5	9·65	9·65
1845·4	9·53	9·72
1850·6	9·50	10·07
1852·5	10·13	10·20
1854·5	10·21	10·33
1855·4	10·91	10·39
1856·5	10·47	10·46
1859·2	10·80	10·63
1867·5	+10·70	+11·09
Nantucket, Mass.		
1775·5	+6·50	+6·50
1834·5	8·45	8·64
1838·9	9·04	8·89
1842·7	9·15	9·11
1843·7	9·17	9·17
1846·6	9·23	9·33
1855·6	9·97	9·83
1867·4	+10·33	+10·42

Year.	Obsd.	Compd.
Providence, R. I.		
1717·5	+9°·60	+9°·73
1720·5	9·47	9·49
1725·5	9·23	9·14
1730·5	8·90	8·85
1735·5	8·65	8·59
1740·5	8·25	8·33
1745·5	7·98	8·02
1750·5	7·67	7·66
1755·5	7·35	7·27
1760·5	6·95	6·88
1765·5	6·72	6·53
1769·5	6·50	6·29
1775·5	6·33	6·15
1780·5	6·27	6·12
1785·5	6·22	6·17
1790·5	6·17	6·25
1795·5	6·17	6·32
1800·5	6·25	6·37
1805·5	6·32	6·40
1810·5	6·40	6·45
1815·5	6·50	6·55
1819·5	6·62	6·75
1825·5	6·85	7·06
1830·5	7·17	7·45
1835·5	7·57	7·90
1840·5	8·42	8·36
1841·5	8·52	8·45
1842·5	8·65	8·53
1843·5	8·77	8·60
1855·6	+9·52	+9·42
Hartford, Conn.		
1786·5	+5·42	+5·28
1810·5	4·77	5·25
1824·5	5·75	5·60
1829·0	6·05	5·76
1859·6	7·29	7·34
1867·6	+7·82	+7·84
New Haven, Conn.		
1761·5	+5·78	+6·04
1775·5	5·42	5·27
1780·5	5·25	5·07
1811·5	5·17	4·77
1819·8	4·42	5·00
1828·5	5·28	5·35
1835·3	5·68	5·71
1836·5	5·92	5·78
1837·9	5·83	5·87
1840·5	6·17	6·02
1845·7	6·29	6·37
1848·6	6·58	6·57
1855·6	7·05	7·08
1872·5	+8·46	+8·37

TABLE II—*continued.*

Albany, N. Y.

Year.	Obsd.	Compd.
1817·8	+5°·73	+5°·71
1818·6	5·75	5·78
1825·3	6·00	6·07
1828·6	6·27	6·26
1830·5	6·30	6·37
1831·6	6·54	6·44
1834·8	6·67	6·64
1836·8	6·78	6·77
1847·9	7·58	7·57
1855·7	7·91	8·16
1856·7	8·58	8·23
1858·4	+8·28	+8·37

Oxford, N. Y.

Year.	Obsd.	Compd.
1794·0	+3·00	+2·96
1817·5	3·00	3·31
1828·5	4·50	3·79
1834·8	3·87	4·13
1836·8	4·15	4·26
1837·5	4·50	4·30
1838·5	4·45	4·36
1849·9	5·18	5·14
1857·3	5·73	5·68
1858·1	5·78	5·74
1859·0	5·83	5·81
1873·9	6·87	6·94
1874·4	+6·93	+6·97

Buffalo, N. Y.

Year.	Obsd.	Compd.
1797·5	0·00	+0·01
1837·5	+1·42	1·17
1839·5	1·25	1·30
1845·5	1·42	1·71
1859·5	2·94	2·81
1872·5	3·87	3·89
1873·5	+3·97	+3·97

Erie, Pa.

Year.	Obsd.	Compd.
1795·5	−0·72	−0·72
1841·6	+0·50	+0·51
1862·6	+1·55	+1·52
1873·4	+2·01	+2·03

Cleveland, O.

Year.	Obsd.	Compd.
1796·7	−2·00	−2·10
1830·5	−1·33	−1·03
1831·6	−1·25	−0·98
1834·1	−0·83	−0·87
1838·1	−0·58	−0·69
1841·3	−0·09	−0·54
1845·5	−0·65	−0·35
1859·5	+0·77	+0·29
1871·8	+0·54	+0·79
1872·5	+0·75	+0·81
1873·5	+0·85	+0·85

Detroit, Mich.

Year.	Obsd.	Compd.
1810·5	−2°·80	−3°·10
1822·5	−3·22	−2·82
1828·5	−2·83	−2·61
1835·5	−2·17	−2·31
1840·5	−1·97	−2·07
1859·5	−0·70	−1·01
1865·5	−0·67	−0·66
1872·4	−0·42	−0·28
1873·4	−0·29	−0·22

New York City.

Year.	Obsd.	Compd.
1686·5	+8·75	+8·78
1691·5	8·75	8·68
1723·5	7·33	7·53
1750·5	6·37	5·85
1755·5	5·00	5·46
1789·5	4·33	4·30
1824·5	4·67	4·64
1834·5	4·83	5·17
1837·5	5·67	5·37
1840·6	5·45	5·61
1841·5	6·10	5·68
1844·6	6·22	5·92
1845·7	6·42	6·01
1846·3	5·56	6·05
1847·8	5·68	6·16
1855·6	6·72	6·73
1860·7	6·73	7·03
1873·8	+7·62	+7·63

Hatboro, Pa.

Year.	Obsd.	Compd.
1680·5	+8·47	+8·49
1690·5	8·25	8·30
1700·5	7·92	7·94
1710·5	7·47	7·49
1720·5	7·00	6·95
1730·5	6·42	6·30
1740·5	5·58	5·56
1750·5	4·92	4·67
1760·5	4·00	3·75
1770·5	2·92	2·89
1780·5	2·08	2·21
1790·5	1·83	1·84
1800·5	1·92	1·79
1810·5	2·00	2·07
1820·5	2·45	2·56
1830·5	3·00	3·20
1840·5	3·83	3·89
1850·5	+4·42	+4·60

Philadelphia, Pa.

Year.	Obsd.	Compd.
1701·5	+8°·50	+8°·63
1710·5	8·50	8·30
1750·5	5·75	5·25
1793·5	1·50	2·27
1802·5	1·50	2·08
1804·5	2·08	2·07
1813·5	2·43	2·12
1837·5	3·87	3·16
1840·5	3·62	3·37
1841·7	3·90	3·46
1846·4	3·85	3·82
1855·7	4·53	4·60
1862·6	5·00	5·22
1872·8	+5·46	+6·14

Washington, D. C.

Year.	Obsd.	Compd.
1792·5	−0·24	−0·08
1809·9	+0·87	+0·25
1841·0	1·34	1·54
1842·0	1·40	1·59
1855·5	2·40	2·25
1856·6	2·36	2·30
1857·2	2·41	2·34
1860·7	2·44	2·50
1862·7	2·66	2·59
1863·6	2·70	2·63
1866·8	2·74	2·77
1867·5	2·80	2·80
1868·5	2·85	2·84
1869·3	2·88	2·87
1870·5	2·89	2·92
1871·5	2·95	2·96
1872·5	3·00	3·00
1873·5	3·00	3·04
1874·5	+3·10	+3·08

Cape Henry, Va.

Year.	Obsd.	Compd.
1732·5	+4·68	+4·74
1809·5	[0·00]	0·03
1832·5	+0·75	0·34
1856·7	+1·47	1·71
1865·8	[+2·54]	+2·40

Charleston, S. C.

Year.	Obsd.	Compd.
1742·5	[−5·38]	−3·69
1775·5	−3·80	−5·06
1784·1	−5·25	−5·13
1785·8	−5·75	−5·13
1825·0	−3·75	−3·75
1837·5	−2·90	−2·95
1841·4	−2·40	−2·69
1847·8	−2·25	−2·27
1849·3	−2·28	−2·17
1874·4	−0·97	−0·82

TABLE II—*continued.*

Savannah, Ga.

Year.	Obsd.	Compd.
1817·5	−4°·00	−4°·68
1839·0	−4·30	−4·18
1852·3	−3·67	−3·52
1857·3	−3·46	−3·24
1874·2	−1·98	−2·23

Key West, Fla.

Year.	Obsd.	Compd.
1829·1	−6·42	−6·57
1843·5	−6·03	−5·84
1849·6	−5·48	−5·49
1860·7	−4·78	−4·81
1861·2	−4·75	−4·78
1862·7	−4·68	−4·69
1863·5	−4·60	−4·64
1864·5	−4·56	−4·58
1865·5	−4·52	−4·52
1866·2	−4·49	−4·47

Havana, Cuba.

Year.	Obsd.	Compd.
1726·5	−4·4	−4·37
1732·3	−4·5	−4·54
1815·5	−7·0	−6·25
1816·6	−5·5	−6·24
1857·1	−5·25	−5·52
1858·5	−5·75	−5·48

Kingston, Jamaica.

Year.	Obsd.	Compd.
1732·2	−6·0	−6·28
1791·8	−6·78	−6·26
1806·0	−6·5	−5·86
1820·5	−4·8	−5·34
1822·5	−4·9	−5·26
1832·5	−5·2	−4·86
1833·5	−4·7	−4·82
1837·8	−4·3	−4·56
1847·3	−3·67	−4·24
1857·2	−3·67	−3·88
1866·5	−4·95	−3·55

New Orleans, La.

Year.	Obsd.	Compd.
1720·5	−2·0	−3·39
1768·5	−7·83	−5·77
1796·5	−5·10	−7·34
1806·5	−8·05	−7·75
1840·5	−8·33	−8·14
1857·0	−8·00	−7·72
1858·3	−7·86	−7·67
1870·5	−7·10	−7·13
1872·1	−6·99	−7·05

Vera Cruz, Mex.

Year.	Obsd.	Compd.
1727·0	−2°·25	−2°·17
1769·4	−6·57	−6·79
1776·5	−7·5	−7·46
1815·5	−10·6	−9·60
1819·3	−9·3	−9·65
1856·6	−8·3	−8·49
1861·0	−8·3	−8·18

Mexico, Mex.

Year.	Obsd.	Compd.
1769·8	−5·45	−5·51
1804·0	−8·13	−7·94
1850·5	−8·59	−8·75
1856·9	−8·77	−8·58
1858·5	−8·37	−8·53
1860·5	−8·50	−8·46
1862·5	−8·34	−8·38
1867·0	−8·15	−8·18
1868·5	−8·17	−8·11

Acapulco, Mex.

Year.	Obsd.	Compd.
1744·5	−3·0	−3·32
1791·3	−7·73	−7·26
1822·5	−8·67	−8·74
1828·5	−9·12	−8·85
1838·0	−8·29	−8·91
1866·5	−8·37	−8·23

Panama, New Granada.

Year.	Obsd.	Compd.
1775·8	−7·8	−7·80
1790·8	−7·8	−7·83
1802·5	−8·0	−7·76
1822·5	−7·0	−7·42
1837·5	−7·03	−7·03
1849·5	−7·08	−7·67
1866·4	−5·93	−6·12

San Blas, Mex.

Year.	Obsd.	Compd.
1791·3	−7·47	−7·46
1822·0	−8·67	−8·64
1837·5	−8·57	−8·92
1839·5	−9·00	−8·94
1841·5	−9·20	−8·95

San Diego, Cal.

Year.	Obsd.	Compd.
1792·5	−11·00	−11·01
1839·5	−12·34	−12·18
1851·3	−12·48	−12·58
1853·8	−12·53	−12·67
1866·4	−13·16	−13·09
1872·9	−13·32	−13·29

Monterey, Cal.

Year.	Obsd.	Compd.
1791·7	−10°·93	−11°·48
1795·5	−12·37	−11·76
1837·5	−14·50	−14·29
1839·5	−14·22	−14·40
1841·5	−15·00	−14·51
1843·5	−14·00	−14·62
1851·1	−14·97	−15·01
1873·7	−15·92	−15·91

San Francisco, Cal.

Year.	Obsd.	Compd.
1792·9	−12·80	−12·97
1827·5	−15·45	−14·80
1829·5	−15·10	−14·90
1837·5	−15·17	−15·27
1839·5	−15·33	−15·35
1841·9	−15·50	−15·46
1850·0	−15·68	−15·78
1852·3	−15·48	−15·86
1866·5	−16·42	−16·28
1872·8	−16·43	−16·41
1873·6	−16·42	−16·43
1874·0	−16·47	−16·44

C. Disappointment, W. T.

Year.	Obsd.	Compd.
1792·3	−18·00	−17·98
1839·5	−19·18	−19·70
1842·5	−20·00	−19·86
1851·5	−20·54	−20·38
1873·8	−21·61	−21·67

Sitka, Alaska.

Year.	Obsd.	Compd.
1804·5	−26·75	−26·58
1824·5	−27·50	−28·18
1827·5	−28·83	−28·36
1829·5	−28·32	−28·46
1830·0	−28·27	−28·48
1838·5	−28·62	−28·83
1839·5	−29·53	−28·86
1842·5	−28·88	−28·95
1851·0	−29·23	−29·09
1867·6	−28·82	−28·95

Unalaska Island, Alaska.

Year.	Obsd.	Compd.
1792·5	−19·0	−18·79
1806·5	−19·4	−19·58
1829·0	−19·9	−20·20
1848·5	−19·51	−20·08
1849·5	−20·00	−20·06
1867·7	−19·79	−19·38
1870.5	−19·75	−19·22
1873·4	−19·00	−19·05

The third table shows the number of observations at each place; the apparent probable error of one observation (including errors arising from want of identity of stations and from instrumental defects) expressed in minutes of arc; the computed epochs of greatest easterly deflection in the secular motion, together with the amount and direction of the declination at that epoch, and the computed annual changes at the epochs 1870 and 1880, expressed in minutes.

TABLE III.

Locality.	Number of Observations.	Apparent probable error of an observation.	Epoch of *easterly* secular digression (needle stationary).	Amount when at easterly digression.	Annual change in 1870.	Annual change in 1880.
Halifax, N. S.	9	±33′	1711	+11°·5	+1′·6	+0′·9
Quebec, Canada.	10	15	1769	+8·8	+1·7	---
York Factory, Hudson Bay.	5	14	----	---	---	---
Portland, Me.	10	9	1764	+8·0	+2·4	+1·6
Burlington, Vt.	12	6	1810	+7·4	+5·7	+6·0
Rutland, Vt.	5	15	1807	+6·1	+5·9	+5·4
Portsmouth, N. H.	4	5	1780	+7·7	+3·1	+2·5
Newburyport, Mass.	4	13	1776	+7·0	+2·9	+2·2
Salem, Mass.	5	26	1796	+6·2	+5·9(?)	+5·0(?)
Boston, Mass.	11	25	1777	+6·6	+3·3	+2·8
Cambridge, Mass.	23	11	1783	+6·9	+2·9	+2·1
Nantucket, Mass.	8	6	1773	+6·5	+2·6	+2·3
Providence, R. I.	30(?)	7	1780	+6·1	+3·8	---
Hartford, Conn.	6	14	1799	+5·2	+3·4	+3·0
New Haven, Conn.	14	9	1801	+4·7	+4·6	+4·3
Albany, N. Y.	12	6	1794	+5·2	+4·3	+3·8
Oxford, N. Y.	13	9	1797	+3·0	+4·5	+4·3
Buffalo, N. Y.	7	8	1802	0·0	+4·9	+4·7
Erie, Pa.	4	--	1793	−0·7	+2·8	+2·5
Cleveland, O.	11	12	1781	−2·2	+2·3	+1·9
Detroit, Mich.	9	11	1801	−3·2	+3·4	+3·0
New York City.	18	15	1797	+4·0	+2·4	+2·5
Hatboro, Pa.	18(?)	6	1797	+1·8	+4·6	+4·5(?)
Philadelphia, Pa.	14	20	1807	+2·1	+4·7	+3·7
Washington, D. C.	19	6	1786	−0·1	+2·4	+1·9
Cape Henry, Va.	5	14	1815	0·0	+4·8(?)	+4·7(?)
Charleston, S. C.	9	19	1784	−5·1	+2·7	+1·8
Savannah, Ga.	5	15	1809	−4·9	+3·6	+3·5
Key West, Fla.	10	4	1797	−7·3	+3·6	+3·4
Havana, Cuba.	6	26	1810	−6·3	+1·9	---
Kingston, Jamaica.	11	25	----	−6·6	+1·9	---
New Orleans, La.	9	30	1831	−8·2	+3·0	+3·4
Vera Cruz, Mex.	7	17	1823	−9·7	+5·3	---
Mexico, Mex.	9	5	1838	−8·9	+3·1	+3·8
Acapulco, Mex.	6	21	1837	−8·9	+3·1	+3·8
Panama, New Granada.	7	13	1787	−7·9	+1·9	+1·8
San Blas, Mex.	5	10	1848	−9·0	+1·3	---
San Diego, Cal.	6	6	1925	−14·2	−1·9	−1·7
Monterey, Cal.	8	21	1903	−16·4	−2·0	−1·5
San Francisco, Cal.	12	9	1893	−16·6	−1·3	−0·7
Cape Disappointment, W. T.	5	12	1932	−23·5(?)	−3·4	−3·1
Sitka, Alaska.	10	18	1855	−29·1	+1·8	+2·9
Unalaska Island, Alaska.	8	17	1835	−20·2	+3·4	+4·4

The probable errors given above will serve to convey some rude idea of the relative value of *each series* of observations; the imperfections in the instrumental means of the older observations in many cases react unfavorably on the modern observations made with more precise instruments; the observations, for instance, taken by Hudson in 1609, in the vicinity of New York Bay, are fairly chargeable with a probable error of ±3° (a single result); those taken by Vancouver on our western coast, between 1792 and 1794, are subject to a probable uncertainty of ±1° (each). Increased precision was obtained with the improvements of the azimuth compass and the allowance for disturbing effect of the ship's iron, and, for shore stations, with the introduction of the theodolite for determining the astronomical meridian. With a portable magnetometer (collimator) the *instrumental* means need not leave a greater uncertainty than about one minute, but the *actual probable error* of any determination is limited by the accidental variations in the mean directions of the magnetic force from day to day, making it desirable to continue the observations for three or more days and to correct them for daily variation. It is principally dependent on the magnitude of the horizontal force.

A cursory examination of the column containing the epochs of greatest *easterly* excursion, the *deflecting* force producing the secular change attaining then an easterly maximum, shows that the needle became stationary in direction and then reversed its secular motion in the New England States toward the end of the past century, in the Atlantic Coast States, to the west and south, early in the present, and in Mexico about the close of the first third of the present century. In California, Oregon and Washington Territory it has not yet reached this condition. We thus have the following epochs for comparison: Halifax about 1711; Portland, Portsmouth, Newburyport, Salem, Boston, Cambridge, Nantucket and Providence about 1799; Hartford, New Haven, New York, Hatboro, Philadelphia, Washington and Cape Henry about 1800; Charleston, Savannah, Key West and Havana about 1800; New Orleans about 1831; Vera Cruz, Mexico, Acapulco and San Blas about 1837; San Diego, Monterey and San Francisco, expected about 1907 (yet very uncertain). We are thus directed to the extreme northeastern States for probable indications of what may be expected to follow on the seaboard in more southern and western States. Respecting the secular movement of the needle, apparently a little more than a century passed before the influence which produced the turning of the north end of the needle westward in Maine (increasing there the western declination) was felt in Lower California (diminishing there the eastern declination); in California, Oregon and

Washington Territory the eastern declination is at present still increasing, but with a losing rate. By the time the western elongation of the secular change is reached in Maine we may expect to see the needle in the opposite phase, or at its eastern elongation, in California. We cannot as yet follow this influence directly over the interior of the United States for want of early observations; the westernmost interior stations for which an epoch could be made out were Buffalo, Erie, Cleveland and Detroit; these give the average turning epoch 1794. It may be quite practicable hereafter to trace out curves uniting all stations where the needle was stationary at a given epoch and again at other epochs for regular intervals of time, say of 10 or 25 years.

Returning to the first table, the constant in each formula would represent the normal direction of the needle, about which the secular change would be performed in an average cycle of about 270 years, and with extreme deflections on either side of it, equal to the co-efficient of the periodic term—all under the *supposition* that the law of the secular movement was truly expressed. It is no doubt much more complex, and besides, may fail at any time; yet as far as our present experience reaches, and within the interval when the first reliable observations were made to the present time, it is found trustworthy.

Table of Decennial values of the Magnetic Declination computed from preceding equations.

These tables have been constructed to facilitate the reduction of observed declinations from one epoch to another; they will be found specially useful, when old lines run by compass have to be retraced and for the construction of isogonic charts for a given epoch.

Blanks occurring in the table indicate either no or doubtful values for the corresponding times; values given to the nearest tenth of a degree are less reliable than those given to hundredths. A + sign indicates west, a − sign east declination.

TABLE IV.

Year (Jan. 1st).	Halifax, N. S.	Quebec, Can.	York Factory.	Portland, Me.	Burlington, Vt.	Rutland, Vt.	Portsmouth, N. H.	Newburyport, Mass.	Salem, Mass.	Boston, Mass.	Cambridge, Mass.	Nantucket, Mass.	Providence, R. I.	Hartford, Conn.	New Haven, Conn.	Albany, N. Y.	Oxford, N. Y.	Buffalo, N. Y.	Erie, Pa.	Cleveland, O.	Detroit, Mich.
1640	...	+15·9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1650	...	16·4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1660	...	16·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1670	...	16·4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1680	...	15·9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1690	...	+15·2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1700	...	...	...	...	...	...	...	...	...	+10·0	+9·8	...	...	...	...	...	...	...	...	...	...
1710	...	...	...	...	...	...	...	...	...	9·3	9·2	...	+10·4	...	...	...	...	...	...	...	...
1720	...	...	+18·6	...	...	...	...	...	...	8·7	8·7	...	9·5	...	...	...	...	...	...	...	...
1730	...	...	19·2	...	...	...	...	...	...	8·1	8·3	...	8·9	...	...	...	...	...	...	...	...
1740	...	...	18 8	...	...	...	...	...	...	7·6	7·9	...	8·4	...	...	...	...	...	...	...	...
1750	+12·5	...	17·2	...	...	...	...	...	...	7·2	7·5	...	7·7	...	...	...	...	...	...	...	...
1760	13·0	...	14·8	+8·1	...	...	...	...	...	6·8	7·2	...	6·9	...	+6·1	...	...	...	...	...	...
1770	13 7	...	11·6	8·1	...	...	+7·8	+7·0	...	6·7	7·0	+6·5	6·3	...	5·5	...	...	...	...	...	...
1780	14·4	...	7·9	8·2	...	+7·0	7·7	7·0	+6·4	6·6	6·9	6·5	6·12	+5 4	5·1	...	...	...	...	...	...
1790	15·1	...	4·0	8·5	+7·7	6·5	7·8	7·2	6·2	6·7	6·9	6·7	6·24	5·2	4·8	...	+3·01	+ 4	−0·7	−2·2	...
1800	15·9	...	+0·1	8·9	7·52	6·2	8·0	7·4	6 2	7·0	7·1	7·0	6·37	5·16	4·7	...	2·96	−0·01	−0·7	−2·0	−3·18
1810	16·7	+11·2	−3·3	9·4	7·39	6·14	8·4	7·8	6·5	7·4	7·5	7·4	6·45	5·24	4·8	+5·4	3·10	+0·05	−0·6	−1·8	−3·11
1820	17·4	12·3	−6·1	10·0	7·58	6·39	8·8	8·4	7·0	7·9	8·0	7·84	6·73	5·46	5·0	5·79	3·40	0·30	−0·3	−1·5	−2·90
1830	18·1	13·4	−8·1	10·6	8·17	6·90	9·35	9·0	7·8	8·43	8·64	8·38	7·43	5·80	5·43	6·32	3·87	0·74	+0·03	−1·[illegible]	−2·55
1840	18·7	14·4	−9·0	11·23	8·94	7.64	9·94	9·6	8·7	9·05	9·33	8·95	8·31	6·24	5·99	6·97	4·46	1·33	0·44	−0·60	−2·09
1850	19·3	15·3	−8·8	11·82	9·62	8·53	10 55	10·23	9·8	9·69	10·03	9·53	9·09	6·77	6·67	7·70	5·14	2·05	0 91	−0·14	1·56
1860	19·8	16 0	−7·5	12·35	10·21	9·53	11·15	10·83	10·9	10·32	10·67	10·06	9·65	7·36	7·41	8·47	5·89	2·85	1·39	+0·31	−0·99
1870	20·1	+16·4	−5·3	12·80	10·97	10·54	11·7	11·4	11·9	10·90	11·21	10·54	10·21	7·99	8·18	9 2	6·65	3·68	1·87	+0·72	−0·41
1880	+20·3	...	...	+13·13	+11·97	+11·49	+12·2	+11·8	+12·8	+11·41	+11·63	+10·93	+10·94	+8·62	+8·9	+9·9	+7·38	+4·49	+2·31	+1·07	+0·13

TABLE IV—*continued.*

Year (Jan. 1st).	New York City.	Hatboro, Pa.	Philadelphia, Pa.	Washington, D. C.	Cape Henry, Va.	Charleston, S. C.	Savannah, Ga.	Key West, Fla.	Havana, Cuba.	Kingston, Jamaica.	New Orleans, La.	Vera Cruz, Mex.	Mexico, Mex.	Acapulco, Mex.	Panama, New Gran.	San Blas, Mex.	San Diego, Cal.	Monterey, Cal.	San Francisco, Cal.	Cape Disappointment, W. T.	Sitka, Alaska.	Unalaska Isl'd, Alas.
1640	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----	----	----	----	----	---
1650	---	--	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----	----	----	----	----	---
1660	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----	----	----	----	----	---
1670	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----	----	----	----	----	---
1680	+8·8	+8·5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----	----	----	----	----	---
1690	8·8	8·3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----	----	----	----	----	---
1700	8·5	7·9	+8·7	---	---	---	---	---	---	---	---	---	---	---	---	---	----	----	----	----	----	---
1710	8·0	7·5	8·3	---	---	---	---	---	---	---	---	---	---	---	---	---	----	----	----	----	----	---
1720	7·6	7·0	7·8	---	---	---	---	---	−4·2	---	−3·4	---	---	---	---	---	----	----	----	----	----	---
1730	7·2	6·3	7·0	---	+4·9	---	---	---	−4·5	−6·2	−3·7	−2·5	---	---	---	---	----	----	----	----	----	---
1740	6·6	5·6	6·2	---	+4·2	−3·1	---	---	−4·8	−6·4	−4·1	−3·6	---	−2·9	---	---	----	----	----	----	----	---
1750	5·9	4·7	5·3	---	---	−4·1	---	---	---	---	−4·7	−4·7	---	−3·8	---	---	----	----	----	----	----	---
1760	5·2	3·8	4·4	---	---	−4·6	---	---	---	---	−5·3	−5·8	−4·7	−4·7	---	---	----	----	----	----	----	---
1770	4·6	2·9	3·6	---	---	−4·9	---	---	---	---	−5·9	−6·8	−5·5	−5·6	−7·7	---	----	----	----	----	----	---
1780	4·4	2·2	2·9	---	---	−5·1	---	---	---	---	−6·5	−7·7	−6·4	−6·4	−7·8	---	----	----	----	----	----	---
1790	4·29	1·8	2·4	−0·1	---	−5·1	---	---	---	−6·3	−7·0	−8·5	−7·1	−7·2	−7·8	−7·4	−11·0	−11·4	−12·8	−18·0	----	−18·6
1800	4·28	1·8	2·1	0·0	+0·2	−4·9	---	---	−6·2	−6·0	−7·5	−9·1	−7 7	−7·8	−7·8	−7·9	−11·1	−12·0	−13·4	−18·1	−26·12	−19·3
1810	4·30	2·03	2·1	+0·3	0·0	−4·5	−4·9	---	−6·26	−5·7	−7·9	−9·5	−8·3	−8·3	−7·7	−8·3	−11·3	−12·6	−13·9	−18·4	−27·11	−19·7
1820	4·47	2·53	2·28	0·6	0·0	−4·04	−4·8	−6·9	−6·22	−5·4	−8·1	−9·6	−8·6	−8·68	−7·5	−8·6	−11·6	−13·3	−14·42	−18·7	−27·89	−20·1
1830	4·91	3·17	2·71	1·0	+0·25	−3·44	−4·5	−6·52	−6·12	−5·0	−8·2	−9·6	−8·8	−8·88	−7·2	−8·8	−11·9	−13·9	−14·92	−19·2	−28·48	−20·2
1840	5·59	3·86	3·33	1·49	0·66	−2·78	−4·14	−6·03	−5·94	−4·6	−8·14	−9.4	−8·9	−8·91	−6·96	−8·94	−12·2	−14·44	−15·38	−19·72	−28·88	−20·2
1850	6·34	4·57	4·11	1·99	1·24	−2·12	−3·65	−5·47	−5·71	−4·2	−7·94	−8·9	−8·76	−8·79	−6·66	−8·97	−12·54	−14·95	−15·78	−20·29	−29·08	−20·1
1860	6·96	5·29	4·99	2·47	1·95	−1·52	−3·08	−4·86	−5·44	−3·8	−7·61	−8·25	−8·48	−8·50	−6·33	−8·89	−12·88	−15·42	−16·11	−20·88	−29·08	−19·7
1870	7·43	6·0	5·89	2·90	2·73	−1·00	−2·48	−4·24	−5·2	−3·4	−7·15	−7·4	−8·04	−8·06	−6·0	−8·7	−13·20	−15·79	−16·36	−21·46	−28·88	−19·3
1880	+7·84	+6·8	+6·76	+3·26	+3·5	−0·62	−1·89	−3·65	---	---	−6·62	---	−7·46	−7·5	---	---	−13·50	−16·08	−16·52	−22·00	−28·5	−18·6

ART. V.—*On the Tails of Comets;* by HENRY M. PARKHURST.

[Read before the Amer. Assoc. for the Adv. of Science, Aug. 18, 1874.]

IN predicting the form and position of a comet's tail, I adopt the theory of Professor Pierce:

"Each particle of the matter which composes the tail is supposed to move in a hyperbolic orbit, with the sun in the focus of the opposite branch, under the influence of a repulsive force emanating from the sun, and decreasing by the law of the inverse square of the distance." (Gould's Astronomical Journal, vol. v, page 186.)

The application of the formulæ gives for any required time one line only, commencing at the comet and extending indefinitely. Professor Pierce adopted, in his computations upon the tail of Donati's comet (Gould's Astr. J., vol. vi, page 51), an excess of repulsive force $1\frac{1}{2}$ times that of gravitation, making his comparisons with the front edge of the tail, and arbitrarily adopting such a repulsive force as best to explain the observations. For the purpose of comparing with the center of the tail, I adopted in my computations a repulsive force exactly equal to and replacing gravitation as the more probable law. On comparison with the observations, however, I find that the computed line closely agrees in nearly every instance with the observed right hand edge of the tail; and I shall, therefore, adopt that as the standard of comparison. Although the comet apparently moved in the other direction, yet in fact that was the front edge of the tail.

Most of the earlier observations were furnished to me by W. S. Gilman, Jr., of New York City, and all the later ones by Lewis Swift of Rochester, whose observations continued several days after the comet had ceased to be visible in New York City.

From June 12 to June 30, I have only the record of the direction of the tail, without reference to stars (G), agreeing with computation. On July 1, the tail "pointed to and reached 55 of Camelus." (P.) The computed line passes nearly through that star. On July 7, the front edge was seen a little to the left of 63 Arg. 749. (Bonn Catalogue.) (P.) The computed line passes a small fraction of a degree to the left of the star. On July 13, the last day when the head of the comet was favorably seen, "the right edge just touched *o* Ursa Major" as seen by Mr Swift, and passed $\frac{1}{2}°$ to the left of it according to my own record. The computed line passes $\frac{3}{4}°$ to the left of it The curvature on this evening was commonly noticed. Computation indicates an arc of about 15°. On July 14, "*h* U. Maj. was in the middle of the tail." (S.) Allowing for the recorded width, it should be in the middle of the tail. On July 17, "v was exactly in the center," and "its left edge just touched α." (S). These are each within $\frac{1}{2}$°. On July 18, "it passed over α," (S.) and α U. Maj. was within the range of the computed tail. "θ and F (φ) were not only in the center of the tail but in line with its axis." (S.) They were within $\frac{1}{4}$° of the computed center, and very nearly in the computed line of its axis at that point. On July 19, "the tail passed midway between α and β, but touched neither." (S.) The computed line passes nearly centrally between them. "Its left edge just touched δ." (S.) Here is an inaccuracy; for it could not have touched δ without passing over β. On July 20, it passed "midway between β and γ U. Maj., and centrally over δ." (S.) This agrees with computation. On July 21, the last day of its visibility, γ U. Maj. was seen "at its right edge, perhaps 1° within it." (S.) The computed line is 1° to the right of γ. "λ and μ U. Maj. were seen in the center of luminosity." (S.) This agrees exactly with computation. "No curvature perceptible." Computation indicates that the tail increased its curvature until about the 13th, a few days earlier the tail being too short for it to be perceptible, and a few days later the curvature itself becoming too small to be perceptible.

In all these cases the accordance of the right hand edge of the tail with the computed line was as close as the nature of the observation would admit. But among the observations kindly furnished me by Mr. Gilman, the accuracy and faithfulness of which I cannot doubt, are two which I cannot in fairness omit. On July 3, he recorded the place of the tail as wholly to the right of the two stars 65 Arg. 606, 607. The computed line passes to the left of those stars. As he did not use a diagonal prism, and inverted his chart in making the comparison, it seems impossible that he should have put it upon the wrong side, especially as his attention was also directed to the star 65 Arg. 599, near the other edge. On July 6, he recorded the place of the tail as passing through the star 63 Arg. 749, the chief star of an unmistakable group. The computed line passes nearly a degree further east. On this diagram you will see that the observed lines, before and after, are nearly parallel, and that these two widely deviate. You will also see, that in each case, connecting the observed point in the tail with the position of the head on the previous evening produces a line parallel to the rest; and although Mr. Gilman himself does not conceive it to be possible that he connected the position of the tail on one day with that of the head upon another, or that he could have even seen the comet on July 5, which was Sunday, I can find no other satisfactory solution of the discrepancy; and that explanation would substitute two observations accurately agreeing with the computations, for two which are entirely inconsistent with the remainder of the series. Perhaps I should add that these observations, and indeed all the observations but one, were made without any expectation that they would ever be of value.

In predicting the width of a comet's tail, it may be assumed to bear a certain ratio to its length. Up to the time of the disappearance of the nucleus, the ratio of one-sixth was sufficiently exact. The tail was then approaching us, and on this account would be expected to appear to grow wider as well as longer. Assuming that it remained unchanged in form, it should have been about six times as wide on July 21 as on July 13. But instead of being 18° wide, it was seen to be only "$4\frac{1}{2}$°, possibly 5°."

I have refrained from alluding to an important point with regard to the front edge. When the tail is coming directly toward us, the front edge becomes the medial line. When the tail is 4° wide, assuming the right hand edge to be the front edge would involve an error of 2°; or, if the tail were 18° wide, as computed, it would involve an error of 9°. There is no such error; therefore, there is no visible portion of the tail to the right hand of the true front edge. If the tail is flat, lying in the plane of its orbit, we may readily understand why it should be so foreshortened when directed toward us. Indeed, this proves too much; for if it were as thin as Saturn's ring, it should have appeared as a mere line instead of being 5° wide. If the form of the section were elliptical, it would account for the observed width on the 21st of July; but when the tail was first seen, the earth was fully 11° above its plane, as seen from the comet, and the tail would have appeared much narrower in all the observations before July 13. The dark line behind the nucleus cannot indicate a hollow conical tail, for a diminution of the central light by $\frac{1}{26}$th part would hardly be perceptible; but that dark line, and the dark lines separating the different envelopes, are perfectly consistent with the theory of a thin flat tail.

There is another important fact. The front edge was toward the right until July 20; but at noon of July 21 the earth passed through the plane of the orbit. On the evening of July 21, therefore, when the tail was 5° wide, the front edge should have been either at the left hand, or at any rate at least 2° from the right hand edge; and yet the latter agreed with the line computed from the same formulæ with those of all the preceding days; and although the tail was seen for five days in succession, during which the earth passed through the plane of the orbit, there is no apparent discrepancy between the computed line and the observed position of the *right hand* edge of the tail.

A diagram I have constructed illustrates several results necessarily depending upon the hyperbolic theory. The black line represents the orbit of the comet of 1843, so far as included within the radius of the earth's orbit. The red lines, starting from the orbit, and after passing their perihelion points radiating in nearly straight lines from the sun, represent the hyperbolic orbits of particles of matter, leaving the head of the comet at the given times.

In these computations, also, I have adopted 1 as the ratio of repulsion. Had Coggia's comet possessed sufficient luminosity to be visible on July 24, it would have afforded a test of the true amount of repulsive force; but as its plane was still turned almost directly toward us when the tail was last seen, a variation in the assumed amount of the repulsive force makes no appreciable difference in its position; and the streamers seen extending from the convex side of the tail of Donati's comet suggest the theory that upon every formation of a new envelope, a small portion of the matter was endowed with a repulsion at least ten times that of the rest of the matter forming the tail.

The blue lines circling around the sun connect the positions of the particles in their hyperbolic orbits at given times, and therefore represent the visible and the invisible tail of the comet. The particles leaving the head of the comet thirty days before it reaches its perihelion, follow nearly behind it, with continually retarded motion, and when the head of the comet reaches the sun, those particles have only passed over half that distance, and are just about to commence their outward course. In receding from the sun the motion is gradually accelerated until the particles reach the same distance from the sun at which they left the head. The moment they pass outside of that point they are irrevocably lost. A reconversion of the repulsive force into attraction would not avail, but they must fly, unless intercepted, beyond the confines of our solar system.

Particles leaving the head of the comet at a later date pursue a somewhat similar course, coming nearer to the sun, but all at about the same time turning and flying off into space. The nearer they come to the sun before commencing their hyperbolic course, the more violent is the repulsion, and the greater their outward velocity. The particles which leave the head of the comet exactly at the perihelion, pursue a line almost directly from the sun, but about 66° from the axis of the comet's orbit. These particles commence their outward course with a velocity sufficient to carry them outside the earth's orbit in a little over two days; and that velocity remains nearly uniform in consequence of the sudden removal of the matter beyond the sphere of the sun's forcible action. Consequently, when we undertake, for the 30th day after the perihelion passage, to trace the entire tail which has left the head during the preceding 60 days, we must pursue a curve commencing at the position of the head of the comet, passing to the right and downward, crossing the perihelion line at a distance from the sun one-third greater than that of the planet Neptune, and re-entering the earth's orbit above.

How much of this will be visible? As we follow the tail from the head it becomes fainter, first, because it is more distant from the sun, and therefore less illuminated. Another reason is that it is more diffused from its rapid expansion like the fire from a catharine wheel, the portion of the tail forming a certain arc, continually forming nearly the same arc of a larger circle. But is that all? Here is a portion of the tail above, more illuminated than the head of the comet itself, and which occupies less than one-fourth the space traveled over by the comet while it was issuing.

While the dark line in the center of a comet's tail seems to disprove the theory naturally suggested by the fact of the front edge being the line of computation, that the resistance of the ether is the cause of the expansion of the tail, the ether may have a perceptible effect upon its form and position. Had the sun an ether of its own, carried with it through that still more rare ether which brings to us the pulsations of light, the effect of the ether upon the tail would be only that resulting from the motion of the comet itself; but leaving the ether behind it in its course toward the constellation Hercules, it will tend to sweep the tail back from that point: and here we may find a possible explanation of the apparent wafting of the tail out of the plane of its orbit, leaving the front edge still on the right, and causing a thin, flat tail to have a visible width tenfold greater than it would have had if strictly in the plane of the orbit.

Note.—Observations in England on July 9, 14, 17, 18, 19 and 21, confirm the positions above given, but are not sufficiently definite for exact comparison. The theory of Prof. Norton (Am. Jour. Sci., 1861), that the width of the tail arises from the variation of the repulsive force exercised upon different particles of the cometary matter, and its thickness from the repulsion of the nucleus itself at the time of emission, I had not seen when the above was written. I have computed a new line consisting of particles equally repelled and attracted, and I find that it nearly corresponds with the former computed line, or with the observed right hand edge of the tail, apparently indicating that the tail was, from some cause, chiefly south of the plane of the orbit. The theory of Prof. Norton affords a plausible explanation of that cause.

New York, Oct., 1874.

ART. VI.—*The very much extended Nebulæ of Sir John Herschel's General Catalogue;* by CLEVELAND ABBE.

[Read before the Philosophical Society of Washington, June 4, 1874.]

In 1865 and 1867, I considered carefully the question of the apparent distribution of the nebulæ in space, basing my studies upon the General Catalogue of Sir John Herschel. Among other points that occupied my attention, I attempted, by separating the several general classes of nebulæ and clusters, to render more definite our ideas as to the different laws that obtain in reference to the distribution of resolvable and unresolved nebulæ.

Some of the conclusions then arrived at were published in the Monthly Notices of the Royal Astronomical Society for 1867, and have been in part confirmed by the subsequent writings of others. Mr. Proctor has rendered good service to this branch of Astronomy by reproducing on equal surface charts the table given by me showing the distribution of the unresolved nebulæ; which charts, published first in the Monthly Notices, and republished in his "Essays on Astronomy" and his "Universe," as well as the more elaborate and beautiful charts of Messrs. Waters and Proctor, are well adapted to convey such information as can be gained from this study. But whether we gauge the stars or the nebulæ, at best we can only obtain results that are exceedingly unsatisfactory, and perhaps no two persons would agree in adopting the same conclusions on this subject. In hopes of adding something more exact to our knowledge of the construction of the universe, I sought, two years ago, to resolve several more definite problems, such as involve fewer assumptions, and one of which I will now present, premising that the subject is brought to your notice, not because I think myself to have obtained anything conclusive, but because the problem seems to direct attention to a point worthy of special observation. In fact, the material I have had to work with has been so unsatisfactory that it will be a sufficient reward if I am able to so attract the attention of those possessing powerful telescopes as to induce them to revise the rough measurements that I have been obliged to content myself with.

The general problem, as it has presented itself to me, may be thus stated: We have thus far studied the distribution in space of the centers of the nebulæ,—are there not planes that have a definite relation to these bodies? Among the stars we have the Milky Way and the orbits of binary stars; among the planets we have their orbits and equators, and the orbits of their satellites; among the nebulæ we may expect to find analogous planes, whose relations to each other and to those already known cannot but be highly instructive. As yet we have but very few double nebulæ, nor can we for a long time hope to determine the planes of the orbits of any binary nebulæ, if such exist; on the other hand, in regard to the axes of rotation of nebulæ or the planes of their equators, there is more room for study. It is a plausible hypothesis that some nebulæ are in rotation about their respective axes, and only in the case of an irregular nebula do we find presumptive evidence of numerous centers of aggregation and rotation; this latter class will not now further claim our attention. Those nebulæ whose whole mass is rotating about a single axis must appear to us either circular or elliptical, according to our position in relation to that axis; we might then at once assume that every well defined circular nebula has its axis of rotation directed toward us, and might thus determine the position of the plane of its equator; this, however, would be hazardous, since not only do we thus assume the fact of a rotation, but also assume that the average rotation of all nebulæ is so rapid that when viewed from any other direction they would present a sensibly elliptical outline; moreover, often globular clusters of stars are recorded as circular or globular nebulæ. I have therefore, for the present, passed by the circular and the ordinary elliptical nebulæ, and have confined myself to those described in Herschel's Catalogue as exceedingly or very much extended; the list of these, amounting in all to fifty-nine, is given in the accompanying table. In regard to them it may be remarked that if these nebulæ are gaseous and without rotation, we can only explain their apparent shape by supposing them to be endowed with a motion of translation, to be in fact wisps, like comet's tails; if, on the other hand, they be in a state of rotation, they must be flat rings or discs or extended flattened ellipsoids, and we are authorized to consider that the planes of their equators do sensibly pass through the position of the observer; similarly, if the nebulous appearance be due to the presence of lenticular or ring-shaped cloud of asteroids, or of meteoric dust, we shall be able to make a determination of the plane of the orbits of these bodies.

The trigonometrical formulæ by which we may compute the right ascension and declination of the poles of a very much extended nebula are given in the following note.

It is evident that the principal elements of uncertainty are, first, the inaccuracy of the adopted angles of position (π), and second, the error of the assumption that the planes of the nebulæ in question are not inclined to the line of sight. The latter error may, on the average, amount to 5° or 10°: the errors of the π may be averaged as about 5°, 15°, or 30°, according as the values are given in Herschel's Catalogue as exact, approximate or rough: the influence of these errors on our results can be easily ascertained by means of the differential formulæ.

Having computed the right ascensions and declinations of the south poles of the fifty-nine nebulæ in question, as given in columns six and seven of the accompanying table, I have also plotted them upon equal surface charts similar to those used by Messrs. Proctor and Waters, on which also have been drawn the limits of the Milky Way as given by those same gentlemen, according to Heis and Herschel. Owing to the fact that the unresolved nebulæ are, as a rule, far more numerous near the poles of the Milky Way than elsewhere, it follows at once that the greater number of the nebulæ now under consideration are near these poles, and therefore our poles of rotation, if we may presume to use that term, lie near the Milky Way itself; but a careful enumeration shows us that in the northern hemisphere these poles lie to the southward of the central portion of the Milky Way, while in the southern hemisphere the reverse holds good; in fact, there exists a medial plane about which the poles of these nebulæ cluster, and which is itself inclined to the plane of the Milky Way at an angle of about 30°, so that if the north pole of the Milky Way be in right ascension 12 h. 45 m. and declination 30°, the pole of the plane near which the rotation axes of the nebulæ lie will have about the same right ascension, but a declination of about 60°. Numerically expressed, this latter plane is so situated that of fifty nine nebulæ twenty-nine have their axes inclined to it by less than 10°, and forty-two have their axes inclined by less than 20°.

It is, I conceive, quite desirable that we should, on the one hand, have more accurate determinations of the position angles of these extended and ray-like nebulæ, and that, on the other hand, the reversion spectroscope of Zöllner should be applied to determine whether or no they be really in a state of rotation.

By adopting some average value for the oblateness of the spheroids, that appear to us as elliptical or oval nebulæ, it will be possible to obtain a certain approximate estimate of the probability that the plane here determined has some bearing upon the general question of the arrangement of the three or four thousand known nebulæ (the clusters being included); but such a computation involves too much of hypothesis to be of interest at present.

It may then in general be stated, that so far as we are able to determine the positions of planes of rotation among the nebulæ, they do not show any such tendency to agree with each other as is shown in the orbits and equators of the major planets of the solar system; that, on the contrary, they are inclined at all possible angles to each other, but have this remarkable feature, that their mutual nodes cluster about a point in right ascension 12 h. 45 m. and north declination 60°.

The Positions of the Poles of the "very much" and "exceedingly" "extended nebulæ" of Sir John Herschel's "General Catalogue," referred to the mean Equinox of 1860.

The Nebula.				Description.		Its South Pole.		
No.	R. A. h. m.	N. P. D. ° ′	π			R. A. h.	m.	N.P.D. °
67	0 23·5	124 1·8	47·5	vB: L; vmE; psbM; f of 2	2†	8	29	127·7
132	0 40·1	111 30·9	172	F: vL; vmE.	2*	18	28	97·3
138	0 40·6	116 3·7	54·5	! !; vvB; vvL; vmE; gbM.	9*†	8	46	136·9
191	0 57·4	156 21·5	145·4	eF: vmE; vlbM.	1	16	48	103·2
361	1 27·8	120 7·6	118·3	vB; vL; vmE; sbM.	5	16	35	139·7
400	1 41·6	84 47·2	165±	vF; vmE; sbM.	3†	19	47	104·9
527	2 13·8	48 16·8	22·3	!; B; vL; vmE.	5†	7	12	106·4
610	2 40·3	120 51·5	151·1	vB; L; vmE; vbMN.	3	19	37	114·5
662	3 5·9	143 52·3	80	B; L; vmE; vgbM.	2	14	16	125·5
776	3 39·1	135 5·3	{221·6 / =41·6}	pB; L, vmE.	1	11	47	117·9
779	3 39·9	135 5·4	42·3	pF; pL; eE; vgpmbM.	3	11	52	118·3
811	4 0·6	144 29.4	10	B; L, vmE; bM.	2	10	33	95·8
823	4 6·6	123 14·1	32·2	B; vL; vmE; psmbM.	3†	11	22	116·4
1035	5 4·9	149 54·2	162	vF; pL; vmE.	2	22	2	98·9
1437	6 31·5	81 8·3	{330 / =150}	B; vmE; Ncom=*11.	7†	0	51	119·6
1472	6 49·4	130 41·5	44·8	pB; pL; vmE, pslbM.	2	15	1	122·3
1674	8 27·2	112 29·8	110·3	cB; L; vmE;	5	23	23	150
1713	8 44	56 3·6	40·9	vB; vL; vmE; gmbM.	5	13	1	122·9
1745	8 55·5	135 20·9	19	!; eeF; vL; vvmE.	1†	15	50	103·3
1823	9 12·3	38 25·6	150·8	vB; L; vmE; vsmbM=*10.	3	4	46	107·7
1931	9 40·3	55 56·2	90	!; cB; L; vimE.	3†	9	40	145·9
1958	9 46·4	87 56	111·5	vF; vL; vmE.	3	4	7	158·5
2003	9 56·7	115 29·4	82·3	cF; vL; vmE; lbM.	2†	20	46	153·5
2008	9 58·2	97 2·5	45	vB; L; vmE; vg, vsmbMEN	3	16	26	134·6
2238	10 44·6	52 38·5	42·5	pB; pL; vmE; ⁑ inv?	3*	14	48	122·5
2318	11 3	33 34·7	79	cB; vL; vmE; pbM; r.	3	11	55	122·9
2378	11 12·9	75 38·5	102	pB; vL; vmE.	8†	8	31	161
2413	11 18·4	45 38·5	0±	vB; cL; vmE; vsmbMN.	4	{17 / or 5}	18	90
2595	11 45·3	116 7·4	59·3	vF; cL; vmE.	1	20	11	140·4
2715	11 59	39 38·8	166·5	pB; vL; vmE; vgvlbM.	3	6	41	98·6
2749	12 2·9	42 46·3	109	pF; cL; vmE; vgbM.	3	10	23	130·0
2761	12 4	38 43·9	60±	pF; cL; vmE.	4	14	30	122·8
2786	12 6·7	74 19	152·1	B; vL; vmE; vsvmbM.	7	6	39	116·8
2806	12 8·8	76 4	17±	vB; vL; vmE; sbMN.	5†	17	52	106·5
2831	12 10·5	51 24·7	43·2	pB; vL; eE; vgbM.	3	16	8	122·4
2877	12 14·6	74 36·9	0±	L; vmE; f of 2.	4	{18 / or 6}	14	90
3066	12 26	89 8·9	95±	cB; vL; vmE; B* in cont.	3	7	4	175
3132	12 32·7	100 50·2	92	!; vB; vL; eE; vsmbMN.	3†	1	15	169·2
3142	12 33·7	27 36·8	118·6	B; L; vmE; glbM.	2	10	27	114
3189	12 37·1	57 3·8	34.3	!; pB; L; vmE; sp of 2.	6*†	17	15	118·2
3240	12 42·6	74 4·3	28.5	cB; pL; vmE; sbMN.	4†	18	8	117·3

The Nebula.				Description.		Its South Pole.		
No.	R. A.	N. P. D.	π			R. A.		N P.D.
	h. m.	° ′				h.	m.	°
3278	12 45·9	78 0·6	34	pB; vmE; 3 B st s; f of 2.	6†	18	14	123·2
3321	12 49·9	67 33·3	120±	!; vB; vL; vmE; bMBRN=* ?	10†	9	3	143·3
3340	12 52·4	54 23	30±	vF, pL; vmE; bet 2 st.	5†	17	38	114
3386	12 57·2	138 32·1	38.7	B; vL; vmE.	1	21	1	114·5
3437	13 4·5	52 11·2	25	vB, vL; vmE; vsbMN.	4	18	0	109·5
3525	13 17·3	132 17·2	122·5	!!; vB; vL; vmE; bifid.	4†	4	11	128·6
3696	13 47·9	83 58·5	15	F; pL; vmE; r.	7	19	40	104·9
3761	13 57·5	40 9·3	90±	pB; cL; vmE; smbMN.	2	13	57	130·2
3822	14 9·7	53 7·6	110·3	cF; pL; vmE; vgvmbM.	2	11	58	138·5
4004	14 47	85 53·1	148·4	F; pS; vmE; gvlbM.	4	8	57	121·5
4086	15 12·–	32 10·–	155	A ray; vmE, par. to 4087.	0	10	38	103
4087	15 12·2	33 10·1	155	cB; vL; vmE; vg, psbMN.	3†	10	38	103·4
4614	20 49·5	146 6·4	0	eeF; vS; vmE; *13 att, n.	2	{2 or 14}	49	90
4663	21 19·2	143 23·3	90·8	eF; pL; vmE.	1	9	23	126·7
4679	21 26·6	145 10·8	127·1	pB; pL; vmE: g, pslbM.	1	12	19	117·1
4830	22 36·5	120 47·1	0	F; pL; vmE; vgvlbM.	1	{4 or 16}	36	90
4860	22 47	130 24·6	43·3	cB; L: vmE; mbM.	2	6	53	121·5
4885	22 54·9	131 34·9	5±	cF: ps; vmE.	2	5	7	89·3

Columns 1–6 are copied from Herschel's General Catalogue. The position angles in column four have been micrometically measured when given to the tenth of a degree; have been carefully estimated when given with an appended ±; have been roughly estimated when given to the nearest 10°.

NOTE.—A nebula which seems a mere ray or line being situated at S′, prolong this ray into a great circle, S′S″, whose south pole is p, and join S′ and p with the north pole of the heavens, P. We now have,

$$\cos (d) = -\sin (\delta) \sin \pi$$
$$\tan (a-\alpha) = +\sec (\delta) \operatorname{cotg} \pi$$

where the sign of sin (d) is positive,
" cos $(a-\alpha)$ is the same as the sign of cos (δ).
" sin $(a-\alpha)$ " " cos π.
π=PS′S″ or the positive angle of the ray measured *n. f. s. p.*
(δ)=PS′.
a=right ascension of south pole of nebula.
(d)=north polar distance of "

For a list of explanations of the meanings of the abbreviations used in the 5th and 6th columns of the accompanying tables, see pp. 11–13 of the original memoir by Herschel, in the Philosophical Transactions for 1874.

Washington, August 1st, 1874.

ART. VII.—*On Venus as a Luminous Ring;* by Prof. C. S. LYMAN.

IN this Journal,* eight years ago, a brief notice was published of some observations made by the writer on Venus when near her inferior conjunction in 1866. The planet was then (for the first time, so far as appears) seen as a very delicate luminous ring. The cusps of the crescent, as the planet approached the sun, had extended gradually beyond a semicircle, until they at length coalesced, and formed a perfect ring of light.

No opportunity has since occurred of repeating these observations until the day of the recent transit. On Tuesday, Dec. 8th, Venus was again in close proximity to the sun, and the writer had the satisfaction of watching the delicate, silvery ring enclosing her disc, even when the planet was only the sun's semi-diameter from his limb. This was at 4 P. M., or less than five hours before the beginning of the transit. The ring was brightest on the side toward the sun—the crescent proper. On the opposite side the thread of light was duller and of a slightly yellowish tinge. On the northern limb of the planet, some 60 or 80 degrees from the point opposite the sun, the ring for a small space was fainter, and apparently narrower, than elsewhere. A similar appearance, but more marked, was observed on the same limb, in 1866.

These observations were made with a five-foot Clark telescope of $4\frac{2}{3}$ inches aperture, by so placing the instrument as to have the sun cut off by a distant building while the planet was still visible. The ring was distinctly seen when the aperture was reduced to one and a half inches. The 9-inch equatorial could not be used, as there were no means of excluding the direct sunlight.

The morning after the transit the sky was slightly hazy and the planet could not be found, though probably it might have been if the small telescope had been mounted equatorially.

On the day following (the 10th), the crescent, extending to more than three-fourths of a circle, was seen with beautiful distinctness in the equatorial, and on this and two subsequent days, measurements were taken with the filar micrometer for the purpose of determining the extent of the cusps, and consequently the horizontal refraction of the atmosphere of the planet, on the assumption that the extension of the crescent and formation of the ring are due to this refraction.

The results of these observations are given below, each result being the mean of the number of separate measurements indicated in the last column. On the 10th, the chord of the arc between the cusps was measured ; on the other days the

* Vol. xliii, p. 129.

distance between lines tangent to the cusps and to the opposite limb.

Mean dates. Dec.	Dist. of centers of ⊙ and ♀.	Extent of Crescent.	Hor. refr. of ♀'s atmos.	Num. of ob. of cusps.
8 3^h 0^m P. M.	0° 36′·6	360° 00′		
10 11 36 A. M.	2 31·7	279 28	46′·6	4
11 10 16 A. M.	4 2·5	233 15	43 ·0	6
11 2 40 P. M.	4 20·4	231 46	45·5	15
12 2 45 P. M.	5 58·3	215 21	42·9	22
		Mean	44·5	

These observations give a mean of 44′·5 as the horizontal refraction of Venus's atmosphere, or about one-quarter greater than that of the earth's. The writer's observations, in 1866, gave 45′·3. Mädler, from observations of the cusps in 1849, when the nearest approach of the planet to the sun was 3° 26′, made the refraction 43′·7.

The formula for the refraction is this:

$$\sin y = \sin d \sin \frac{c-180^\circ}{2}. \qquad 2x = y - \frac{r}{\rho}.$$

in which d = distance of centers of ⊙ and ♀.
c = arc of crescent.
r = sun's semi-diameter.
ρ = radius vector of Venus.
x = horizontal refraction of Venus's atmosphere.

Six measurements of the diameter of the planet on the 10th give 63″·1. Twenty-four, on the 11th, give 63″·75. The English and American Almanacs give 62″·4 and 64″·5 respectively.

ART. VIII.—*Discovery of a New Planet;* by Professor JAMES C. WATSON. From a letter to one of the editors, dated Peking, China, October 17, 1874.

I have the pleasure to send you the following places of a new planet which I discovered at 8^h 30^m on the evening of Oct. 10th.

	Peking M. T.	α	δ
1874, Oct. 10,	13^h 30^m 0^s	0^h 58^m $1·68^s$	+10° 42′ 52·0″
" 11,	9 58 15	0 57 15·48	10 40 33·9
" 11,	10 43 44	0 57 13·70	10 40 22·7
" 11,	11 31 0	0 57 11·75	10 40 24·8
" 13,	8 33 39	0 55 29·90	10 34 56·9
" 13,	9 43 44	0 55 27·67	10 34 38·5
" 13,	9 56 45	0 55 27·22	10 33 47·8
" 14,	9 35 11	0 54 33·71	10 31 57·3
" 15,	7 49 29	0 53 43·70	10 29 10·6
" 16,	8 58 34	0 52 46·46	10 26 15·0

The planet resembles a star of bright 11th magnitude.

ART. IX.—*Ancient Lake basins of the Rocky Mountain Region;* by Prof. O. C MARSH.

THE existence of several large fresh water lakes in the Rocky Mountain region, during Tertiary time, is now well established, mainly through the researches of explorers whom the striking scenery of the "Bad Lands," or the extinct animals entombed in them, have attracted thither. The geological age of some of these lakes, however, seems to be still in doubt, at least widely different opinions on this point are freely expressed. The extent of these various lake-basins, and their relations to each other, are likewise a subject on which information is especially desirable, and hence the results of some recent observations are here presented.

The deposits left in these old lakes show them to be of Eocene, Miocene, or Pliocene age, the fauna of each formation being entirely distinct, as well as quite different from existing species.

I. *Eocene Lake-basins.*

The oldest of the great Tertiary lake basins of the West are of Eocene age. The one first discovered and best known, which has been called the Green River basin, lies between the Rocky Mountains and the Wasatch range, in the depression now drained by the Green River. It has the Uintah Mountains for its southern border, and extends north at least as far as the Wind River range. This basin was visited by the writer in 1868, but first explored in 1870, when he traced its deposits for several hundred miles, and from the rich vertebrate fauna fully determined its Eocene age.* These same beds have since been pronounced Miocene by Prof. Hayden and others, but the 150 species of extinct vertebrates now known from them prove them Eocene as conclusively as any single formation has yet been determined in this country. A comparison of almost any group of these fossils with the corresponding one from the Paris basin will afford sufficient evidence on this point. Some of the extinct mammals, indeed, indicate a still lower horizon, or one nearly equivalent to the Lignite beds of France.

The Tertiary deposits in the Green River Basin are all of fresh-water origin, and of enormous thickness,—6000 feet at least. They are nearly or quite horizontal, and as a rule rest unconformably on the Cretaceous coal-bearing rocks below. The latter are in part brackish water beds, containing, with some characteristic Cretaceous fossils, many remains of plants, which have led Hayden, Lesquereux, and others to regard them as Tertiary. The evidence from the fossil plants is far from conclusive, while the Cretaceous age of essentially the same

* This Journal, vol. i, p. 191, March, 1871.

beds has been clearly made out at several different localities. At one of these, in 1870, the writer found above a seam of coal *Ostrea congesta* Conrad, a typical Cretaceous fossil, and a crinoid allied to *Marsupites* of the English Chalk. Below the coal, but in the same series, were remains of fishes and turtles, both of Cretaceous types, and teeth of a Dinosaur.* Nearly as conclusive evidence has since been found at other localities. In considering a question of this kind, where the evidence from fossils appears conflicting, it should especially be borne in mind that vertebrates afford a much more accurate guide to climatic and other geological changes than invertebrates, and vastly more so than plants.

This Eocene lake basin remained dry land during all of Miocene time, and perhaps much longer. It was then again submerged for a short period, and its eroded surface covered with water-worn debris from the surrounding mountains. The evidence of this is seen in the coarse conglomerate crowning the highest buttes, which have thus escaped in part the enormous denudation most of the deposits in this basin have suffered.

South of the Uintah Mountains, a second and larger lake existed in the Eocene. It was 2,000 feet or more lower than the northern lake, and received part of its waters from that source. It had the Rocky Mountains for its eastern border, the Wasatch range on the west, and extended from the Uintahs far to the southward, doubtless quite to the present territory of New Mexico. This basin was first explored, and its Eocene age established, in 1870, by the writer, who finding it distinct from the Green River basin on the north, named it the Uintah basin.† These two lakes were contemporaneous, for a long period at least, and undoubtedly were connected together east of the present Green River cañon. There is evidence that the southern lake continued for some time after the northern one dried up. The deposits of the Uintah basin are of very great thickness, and are underlaid by Cretaceous beds, in some places much inclined.

The fauna entombed in both these Eocene lakes is essentially the same, and indicates a tropical climate. This is seen especially in the great number of Tapiroid mammals, monkeys, crocodiles, lizards and serpents. Remains of *Dinocerata*, the largest of Eocene mammals, have as yet been found only in the northern basin, and there are some other important differences at present, which future discoveries may remove.

There are indications of another Eocene lake in Eastern Oregon, west of the Blue Mountains, but as only a few plants have hitherto been found in its deposits, its relations in time to the great central Eocene lakes cannot as yet be determined.

* This Journal, vol. i, p. 195, March, 1871. † Loc. cit., p. 196.

II. *Miocene Lake-basins.*

The Tertiary lake-basin first made known in the Rocky Mountain region is that south of the Black Hills, so long famous for its "*Mauvaises Terres*" or "Bad Lands," and for its wonderful vertebrate fauna, which Prof. Hayden has done so much to bring to light. This ancient lake, which was comparatively shallow, appears to have extended south from the Black Hills to near where the Republican River now is, or from about the 44th to the 40th parallel of latitude. Its western border was the Rocky Mountains, and its eastern margin probably not far from the 99th meridian. The strata in this basin are all nearly horizontal, and indicate quiet waters. They are lighter in color, and much less arenaceous than those of the Eocene lakes. The best exposures of these Miocene beds are seen near the White River, and this name has very appropriately been used by Prof. Hayden to distinguish the lake basin in which they were deposited. In Northeast Colorado the same formation is well developed. The "Bad Lands" there were discovered and first explored by the writer in 1870.* These Miocene strata rest, with more or less unconformity, on an extensive series of lignite-bearing beds, which in many respects resemble those beneath the Eocene basins. The age of these beds, also, is in dispute, but the remains of Dinosaurs and some other typical Mesozoic vertebrates, which have now been found at many widely separated localities, leaves little doubt that they should be placed in the Cretaceous, the great coal-bearing formation of the Rocky Mountains.

After this Miocene lake was filled up, and its surface more or less eroded, a great subsidence took place, and a second larger lake was formed, in which extensive beds of clay and sand were deposited over the same area. As both series of strata are essentially horizontal, and of nearly the same color, the dividing line in many places can be made out only by means of the vertebrate fossils they contain. In this way, the writer has recently ascertained, by personal observation, that most of the upper beds (D and E), 500 feet at least in thickness, which were called Miocene by Prof. Hayden,† are deposits of the more recent Pliocene lake. This would leave for the true Miocene beds a thickness of about 300 feet. The upper strata will be again referred to in considering the Pliocene lake.

The fauna of the White River lake-basin is now well known to naturalists. It indicates a climate much less tropical than that of the Eocene lakes, as is seen in the absence of monkeys and scarcity of reptilian life. The *Brontotheridæ*, the largest known Miocene mammals, are peculiar to the lower strata of this basin. They fully equalled the Eocene *Dinocerata* in size.

* This Journal, vol. l, p. 292, Sept., 1870.

† Transactions American Phil. Soc. vol. xii, p. 105, 1862.

A still more ancient Miocene lake existed, in about the same latitude, on the Pacific slope, near the central part of the present State of Oregon. The Blue Mountains formed the eastern and southern shores of this lake, but its other limits are difficult to ascertain, as this whole country has since been deeply buried by successive outflows of volcanic rocks. It is only where the latter have been washed away that the lake deposits can be examined. The discovery and first explorations in this basin were made by Rev. Thomas Condon, the present State geologist of Oregon. The typical localities of this Miocene basin are along the John Day River, and this name may very properly be used to designate the lake-basin. The strata in this basin are more or less inclined, and of great thickness. One section, near the John Day River, examined by the writer in 1871, and again in 1873, seems to indicate a thickness of not less than 5,000 feet. The upper beds alone of this series correspond to the deposits in the White River basin. The lower portion also is clearly Miocene, as shown by its vertebrate fauna, which differs in many respects from that above. Beneath these strata are seen, at a few localities, the Eocene beds containing fossil plants, mentioned above. They are more highly inclined than the Miocene beds, and some of them show that they have been subjected to heat. The inferior strata elsewhere are Mesozoic, and apparently Cretaceous. Above the Miocene strata, Pliocene beds are seen in a few places, but basalt covers nearly all.

III. *Pliocene Lake-basins.*

At the close of the Miocene, a subsidence took place east of the Rocky Mountains. A great Pliocene lake was thus formed directly over the eastern Miocene basin, having nearly the same boundaries on the north and west, but extending much farther east, and stretching south nearly to the Gulf of Mexico. It covered an area at least five times as great as the older lake, while its deposits attained a thickness of nearly or quite 1,500 feet. This lake basin may with great propriety be called the Niobrara basin, since the Niobrara River cuts through its typical strata for more than 200 miles of its course.

The beds in this basin lie nearly horizontal. They are light in color, and much more arenaceous than the Miocene below. The upper strata consist of hard sandstones or calcareous grits, which weather but slowly, and hence still form the great table-lands over much of the area of the basin. The writer has traced these high plateaux and the intervening isolated buttes from near the Black Hills south to the Arkansas River, and found them all of Pliocene age. South of the Smoky Hill River these strata rest directly on the Cretaceous.

The fauna of this lake-basin indicates a warm temperate climate. The more common mammals are a mastodon, rhinoceroses, camels and horses, the latter being especially abundant.

[To be continued.]

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *Theory of Electricity.*—Mr. E. Edlund has published in full his theory that electricity is identical with the luminiferous ether. He first shows that the velocity h, with which the ether particles move, differs from v, the velocity with which this motion is propagated; h depends on the current and increases with it, while v depends on the ratio of the electricity to the density, but is independent of the current. It is the velocity v which Wheatstone, Fizeau and others have attempted to measure. The objection to this theory raised by MM. Roiti and Herwig are due to their overlooking the differences in these velocities.

The memoir deduces theoretically Ampère's general formula and the law of the division of the current between several conductors, when these contain electro-motive forces. Kirchhoff's laws are therefore an immediate consequence of the proposed theory. The heating produced by a galvanic current and by an electric battery are also given. The law for the duration of the discharge has also been deduced, and agreed with that found experimentally by M. Reiss. The oscillatory discharge of a battery and the phenomena of Peltier again give the same result as that deduced experimentally; and the same may be said of the laws experimentally established by Wiedemann for the transport of liquid in the direction of the galvanic current and for currents through a diaphragm, discovered by M. Quincke.

As to the rotation of the plane of polarization of light by a current, M. C. Neumann has shown that it can be explained satisfactorily if we admit that the molecular currents of Ampère act upon the molecules of ether in vibration precisely as if these last were electric molecules. The demonstration is based on the formula given by Weber for the action of an element of a current upon an electric molecule in motion. But as, according to Edlund, the electric fluid is nothing but the ether itself, evidently Neumann's hypothesis is confirmed, since according to the views of the author the molecular currents of Ampère are merely currents of ether.

The author says, in conclusion, that the theory proposed explains satisfactorily all the electric phenomena for which one can demand an explanation, based simply on such a theory. The explanation of many phenomena evidently demands the knowledge of the laws of other forces than electricity, since they unite with it in producing the phenomena in question. For instance, Faraday's law, that when a current traverses several electrolytes, the decompositions are proportional to their chemical equivalents, requires for its theoretical proof a much more exact knowledge of chemical forces than we at present possess. It is not then in the nature of things that such a law can be deduced exclusively from a theory of electrical phenomena.—*Mem. Swedish Acad. of Sci.*, XII, No. 8; *Bib. Univ.*, ccii, 174. E. C. P.

2. *Electrostatic Induction.*—M. NEYRENEUF has repeated with a Holtz the experiments of MM. Verdet and Masson, to determine the direction of the induced current with the electric egg. Two Matteucci disks contain, one the inducing, the other the induced spiral. This latter is put in connection with the two extremities of a cylindrical Geissler tube 50 cms. long. The first spiral is connected by one end with the negative armature of the machine, while the other is attached to one plate of a condenser with air film, whose collector communicated with the positive armature. The spark leaps between the two armatures of the machine from which the condensers have been removed. Two currents in opposite directions traverse the inducing spiral under these conditions, the one to charge, the other to discharge the condenser. Those produced in the second spiral illuminate the Geissler tube very brilliantly.

With an explosive distance of 5 cms. we observe clearly the difference in appearance of the two poles; but we can, by diminishing it continuously, produce three separate inversions at the instants when the appearance of the two poles is identical. When the striking distance is 3 cms. large and widely separated stratifications are formed, but presenting before the last inversion all the characters produced by a Ruhmkorff coil. The same effects are produced by altering the distance of the spirals or of the plates of the condenser. These condensers show that the phenomenon in question bears no relation to the lateral discharge, characterized especially by the constancy of the direction of the current it produces.—*Comptes Rendus*, lxxix, 1071. E. C. P.

3. *Effect of Flame on an Electric Spark.*—Mr. S. J. MIXTER notices a curious effect of a gas flame on the current of a Holtz machine. The jet consisted of a glass tube drawn out to a point, and the flame had a length of about an inch and a diameter of only an eighth of an inch. Inserting this between the two terminals of the machine, the length of spark obtainable was at once increased from less than ten inches to over twelve, the full distance to which the balls could be separated. The same increase was not obtained by simply inserting a conductor between the two terminals, a ball an inch in diameter only lengthening the spark about an inch.

E. C. P.

4. *Laws of Tuning Forks.*—M. MERCADIER has determined experimentally the effect of a change in the dimensions of a tuning fork on its number of vibrations. A style is attached to the end of the prong and draws a sinuous line on a revolving cylinder covered with lampblack. Another style attached to an electro-magnet registers the beats of a clock giving seconds. The vibration of the fork is maintained electrically. By the thickness of prong is meant its dimension parallel to the vibrations, by its breadth, the perpendicular direction. A fork having a breadth of 35·3 mms. gave 144·7 vibrations. Reducing its breadth to 30·9 and 24·8 it still gave 144·7 and 144·9 vibrations. Hence the number of vibrations is independent of the breadth. A similar meas-

urement was made with different thicknesses from 20·25 mms. to 4·37 mms. and showed that the number of vibrations was nearly proportional to the thickness. A fork three decimeters long was then shortened 20 mms. at a time and the vibrations measured in each case. The length of the prong being altered from 295 to 57 mms., the number of vibrations increased from 40 to 974. Hence the vibrations are inversely proportional to the square of the lengths, calling the latter the projection of the line bisecting the prong, or the axis plus a small quantity y, which in this case equalled 3·8 mms. These laws may be written in the form of the equation $n=\frac{Ke}{(l+y)^2}$, in which n is the number of vibrations, e the thickness, l the length, y a small constant, and K a constant depending on the material. For steel, K=818270. To compare this constant with theory, K was computed from the formula for the number of vibrations of an elastic bar in terms of v, the velocity of sound in it; taking v=4985 m., according to the experiments of Wertheim; K in this case became 820131, a result differing from that previously obtained by only a fifth of one per cent. The number of vibrations of three forks were found by measurement to be 144·7, 77·7, 29·7, and by the formula 146·4, 79·0, 29·0. Hence forks may be made by calculation to give any desired number of vibrations within one or two per cent.—*Comptes Rendus*, lxxix, 1001, 1069. E. C. P.

5. *Polarization of Light;* by WILLIAM SPOTTISWOODE, M.A., LL.D., F.R.S. 130 pp. 12mo. London: 1874. Nature Series. (Macmillan & Co.)—This small treatise on the Polarization of Light, as the Preface states, contains the substance of lectures delivered by the author at various times to his work-people, and "constitutes a talk rather than a treatise on Polarized Light." The fundamental principles of the subject are explained in a simple manner, and are well illustrated by means of two beautifully colored plates, besides a number of wood-cuts.

II. GEOLOGY AND NATURAL HISTORY.

1. *Earthquakes of North Carolina.*—An excellent article on earthquakes in the mountain region of North Carolina has been published by Hon. T. L. Clingman in the *Western Expositor* of Asheville, N. C. He states that more than thirty years since his attention was called to statements that a mountain in the northern part of Haywood County was shaken at intervals of two or three years; and in 1848 he visited the region and published a paper on it. The principal facts stated were these:

Between the Blue Ridge, which in North Carolina separates the waters falling into the Atlantic from those discharged into the Mississippi, and the great chain on the Tennessee border designated in its course by such names as Iron, Unaka, and Smoky, there is an elevated plateau of over two hundred miles in length, with an average breadth of fifty miles. The beds of the larger streams are two thousand feet above the sea, and the general level of the country, exclusive of the mountain ranges, may be estimated at twenty-five hundred feet above tide-water. Haywood County joins the State of Tennessee on its northern border, and the seat of the disturbance is within less than twenty miles of the line of that State. A considerable range of mountains extends north and south along the line which separates the counties of Buncombe and Haywood. From the west side of this extends a ridge, which terminates near the head of Fines Creek. A quarter of a mile from its western end, as one moves up it toward the east, is the locality referred to. The effect of the disturbance is visible near the crest of the ridge and extends in a direction nearly south, down the side of the little mountain, four or five hundred yards, to the level ground, and across it for some distance and along the elevations beyond. The whole extent may be a mile in length, with a breadth of not more than a couple of hundred yards at any point. The top of the ridge, where evidences of violence are seen, is perhaps three or four hundred feet higher than the ground below. There are cracks in the solid granite of which the ridge appears to be composed, but the chief evidences of violence were observable a little south of the crest. From thence along the side of the mountain, as one descends, there were chasms, none of them above four feet in width, generally extending north and south, but also occasionally seen in all directions. All the large trees had been thrown down. There were a number of little hillocks, the largest eight or ten feet high and fifty or sixty feet in diameter. They were usually surrounded by what appeared to have been a narrow crevice. On their sides the saplings grew perpendicularly to the surface of the ground, but obliquely to the horizon, making it manifest that they had attained some size before the hillocks had been elevated. I observed a large poplar or tulip tree which had been split through its center, so as to leave one-half of it standing thirty or forty feet high. The crack or opening under it was not an inch wide, but could be traced for a hundred yards, making it evident that there had been an opening of sufficient width to split the tree, and that then the sides of the chasm had returned to their original position without having slipped, so as to prevent the contact of the broken roots.

When I was there I was told that three years had elapsed since the last previous shock. They were first noticed about the year 1812, and usually repeated at intervals of two or three years. In 1851 I visited the locality again, having been informed that a feeble jar had occurred. As soon as I arrived at the locality, I was struck with the truthfulness of what many persons had told me, that after each shock the appearance of the place was so much changed that it did not at all resemble itself. On this occasion, though the shock had been a feeble one, I found the appearances very different. The greatest evidences of violence were near the foot of the ridge, the branch having been somewhat turned out of its course. Near this place a rock of considerable size had been thrown up and had only partially settled back, owing to the closing of the opening under it, so that the former earth marks were seen several feet above the ground on its sides.

In the year 1867 I saw the locality again. A number of shocks had in the meantime occurred, and the appearances were very different from what they had been. From the top of the ridge to the base it seemed a mass of rocks, most of the earth having been carried away. The depression at the top was greater, while the successive jars had, under the action of the force of gravity, moved the mass downward, and had forced the stream still further away from the hill. The violence had at one point extended itself a little further to the east. A large oak tree of great age and four or five feet in diameter had been entirely split open from root to top, and thrown down so that the two halves lay several feet apart.

In my former publication, it was suggested that if the phenomena at this point were due to volcanic action, similar disturbances would be noticed at other localities in the Alleghany range. I was soon informed that three or four years previously, in the southeastern part of Macon County, between the Tuckasegee River and the Cowee Mountain, the ground was shaken violently for several minutes. A few days afterward some persons discovered a fresh chasm, two or three feet wide, which extended more than a mile. This was in the month of June, and they said the leaves and branches of timber immediately above the chasm, in places, presented the appearance of having been scorched. Though I was not able to visit the place, yet from the character of my informants I do not doubt but that the facts were as above stated.

I have also been informed that in the county of Cherokee, in the year 1829, or thereabouts, the Valley River Mountain was cleft open for a considerable distance, during a violent shaking of the earth in that vicinity. The chasm, though partially filled up, is represented as still visible.

Mr. Silas McDowell, of Macon County, a highly respectable and intelligent gentleman, accustomed to observe and write on such subjects, has stated recently in a paper published at Asheville, that many years since there was a violent shock in the neighborhood where he resides, during which a chasm was opened on the north side of the mountain which separates the Ellejay waters from those of the Sugar Fork River. He states that the opening is still visible. This locality is eight or ten miles to the southeast of Franklin, in Macon County.

About three years since I heard from many persons, that for several weeks smoke continued to issue from a small crevice in the rock, in Madison County. Not long afterward I went to the place, and though the smoke had previously ceased to issue, yet there was evidence that the locality had at some time, probably during the present century, been subjected to violence, that had changed the outlines of the ground and surface rocks. This spot is about fifteen miles east of the Haywood Mountain, and about as far from the Warm Spring to the northwest of it.

Lastly, we have to notice the disturbance of the Bald and Stone Mountains. They are situated six or eight miles to the east of the Blue Ridge. Between the headwaters of the Catawba and those of Broad River, there extends many miles eastward a range of mountains attaining the height in places of four thousand feet. The Bald and Stone Mountains, from their appearance, are probably the highest part of this ridge, and nearly equidistant from the Catawba and Broad Rivers. My information in reference to them is derived entirely from conversations with a number of gentlemen, and from the accounts published in the newspapers. The first shocks were perceived on the 10th of February last, and they were for the first month or two more frequent than they have since been. During the last two months they have occurred at intervals of a week or two, but have been rather more violent than the average. Within the last five months probably a hundred shocks, accompanied with noises, have occurred.

The distance from this point to the Valley River Mountain, in Cherokee, nearly due west, is more than one hundred miles in a direct line. From the mountain in Haywood, to reach the parallel of latitude passing through the mountain near Ellejay, in Macon, one must travel more than thirty miles south. It is thus manifested that there is a belt of country more than a hundred miles in extent from east to west by thirty in breadth in which such disturbances have been observed. In the present state of scientific knowledge, it may not be an easy task to offer an explanation of the causes which will be generally accepted as satisfactory.

When we take into account these indications at different points in the North Carolina mountains, it seems evident that there is beneath the surface a condition of things that extends over a considerable area. A portion of the globe which, from its geological structure, ought to be regarded as being as stable as any part of our planet, is nevertheless not free from change. Whether this is to be regarded as due to the diminishing force, which at one time was sufficient to heave up this tract of country, with all its mountain chains, or whether it is to be considered as evidence of a gradual return of that volcanic action which manifests itself still elsewhere, to so great an extent, it is perhaps difficult to decide until further observations have been made. Is it not of sufficient interest to justify the managers of the Coast Survey, or some other competent agency, to make such careful measurements of the height of certain points, as to ascertain, within the next twenty-five or fifty years, whether any, and to what extent, changes may be occurring in this region?

2. *Porphyry of the Island of Lambay, a few miles north of Dublin Bay.*—Professor Edward Hull finds this green porphyry (Geol. Mag. for Oct., 1874) to consist of a felsitic base, which is penetrated throughout with grains of a chloritic mineral and magnetite, and crystals of orthoclase. Minute cavities have sometimes clusters of crystals of magnetite on the inner surface, and chlorite, or calcite, or both, in the interior. The

chlorite is regarded by the author as of secondary origin, and as "introduced by the agency of water, which has permeated the whole mass of the rock through channels inconceivably narrow." The calcite is diffused throughout the rock and also in its minute rifts and cavities, and the author remarks also that "it is unquestionably due to infiltration;" adding that "it is easy to conceive that water percolating downward through to the limestone and the thin coating of Old Red Sandstone beneath, would become thoroughly impregnated with carbonate of lime, which it would deposit amongst the fissures and cells of the older rocks beneath."

As urged in this Journal, vol. vi, p. 107, with reference to the Mesozoic trap of the vicinity of New Haven, Connecticut (and applied also to other traps or dolerytes), it seems to be quite certain that the chlorite in the above mentioned porphyry, and in igneous rock generally, was not only derived from ingredients in the rock, but was made through the agency of water that gained admission from some subterranean source *when the melted rock was ascending to the surface;** that the same is true for other hydrous minerals disseminated through the mass of any igneous rock, for example, the zeolitic, in phonolytes. The same kind of evidence sustains, as stated in the same place, the conclusion that all amygdaloidal rocks owe the cavities which they contain (the cavities occupied by the amygdules), and a large part of the zeolitic and other minerals in the cavities, mainly to the action of the same waters on the rock—first while melted and then while cooling from a state of fusion. Further, such waters may have carried into the cavities not only hydrous minerals, but also anhydrous. Melted rock rising in a fissure would take in also any gas or vapor that was evolved by the heat from rocks adjacent to the fissure, and would thus become more or less penetrated with the gas or vapor, and by this method carbonate of lime might have been made with any lime in the rock, if carbonic acid were the gas received, or other minerals with the aid of other vapors, even, it might be, metallic ores. If cavities exist they are sure to become filled, because all solutions would pass into them and keep depositing until they were full; and the rock, if the cavities were numerous, might thus be drained of a large part of the minerals formed, the chlorite excepted. These cavities have no doubt sometimes received mineral material from infiltrations of later date, but not so the body of the rock. J. D. DANA.

3. *Geological and Topographical Survey of the Territories.*—Concerning the work of the season just ended, the Secretary of the Interior makes the following Report to Congress:

"The first division of the survey under Mr. Hayden completed the unfinished work of the preceding season in the central portion of Colorado Territory, and extended its operations westward over that portion of said territory lying between the one hundred and

* The conclusion, as far as it regards the trap of the Connecticut Valley, is sustained by the microscopic researches of Mr. E. S. Dana, an abstract of whose paper is given on page 390 of the last volume of this Journal.

eighth and one hundred and tenth meridians of west longitude. About eighteen thousand square miles were surveyed, covering a section of country probably more generally elevated above the sea-level than any other within the borders of the United States. As an illustration of the uniform great elevation of extensive sections of this region, it may be mentioned that one of the subdivisions of the survey, in exploring an area of nearly three thousand square miles, was compelled to operate above the timber-line (about 11,500 feet above the level of the sea) for over a month. The necessary materials have been collected for constructing accurate maps of the region surveyed, which will require for illustration six sheets or maps of the physical atlas. Special attention was given to the mining and agricultural resources of the country, and those portions of it which can be redeemed by irrigation will be properly indicated on the maps. The San Juan mining region in southern Colorado was included in the survey, and over fifty mines therein were properly located. Many valuable specimens of ores, minerals, fossils, Indian art, &c., were collected. Numerous ruins of towns and dwellings of an extinct race of people which once inhabited the mèsas and cañons of western Colorado were found, and remarkable fortifications of hewn stone laid in mortar discovered in the sides of deep cañons, many of which are situated a thousand feet vertically from the stream below. The structure of these fortifications and dwellings, and the peculiar glazed pottery in the vicinity, indicate the existence of a people inhabiting this region many centuries ago, who were much further advanced in the arts than any of the Indian tribes of the present day. The results of the work of the past season will exceed in quantity and interest those of any previous year.

The field of operations during the past season of the second division, under Mr. Powell, was the central and northeastern portions of Utah Territory, and its labors were principally confined to the completion of the unfinished work of the preceding year. The main party is still in the field, so that the full results of the season's survey cannot at this date be given. It may be stated, however, that material has been collected for the mapping of an extensive region of country heretofore but little known; that the positions of many of the more important mineral lodes have been determined, and will be represented on the "general" maps; and that the area and distribution of such portions of the country surveyed as can be redeemed by irrigation will be properly indicated on the "special" maps. Extensive coal-beds have been discovered and traced, interesting and valuable specimens of fossils, rocks, minerals, and ores obtained, and a large collection made of Indian relics and articles, illustrating the arts existing among the Indians inhabiting that region. Mr. Powell had, in former surveys, discovered many ruins of towns and hamlets once occupied by the ancient inhabitants of the valley of the Colorado River; and during the past season many other such ruins have been found, some of their ancient picture-writings and many of their stone implements collected. The positions of many scores of these ruined towns will be accurately indicated on the "general" maps. The researches of this division among the extinct races, as well as the present inhabitants of this interesting region, have embraced polity, mythology, traditions, language, poetry, arts, habits, customs, and the means of obtaining subsistence, together with pre-historic remains; and when the results obtained shall have been published, it is believed that they will constitute an important contribution to the ethnography of American tribes.

These surveys have, so far as they have been prosecuted, resulted in affording much information of great value to our people, as well as to the scientific world. The construction of a physical atlas of the Territories, which will show all the results of the surveys as rapidly as they can be prepared for publication, is designed to preserve, for convenient reference, the information thus obtained; and if a continuation of the surveys should be authorized, such an atlas would become, in time, of intrinsic value, not only to the people at large, but to other nations.

In view of these and other considerations, I regard the moderate cost of these surveys as more than compensated by the value of the information thereby obtained, and therefore cordially recommend a continuation of the United States geological survey of the Territories."

The many photographs taken by the artist, Mr. Jackson, during the past season, are admirable specimens of the photographic art. There is not as bold scenery as in some Rocky Mountain views, but there is wonderful beauty of landscape, which is heightened by the perfect aerial perspective given the pictures and the well-selected foreground. Lakes, rivers, cañons, hills, eroded strata, mountain ridges and distant snowy ranges, are the different elements in the views. They are from the Middle Park, the Grand River region and other places. A considerable number of them represent cave-dwellings high up on cliffs, in the cañon of the Mancos, and near the McElmo, and ruins of walls and other structures of stone in the vicinity of the same—the dwellings and fortified places of a semi-civilized race now extinct.

4. *On the more rapid deposition of Sediment in Salt than in fresh water.*—Prof. T. Sterry Hunt, in a recent article in the Proceedings of the Boston Natural History Society, calls attention to the fact that the effect of salt in water on the rate of deposition was first mentioned by Mr. Slidell, in Humphrey and Abbott's Report on the Mississipi River, and then explains it on the ground of the less cohesion between the particles of salt water, as proved by the fact that drops of salt water are smaller than those of fresh water.

5. *Artesian boring at the St. Louis Insane Asylum.*—Mr. G. C. Broadhead, State Geologist of Missouri, gives the details respecting this boring, in the Transactions of the St. Louis Academy of Sciences, vol. iii, 216. The whole depth is 3,843·5 feet; of this the last 40 feet were through Archæan granite; above, the beds

were of the Lower Silurian and Carboniferous formations. The Carboniferous at the well had a thickness of 873 feet—80 of it Coal-measures, 670 feet Subcarboniferous, 93 feet Choutean group (referred by most authors to the Subcarboniferous, and called in Iowa and Illinois the Kinderhook group). The Lower Silurian, beginning above, consists of Trenton 421 feet; first magnesian limestone 148 feet; sandstone (called saccharoidal sandstone, used in glass-making) 133 feet; second limestone 517 feet; second sandstone 82 feet; third limestone 838 feet; third sandstone 98 feet; fourth limestone 384 feet; fourth sandstone, called Potsdam, 299·5 feet. Salt water was obtained (in place of fresh) at 1,220 feet, and a sulphur water at 2,140 feet. At 2,256 the water in the sand-pump indicated 3 per cent of salt; at 2,957 feet, 4½ per cent; at 3,293 feet, 2 per cent; at 3,367 feet, less than 2 per cent; at 3,384 feet, 3 per cent; and below 3,545 feet, 7 to 8 per cent. With a Fahrenheit self-registering thermometer, the temperature obtained at depths from 3,127 to 3,837 varied from 107° to 104½°, being 105° at the lowest point reached.

In an artesian well at Belcher's sugar refinery, St. Louis, salt water was obtained at 610 and 849 feet below the surface at the place, or 790 and 1,029 feet below the level of the surface at the asylum well.

6. *Return of Professor Marsh's Expedition.*—Professor MARSH returned to New Haven, Dec. 12th, after an absence of two months in the West. The object of the present expedition was to examine a remarkable locality of fossils, discovered during the past summer in the Bad Lands south of the Black Hills. The explorations were very successful, notwithstanding extremely cold weather and the continued hostility of the Sioux Indians. The latter refused to allow the expedition to cross White River, but a reluctant consent was at last obtained. They afterward stopped the party on the way to the Bad Lands, attempted a night attack on their camp, and otherwise molested them, but the accompanying escort of United States troops proved sufficient for protection. The fossil deposits explored were mainly of Miocene age, and, although quite limited in extent, proved to be rich beyond expectation. Nearly two tons of fossil bones were collected, most of them rare specimens, and many unknown to science. Among the most interesting remains found were several species of gigantic *Brontotheridæ*, nearly as large as Elephants. At one point these bones were heaped together in such numbers as to indicate that the animals lived in herds, and had been washed into this ancient lake by a freshet. Successful explorations were made, also, in the Pliocene strata of the same region. All the collections secured go to Yale College, and will soon be described by Professor Marsh.

7. *Survey of the 40th Parallel.*—The preparation of the final reports on this Survey, by CLARENCE KING, is in rapid progress, and their publication is expected to go forward during the present year. Prof. ZIRKEL, of Leipsic, was in the country during the month of September, at Mr. King's solicitation, to examine rock

specimens, and to take for study the thin sections of the rocks which had been made—more than a thousand in number—and will prepare a report upon them for publication in the 40th Parallel series.

8. *Geological Sketch of the State of Missouri, illustrated by maps;* by GEO. C. SWALLOW, A.M., M.D., late State Geologist, and Prof. Agric., Geol. and Bot. in the Univ. of the State of Missouri. 10 pp. large 4to. St. Louis, 1873. (R. A. Campbell.) This sketch by Professor Swallow presents a brief review of the Geology of the State of Missouri and is accompanied by a colored section and a colored geological map. The section makes the third and fourth magnesian limestones, with the intervening sandstone, equivalents of the Primordial.

9. *Das Elbthalgebirge in Sachsen* of Dr. GEINITZ.—The fifth number of Part II has been issued by the publisher, T. Fischer, of Cassel. It contains the Gasteropods and Cephalopods, with plates 29 to 36 inclusive.

10. *Preliminary Notice of Chondrodite Crystals from the Tilly-Foster Iron Mine, Brewster, N. Y.;* by EDWARD S. DANA.—The occurrence of chondrodite in large quantities at the Tilly-Foster Iron Mine has already been described by Professor Dana in an article upon "Serpentine Pseudomorphs," published in the two preceding numbers of this Journal. In addition to the common massive variety of the species, and that occurring in large coarse crystals, there have been found also, though very rarely, some small but very fine crystals, admitting of the most accurate measurements. These crystals are of a rich garnet-red color, with absolutely faultless luster, and are modified by a very large number of planes. The special interest of chondrodite arises from its relation to, or more properly identity with, the Vesuvian humite, whose remarkable crystallographic character in its three types of forms has been made known in full by the labors of Secchi and vom Rath. Kokscharow has shown that the chondrodite of Pargas is identical in angle with the *second* type of humite, and vom Rath has since obtained the same result for the Swedish specimens. The examination of the Brewster crystals, which I have been carrying on for the past few months, shows that they also belong, for the most part, to the *second* type, though among a considerable number of crystals I have identified also representatives of *the third type.* A few angles will show how close is the resemblance to the humite. (The letters for the planes are those used by vom Rath.)

	II Type.		III Type.	
	Humite (v. Rath).	Chondrodite (E. S. Dana).	Humite.	Chondrodite.
$A:\frac{1}{7}r$	135° 18′	135° 19′	$A:\frac{1}{5}r$ = 111° 51′	111° 49′ 111° 44′
$A:\frac{1}{5}r$	125° 49′	125° 50′	$A:i$ = 109° 28′	109° 25′
$A:e$	108° 58′	109° 3′	$A:\frac{1}{2}i$ = 125° 15′	125′ 13′
$A:i$	122° 28′	122° 28′		

The planes, which occur constantly, are the same that are found on humite, and the kind of hemihedrism is the same. This is true for both types; thus in type II the planes identified on chondrodite are A, B, C, $+r$, $+\frac{1}{5}r$, $-\frac{1}{3}r$, $-\frac{1}{7}r$, n, $\frac{1}{3}n$, $-m$, i, e, $\frac{1}{3}e$, etc. Type III, chondrodite, $+r$, $+\frac{1}{5}r$, $+\frac{1}{9}r$, $-\frac{1}{3}r$, $-\frac{1}{7}r$, $-\frac{1}{11}r$, n, $\frac{1}{3}n$, $\frac{1}{7}n$, i, $\frac{1}{3}i$. etc.

In addition to these prominent planes, I have measured, and more or less surely determined, upwards of a *hundred* other planes, very minute, and yet flat and giving in many cases perfectly reliable angles. As would naturally be expected, the indices of these planes are in general anything but simple. The discussion of these, and the description of other points of interest which have been observed, including several twins, must be deferred till the final completion of the memoir, which, it is hoped, will not be long delayed.

11. *Livingstonite.*—This mineral, recently described by Señor M. Bárcena (see this Journal, last vol., p. 145), has been analyzed by its describer with the following results: Sulphur 29·08, antimony 53·12, mercury 14·00, iron 3·50 = 99·70; whence the atomic ratio for the sulphur, antimony, mercury and iron 18·17 : 8·7 : 1·4 : 1·2 = (nearly) 15 : 7 : 1 : 1.

The livingstonite occurs at Huitzuco, in the State of Guerrero, in a matrix of carbonate and sulphate of lime, along with native sulphur, cinnabar, valentinite and stibnite. The author mentions the occurrence of some specimens of cinnabar at the locality which have the form of livingstonite, and which, therefore, are pseudomorphous.

12. *On Dawsonite, a new mineral;* by B. J. Harrington, Chemist and Mineralogist to the Geological Survey of Canada. (Canadian Naturalist, vii, August, 1874.)—Dawsonite is from a whitish felsitic dike near the western end of McGill College, Montreal. Hunt obtained for the rock (which he calls trachyte), after separating 9·55 by nitric acid (Geol. Can., 1863, 659, 660), silica 63·25, alumina 22·12, lime 0·56, potash 5·92, soda 6·29, volatile 0·93=99·07. The portion dissolved out by nitric acid contained: Silica 1·43, alumina 2·43, peroxide of iron 2·40, red oxide of manganese 1·31, lime 0·60, potash 0·40, soda 0·98=9·55. In the joints of this rock occurs a white-bladed mineral, which is the Dawsonite.

The following are its characters. Hardness 3; G=2·40; luster vitreous; transparent to translucent. The blades are somewhat fibrous in structure, and the crystallization is probably monoclinic, with the inclination of the vertical axis about 75°. It shows bands of colors in polarized light. B. B. becomes opaque and often exfoliates or swells into cauliflower-like forms. In the closed tube yields water and carbonic acid. Dissolves completely in cold dilute hydrochloric or nitric acid. Two analyses, made at different times, the last from portions of several specimens, afford Mr. Harrington—

$\ddot{\mathrm{Si}}$	$\ddot{\mathrm{C}}$	$\dddot{\bar{\mathrm{A}}}\mathrm{l}$	$\dot{\mathrm{M}}\mathrm{g}$	$\dot{\mathrm{C}}\mathrm{a}$	$\dot{\mathrm{N}}\mathrm{a}$	$\dot{\mathrm{K}}$	$\dot{\mathrm{H}}$
0·40	29·88	32·84	tr.	5·95	20·20	0·38	11·91=101·56.
——	30·72	32·68	0·45	5·65	20·17		[10·32]=100.

Mr. Harrington inclines to the conclusion that the mineral is a hydrous carbonate of alumina, lime and soda; and that it is related therefore to hovite, which the Messrs. Gladstone made a carbonate of alumina and lime. Its crystalline character and its uniformity in optical and chemical characters show that it is not a mechanical mixture.

13. *Tables for the Determination of Minerals, by their Physical properties, ascertainable by the aid of such simple instruments as every student in the field should have with him.* Translated from the German of WEISBACH. Enlarged, and furnished with chemical formulas, a column of specific gravities and one of the characteristic Blowpipe reactions; by PERSIFOR FRAZER, Jr., A.M., Assist. Geol. in the Second Geol. Survey of Pennsylvania, etc. 118 pp. 8vo. Philadelphia, 1875. (J. B. Lippincott & Co.)—All helps to the determination of minerals will be welcomed by the student in the science, and Weisbach's tables are among the best of those based chiefly on the physical characters. We notice that the species of minerals that are peculiarly American are mostly omitted, and many of the recently described foreign species; the addition of these will give increased value to another edition of the work. The volume is very clearly printed, on good paper.

14. *Notes on the Tree-Ferns of British Sikkim, with Descriptions of three New Species, and a few Supplemental Remarks on their Relations to Palms and Cycads;* by JOHN SCOTT, Curator of the Royal Botanical Gardens, Calcutta. This paper, recently published in the thirtieth volume of the *Transactions of the Linnean Society*, was read in Feb., 1870. It is illustrated by 18 plates, eleven of which relate to the structure of the stem, etc., a subject which is here treated with freshness and ability, as well as tersely, and to which interest is added by some ingenious speculations as to history and origin. In the concluding summary, considering the relationship of Ferns, "as founded on the structure of the stem," the author remarks: "First, then, they agree with Palms in their mode of growth and in the manner in which the leaves are arranged. I fail to see why the growth of the one should be termed endogenous, and the other acrogenous. If the peculiarity of endogeneity is the downward growth of a series of vascular bundles from the leaves in a curvilinear mode, from the interior to the periphery, not a few of the tree-ferns have very similar characteristics. In both, diametrically and longitudinally, growth is strictly apical; in both the stems are limited in their diametrical growth, and from the first traces of their formation the axial and peripheral developments are simultaneous; and as soon as the normal thickness has been attained, all further peripheral increase ceases, and the axis grows upward in a cylindrical form. In Palms the growing point is conical, and in tree-ferns terminally flattened; so that in the one case the nascent vascular bundles are almost horizontally arranged at the apex, in the other they are from the beginning vertical; but in both all cellular increase of the body of the axis has ceased ere the fronds have

attained their full development. Another point in which they agree is in the development of a system of free vascular bundles, which, originating in the apex of the stem, grow upward into the fronds and downward into the axis. In other respects they present many important points of difference, as in the free anastomoses of the fibro-vascular bundles, and the formation of a woody circle surrounding the central cellular axis, which, however, is partially represented in certain Palms (vide plate XII), as *Euterpe oleracea*, by a dense zone of vascular bundles, which very distinctly separates the central, in which the cellular tissue predominates, from the peripherical and essentially vascular. The tissues of this median zone are developed, I believe, exclusively from below upward, the growing points surrounding the apex of the stem and passing outward into the fronds. Dense though this zone is, the bundles do not, in any case that I have observed, inosculate with each other. Another important difference is presented in the passage of these bundles to the fronds. In Ferns, small ramifications of the bundles only pass into any given frond, while in Palms the entire bundle enters the frond. I need scarcely remark that there are also important differences in the minute structure of the woody bundles of Ferns and Palms, the former being much more simple, though apparently similarly limited in their period of growth. In thus noting the structural affinities and differences of the stems of tree-ferns and palms, I by no means ascribe to them an equal grade of organization; tree-ferns are decidedly inferior in rank. They have, however, sufficient in common to justify the opinion of their being differently diverged and progressed forms of a common ancestor, which must have been of great antiquity, considering that both apparently presented much the same characteristics in the Carboniferous epoch as they do now." (p. 28–29.)

The analogies between the monocotyledonous stem and that of *Nymphæa* is next referred to, and also of *Cacti* with *Cycas*. More practical is the author's correction of the current statement that *Cycas* has a circinate vernation, whereas *C. circinalis* and all the rest have a perfectly straight vernation, with only the leaflets involute. A. G.

15. *Flora Brasiliensis.*—Fasciculus 53, issued in April last, contains the *Polygaleæ*, by A. W. Bennett of London, 82 pages of letter press and 30 plates, a liberal allowance. *Polygala* is largely represented in the Brazilian empire, viz: by 86 species; *Monnina* by 11, and *Securidaca* by 18 species. *Krameria* is included in the order, and has six species. It was this latter genus, and not *Polygalaceæ* in the restricted sense, that the present writer thought nearer *Leguminosæ Cæsalpineæ* than to anything else in general floral structure, and he was disposed to regard the contrary position of the odd sepal and petal, and the simple carpel, as more important than they seem to subsequent authors; also, the floral structure of *Polygaleæ* most resembles *Sapindaceæ*. But, in fact the order is very peculiar.

Fasciculus 64, of the same work, issued in May, comprises the concluding half of J. Muller's elaboration of the Brazilian *Euphorbiaceæ.* This and fasc. 61 together comprise vol. xi, pars ii, a very substantial volume indeed, filled by this one order; 752 pages of letter press, 104 plates—a great undertaking, well and happily brought to a conclusion by the excellent botanist to whom this task was assigned. A. G.

16. *Journal of the Linnean Society*, No. 77, issued in October, contains ten papers, by Mr. Moseley and several others, collected under the general head of *Contributions to the Botany of the Expedition of H. M. S. Challenger.* They relate mainly to Marine Algæ and the maritime plants, and to Algæ from hot springs in the Azores. The value of the observations upon the vegetation of thermal waters is much diminished by the total lack of all record of the precise temperature of the waters in question.

A. G.

17. *Transactions and Proceedings of the Botanical Society.* Edinburgh. Vol. xi, part iii, 1873.—This part completes the eleventh volume of the series. It contains the President's (Prof. Wyville Thompson's) Address, delivered in November, 1872, a notable production, which was printed in some of the journals at the time, and excited much attention, being a lucid exposition of fermentation and putrefraction, and of the Mould-Fungi that produce and govern these decompositions. Biographical notices of the late Hugo von Mohl and of Andres Œrstedt are appended. Prof. William R. M'Nab contributes an elaborate paper on the organization of *Equisetum* and *Calamites.* Mr. Wilson's interesting paper here appears, in which he disproves the popular and long-current notion that Darnel grain is poisonous or even injurious. His paper was noticed in this Journal; but it may not be amiss to recapitulate, in the author's own words, that, after feeding upon the seeds himself freely, he concludes that, in his own case "darnel is not justly called *temulentum*;" its seeds and husks are not "infelix," are not "acrid," are not "unwholesome," are not "injurious," do not cause "delirium," do not produce "stupefaction," and are not "poisonous" nor productive of "fatal" results. Dr. Robert Brown (may he prove himself worthy of the name!) gives some notes upon Dichogamy and other allied subjects, instancing *Clerodendron Thompsoniæ* as an admirable example of "protandrous dichogamy;" the first time, so far as we know, in which this has been spoken of in Great Britain, although here long familiar. Other Clerodendrons show it, but none so beautifully. W. Ramsay Wright gives a digest of Dr. Eichler's well-known essay, entitled: "Are the Coniferæ gymnospermous or not?" These are only the more scientifically interesting articles.

A. G.

18. *Florida Plants.*—Dr. Edward Palmer made last year a collection of dried specimens of the plants of East Florida and the Keys. Four or five sets of these, named, are on sale, and may be ordered of S. Watson, Harvard University Herbarium, Cambridge. These sets range from 250 to 630 species, and cost $8 the hundred.

Dr. Palmer is now on his way to an exploration of the Islands of the southern part of California. A. G.

19. *The American Naturalist* closes its 8th volume with the December number just issued, and appeals for the moderately larger support needful to make this, our only natural history magazine, self-sustaining. We well understand what that means. When the paid-up subscription rises so as to cover the actual outlay in the production, the public should still take to heart the fact that all the scientific talent and effort, and the editorial labor, will still be unpaid for. The editors in this case are entitled to great credit for the zeal, perseverance and sacrifice with which they have kept this magazine, not only alive, but every year more worthy of life; let us add that they are also entitled to a more generous patronage. There are many more than the five hundred new subscribers for whom they now call, to whom the Naturalist would be of great use and interest. A. G.

20. *Botanical Necrology.*—On turning over the pages of the *Botanische Zeitung* for the year 1874 (received down to the end of November), we find no record of the death of any botanist, except that of Pritzel.

George Aug. Pritzel, of Berlin, was born in 1815, and died on the 14th of June last. His only botanical publication was a revision of the genus *Anemone*, contributed to the Linnæa in 1842. The valuable services which he rendered to the science, and which should preserve his memory, were by the faithful preparation of the indispensable *Thesaurus Literature Botanicæ* in 1851; of the *Iconum Botanicarum Index locupletissimus* in 1855, with a re-issue and supplement in 1866, and by the new edition of the *Thesaurus* in 4to, of which four parts, carrying the alphabetical portion of the work down to the word *Tournefort*, were issued in 1872. A severe illness, from which the author appears never to have recovered, interrupted the publication. This work and the *Iconum Index* are models of editorial and typographical excellence.

Rev. Richard Thomas Lowe, a much respected English botanist, born in 1802, who passed most of his life since 1828 in Madeira, and diligently investigated its botany, was lost at sea in April last, by the foundering of the Steamer Liberia, in which he was a passenger on his way to Madeira. His principal publications were the *Primitiæ Faunæ et Floræ Maderæ*, which appeared in the Cambridge Philosophical Transactions in 1830, with a supplement (*Novitiæ*, &c.) in 1838; and a *Manual Flora of Madeira*, begun in 1857, continued into the second volume in 1872, and left unfinished.

Mrs. Hooker.—With inexpressible sorrow we record the death of this excellent and accomplished lady, the wife of Dr. Hooker, Director of the Royal Gardens at Kew, and the President of the Royal Society, and the daughter of the late Professor Henslow. This sad event occurred on the 13th of November, of heart-disease. Of the great practical services rendered to science by most efficient aid to her husband we may not speak; but her name has of late become well known in Botany, through her able translation of Le Maout and Decaisne's *Traité de Botanique*, for the English edition edited by Dr. Hooker.

JOHN TRAHERNE MAGGRIDGE (as the English journals at this moment inform us) died at Mentone, on the 24th of November, at the age of 32 years. His contributions to the Flora of Mentone, with its exquisite illustrations by his facile pencil, and not less admirable letter-press, his work on Harvesting Ants and Trap-door Spiders (published by Reeve & Co., London), and many short articles or notes in Nature and other journals, have made this charming young man's talents and keen powers of observation most favorably known to the scientific world. He has been for years an invalid, and took up his residence in the Riviera for the sake of a better winter climate than his native England. Here his scientific investigations have mainly been prosecuted,—were perhaps undertaken for the sake of occupation and interest during the slow progress of fatal pulmonary disease. A. G.

21. *Traité de Botanique conformé a l'état présent de la Science*, par J. SACHS; traduit de l'Allemand sur la 3e édition et annoté par Ph. Van Tieghem. Paris, 1874. *Lehrbuch der Botanik*, 4te Auflage, Leipzig, 1874.—The third edition of Professor Sachs's treatise was noticed in this Journal, May, 1873.

Professor Van Tieghem's translation and the new German edition are both revisions and demand a further notice.

The French revision is an accurate translation and displays great editorial skill. The entire treatise has been divided into topical paragraphs, to each of which a telling title has been given. In not a few instances, the heading embodies the substance of the section, and greatly increases the value of the book as a work of reference. This may be illustrated by a single chapter,—On the relation between the morphological nature of organs and their adaptation to the conditions of plant life. This chapter in the German edition occupies seven closely printed pages and has no division into subordinate sections, but in the translation the following headings are given:

Metamorphosis, adaptation and utility express one and the same fact, and are synonymous terms.

The same members of a plant can adapt itself to the most varied functions, and the same function can be performed by most widely different members.

Organic arrangements useful to the plant are reached by most varied adaptations.

Examples.—1. Vertical growth of the stem. Its utility. Different ways in which it is secured. By (a) Ascending stems. (b) Twining stems. (c) Climbing with tendrils, different adaptations of tendrils. (d) Stems climbing without tendrils.

2. Subterranean growth. Its utility. Different ways in which it is brought about.

3. Dissemination of seeds. The methods by which it is secured. There are gradual transitions in adaptations.

The editorial notes communicated by Professor Van Tieghem, in the departments of microscopic anatomy and morphology, are numerous and important. Considerable prominence is given to his well known view that the elements of a fibro-vascular bundle are differently arranged in the root, stem and leaf.

The new German edition gives evidence of thorough revision. Numerous slight changes in phraseology, greatly for the better, have been made throughout the book, and several chapters have been added. The most important of them are the following: Supplementary growth in thickness; alternation of generation; periodical movements of developing organs.

A change in arrangement which will provoke much adverse criticism is the new classification of the Cryptogamic plants. This re-arrangement is based partly on morphological and partly on physiological grounds, and brings into strange fellowship plants which have heretofore been placed in quite different orders, as the following synopsis will show:

First Group. THALLOPHYTES.

Class I. PROTOPHYTES.

Forms containing chlorophyll.—A. Cyanophyceæ.—B. Palmellaceæ.

Forms devoid of chlorophyll.—A. Schizomycetes.—B. Fermentation-fungi.

Class II. ZYGOSPOREÆ.

Forms containing chlorophyll.—A. Volvocineæ.—B. Conjugatæ and Diatoms.

Forms devoid of chlorophyll.—A. Myxomycetes.—B. Zygomycetes.

Class III. OOSPOREÆ.

A. Sphæropleæ.—B. Cœloplastæ. Vaucheria, &c. Saprolegnia, Peronospora.—C. Œdogoniæ.—D. Fucaceæ.

Class IV. CARPOSPOREÆ.

Forms containing chlorophyll.—A. Coleochætæ.—B. Florideæ.—C. Characeæ.

Forms devoid of chlorophyll (or true Fungi.)—A. Ascomycetes.—B. Æcidiomycetes (Uredineæ.)—C. Basidiomycetes.

An examination of the foregoing synopsis will plainly show that Professor Sachs is largely influenced by the theory of descent. It is worth while to compare his views with those of Professor Fischer, as communicated by Dr. Brefeld (Lehrb., p. 248–9). After presenting a sketch of Fischer's new classification, Professor Sachs says: "Professor Fischer regards Fungi and Algæ as two completely separated series developing in parallel lines, while I assume that in each class Fungi have diverged as branches from the different types of Algæ.

In conclusion, the hope must be expressed that the forthcoming English translation of this admiriable work will be as worthy of honest praise as the French edition. G. L. G.

22. *Notice of some Fresh-Water and Terrestrial Rhizopods.*—Prof. LEIDY stated that among the amœboid forms noticed by him n the vicinity of Philadelphia, there was one especially remarkable or the comparatively enormous quantity of quartzose sand which it

swallowed with its food. The animal might be viewed as a bag of sand! It is a sluggish creature, and when at rest appears as an opaque white, spherical ball, ranging from $\frac{1}{8}$ to $\frac{3}{8}$ of a line in diameter. The animal moves slowly, first assuming an oval and then a clavate form. In the oval form one measured $\frac{3}{5}$ of a line long by $\frac{2}{5}$ of a line broad, and when it became clavate it was $\frac{2}{3}$ of a line long by $\frac{1}{8}$ of a line broad at the advanced thick end. Another, in the clavate form, measured $\frac{7}{8}$ of a line long by $\frac{1}{3}$ of a line wide at the thick end. The creature rolls or extends in advance, while it contracts behind. Unless under pressure it puts forth no pseudopods, and the granular entosarc usually follows closely on the limits of the extending ectosarc. Generally the animal drags after it a quantity of adherent dirt attached to a papillated or villous discoid projection of the body.

The contents of the animal, besides the granular matter and many globules of the entosarc, consists of diatoms, desmids, and confervæ, together with a larger proportion of angular particles of transparent and mostly colorless quartz. Treated with strong mineral acids so as to destroy all the soft parts, the animal leaves behind more than half its bulk of quartzose sand.

The species may be named AMŒBA SABULOSA, and is probably a member of the genus *Pelomyxa*, of Dr. Greef (Archiv f. Mik. Anat., x, 1873, 51).

The animal was first found on the muddy bottom of a pond, on Dr. George Smith's place in Upper Darby, Delaware County, but has been found also in ponds in New Jersey.

When the animal was first noticed with its multitude of sand particles, it suggested the probability that it might pertain to a stage of life of *Difflugia*, and that by the fixation of the quartz particles in the exterior, the case of the latter would be formed. This is conjectural and not confirmed by any observation.

A minute amœboid animal found on *Spirogyra* in a ditch at Cooper's Point, opposite Philadelphia, is of interesting character. The body is hemispherical, yellowish, and consists of a granular entosarc with a number of scattered and well-defined globules, besides a large contractile vesicle. From the body there extends a broad zone, which is colorless and so exceedingly delicate that it requires a power of 600 diameters to see it favorably. By this zone the animal glides over the surface. As delicate as it is, it evidently possesses a regular structure, though it was not resolved under the best powers of the microscope. The structure probably consists of globular granules of uniform size alternating with one another, so that the disk at times appears crossed by delicate lines, and at others as if finely and regularly punctated. The body of the animal measures from $\frac{1}{66}$ to $\frac{1}{50}$ of a line in diameter, and the zone is from $\frac{1}{333}$ to $\frac{1}{200}$ of a line wide. The species may be named AMŒBA ZONALIS.

The interesting researches of Prof. Richard Greef, of Marburg, published in the second volume of Scholtze's Archiv f. Mikroskopische Anatomie, on Amœbæ living in the earth (*Ueber einige* *in der Erde lebende Amœben, etc.*), led me to look in similar positions for Rhizopods.

In the earth, about the roots of mosses growing in the crevices of the bricks of our city pavements, in damp places, besides finding several species of *Amœba*, together with abundance of the common wheel-animalcule, *Rotifer vulgaris*, I had the good fortune to discover a species of *Gromia*. I say good fortune, for it is with the utmost pleasure I have watched this curious creature for hours together. The genus was discovered and well described by Dujardin, from two species, one of which, *G. oviformis*, was found in the seas of France; the other, the *G. fluviatilis*, in the River Seine.

Imagine an animal, like one of our autumnal spiders, stationed at the center of its well-spread net; imagine every thread of this net to be a living extension of the animal, elongating, branching, and becoming confluent so as to form a most intricate net; and imagine every thread to exhibit actively moving currents of a viscid liquid both outward and inward, carrying along particles of food and dirt, and you have some idea of the general character of a *Gromia*.

The *Gromia* of our pavements is a spherical cream-colored body, about the $\frac{1}{16}$th of a line in diameter. When detached from its position and placed in water, in a few minutes it projects in all directions a most wonderful and intricate net. Along the threads of this net float minute Naviculæ from the neighborhood, like boats in the current of a stream, until reaching the central mass they are there swallowed. Particles of dirt are also collected from all directions and are accumulated around the animal, and when the accumulation is sufficient to protect it, the web is withdrawn and nothing apparently will again induce the animal to produce it.

From these observations we may suppose thet the GROMIA TERRICOLA, as I propose to name the species, during dry weather remains quiescent and concealed among accumulated dirt in the crevices of our pavements, but that in rains or wet weather the little creature puts forth its living net, which becomes so many avenues along which food is conveyed to the body. As the neighborhood becomes dry, the net is withdrawn to await another rain. The animal with its extended net can cover an area of nearly half a line in diameter. The threads of the net are less than the $\frac{1}{30000}$th of an inch in diameter.—*Proc. Acad. Nat. Sci. Phil.*, 1874, p. 88.

23. *Nature of the Sea-bottom.*—Prof. C. WYVILLE THOMSON has presented to the Royal Society a paper entitled Preliminary Notes on the nature of the Sea-bottom procured by the soundings of H. M. S. Challenger during her cruise in the Southern Sea in the early part of the year 1874, which are published in "Nature" for December and January. The following are extracts from it.

a. *Green-sand.* In the region of the Agulhas Bank, off the south extremity of Africa, from 98 and 150 fathoms, a greenish sand was brought up which was found to consist of casts of foraminifers in a glauconite-like material. The genera included Miliola, Biloculina, Uvigerina, Planorbulina, Rotalia, Textularia, Bulimina and Nummulina, and, of much less abundance, Globigerina, Orbulina and Pulvinulina.

b. *Globigerina, gray and red ooze.* From Cape Agulhas to lat. 46° 16′, the greatest depth was 1,900 fathoms; and the bottom was Globigerina ooze, it consisting mostly of the shells of Globigerina, more or less broken, with a few of Pulvinulina and Orbulina.

The limit of the pure Globigerina ooze is near 2,250 fathoms. Passing to greater depths, the material of the bottom is first a "gray ooze," and then generally for all depths below 2,500 or 3,000 fathoms it is the "red ooze" or clay, which consists of a silicate of alumina and red oxide of iron. The transition is gradual, the shells first losing their sharpness of outline and becoming mixed with more or less of red-brown amorphous powder, which is so fine as to take days to settle. In the section between Teneriffe and St. Thomas, at the first four casts, the Globigerina ooze was obtained at depths from 1,525 to 2,220 fathoms; then at a depth of 2,740 fathoms, 500 miles from Teneriffe, and of 2,950 fathoms, 750 miles off, the ooze is gray but is largely the red clay mixed with some of the calcareous; and at 3,150 fathoms, 1,150 miles from Teneriffe, the bottom was a pure and smooth clay with scarcely a trace of lime. From this great depth the bottom rises, and the gray color and calcareous nature of the ooze returns, soundings in 2,050, 1900 and 1950 fathoms on the "Dolphin Rise" bringing up the Globigerina ooze. But passing from the middle plateau of the Atlantic into the western trough, where the depth is a little over 3,000 fathoms, the red clay returned in all its purity.

Prof. Thomson states that Mr. Murray, after a careful study of all the facts, has come to the conclusion, presented years ago by Professor Bailey, that the Rhizopods are not living in the deep ocean, but belong to the superficial waters. Facts prove that they are very abundant in these upper waters, that the shells have a perfection in the living state that is not found in the deep water specimens. With regard to the red ooze, which is almost destitute of life, the opinion is put forth that beyond a certain depth the shells of the Globigerinæ and other Rhizopods are dissolved, and that the alumina and iron which experiment has proved they contain are the source of the broad and barren regions of clay.

24. *Index to Volumes I to XIII of Observations on the Genus Unio*, together with descriptions of new species of the Family Unionidæ, and descriptions of new species of the Melanidæ, Paludinæ and Helicidæ, etc.; by Isaac Lea, LL.D. Vol. III.—This is a supplementary Index to the previous Indexes published in 1867 and 1869, giving what was omitted in the others, references to anatomical and structural details, habits, etc.

25. *Reliquiæ Aquitanicæ*, being Contributions to the Archæology and Palæontology of Périgord and the adjoining Provinces of Southern France, by E. Lartet and H. Christy, edited by Thomas Rupert Jones, F.R.S., &c.—Part xv of this valuable work, for September, 1874, contains pages 205–224, 173 to 182, and Plate A xlii.

III. Astronomy.

1. *The Transit of Venus, December 8th.*—Telegrams announce successful observations of the Transit at Yokohama, Nagasaki, Vladivostock, Teheran, Cairo, Suez and Thebes, at points in India, China, Adelaide and Melbourne, and less perfect at Hobart Town. One hundred photographs are reported from India, and thirteen from that at Vladivostock. Failures are reported at Shanghai, and at the Russian stations of Omsk, Orenburg, Kasan, Uralsk, Astrachan, Kertch, and Tiflis. Twenty other Russian stations, Kerguelen's Land, the Sandwich Islands, Mauritius, and many other points, are yet to be heard from. The probabilities are that greater success has been attained, on the whole, than could reasonably have been expected, and that the successes have, in the main, been at the more important stations for determining the parallax.

IV. Miscellaneous Scientific Intelligence.

1. *Exploration in South America.*—Prof. Alexander Agassiz left the country near the close of November, on a trip to South America, especially to Chili and Bolivia. At Lake Titicaca he expects to dredge, besides making temperature observations. Mr. Garman, of the Museum of Comparative Zoology, accompanied him, and will go directly to Lake Titicaca to collect. Mr. Agassiz's health has been poor, since the great afflictions which befel him in the death of his father and, almost immediately after, that of his gifted wife. It is now somewhat improved, and it is believed that the journey will make the restoration complete.

2. *Observatory at Cordoba, Argentine Republic.*—Dr. B. A. Gould, the astronomer, after a brief visit to his home and friends at Boston, has left again for Cordoba, to resume his great work there with regard to the southern constellations, which is now far advanced toward completion.

3. *Cañons of the Colorado.*—Major J. W. Powell, the explorer of the Cañons of the Colorado, has a valuable article on the Colorado Basin and its Cañons in the January number of Scribner's Monthly. With the usual liberality of this excellent Monthly, the article is illustrated by many fine engravings, from the photographs taken by the artist of Powell's expedition.

4. *Statistical Atlas of the United States;* by Francis A. Walker. Authorized by the Act of Congress of March 3, 1873. —The great variety of valuable material locked up in a Census Report can be brought out for use only through laborious and critical study on the part of one who understands fully the philosophical bearing of the facts. Such a study has been made of the returns of the recent United States Census by Mr. Walker. His Statistical Atlas, Parts II. and III. of which have recently been published, presents to the eye the chief results arrived at, and attests, in every part, to the learning, judgment, and thoroughness of the author. By means of maps and diagrams the great facts in political and social science are made readily and impressively

intelligible in all their relations. Part II. embraces the department of *Social and Industrial Statistics.* The charts show, by colors, the growth of the United States in population from 1790, when the first census was taken, through eight decades to 1870; also the center of population for the different periods; the constituents of the population of each State at the present time; the distribution, absolute and relative, of the colored population; of foreigners and persons of foreign birth; as to illiteracy; also the distribution of wealth over the country; of public indebtedness; of taxation; of the most important crops; the relative amount of church and school accommodation; and so on. Part III. covers the *Vital Statistics*, and contains eighteen charts illustrating the distribution of population by age and sex; of native and foreign population; prevalence of various diseases for the two sexes, in different parts of the country and for the successive seasons of the year; relative birth rate; relative death rate for different diseases; relative number of blind, deaf, insane and idiotic persons, with the rate of increase or decrease for the decade from 1860 to 1870, and many other topics. The charts with reference to the blind and idiocy were prepared by F. H. Wines.

Part I, devoted to the *Physical Features of the United States*, is now in the press.

5. *Cave Hunting: Researches on the evidence of Caves respecting the early inhabitants of Europe*; by W. Boyd Dawkins, M.A., F.R.S., F.G.S., Curator of the Museum and Lecturer in Geology in the Owens College, Manchester. 456 pp. 8vo. Illustrated by a colored plate and many woodcuts. London, 1874. (Macmillan & Co.)—The author of this new volume on British and European Caves is one of the most prominent of British geologists, and one who has made a special study of the caves and the cave animals. The first and second chapters treat chiefly of the history of cave exploration, and the physical history of caves. Next follows chapters on the historic caves of Britain and their relics; caves used in the ages of Iron and Bronze; caves of the neolithic age; Range of æolithic dolicho-cephalic and brachy-cephalic men; Pleistocene caves of Germany and Great Britain; evidence from the cave inhabitants as to the Atlantic and Mediterranean coast line in the Pleistocene, illustrated by a map; the European climate in the Pleistocene; and on the instruments and methods of cave-hunting. Prof. Dawkins recognizes the existence of two Glacial eras in Great Britain: the older, or that commonly so called, one of greater elevation than now, was followed by an era of subsidence; and this by another era of elevation and glaciers, but of less extent of ice than in the first glacial era. The illustrations are numerous and excellent, and the work, while exact and thorough in its science, is popular in style and full of interest to all classes of readers.

Report of the Commissioner of Agriculture for 1873; 496 pp. 8vo. Washington, 1874.

Recent change of level on the Coast of Maine; by N. S. Shaler. 20 pp. 4to. From the Memoirs of the Boston N. H. Society. Volume II, Part 3, No. 3.

OBITUARY.

FRANCIS WALKER.—An exception to the precedent of speaking well of the dead is offered by the Entomologist's Monthly Magazine in its obituary notice of the late Francis Walker as an entomologist. And we who have written of Mr. Walker's work, after having examined his material in the British Museum Collection, can only endorse what is actually a repetition, in other words, of our statements in the Transactions of the American Entomological Society for July, 1868. With regard to the responsibility for the indifferent work in the British Museum lists, this lies, as the writer in the Entomologist's Monthly Magazine says, and as we had previously pointed out, with the authorities in the British Museum who authorized the publication of these lists. As their preface gives their authority, their publication is due to Mr. John Edward Gray, to whom science is so widely indebted that this error in judgment on his part must be condoned. For our part, from first to last, so far as our special branch is concerned, we have steadily opposed any total rejection of Mr. Walker's works as affording a bad precedent, and this contrary to the opinions of those yet eminent entomologists in whom we have learned to have confidence. At this moment, when a kind and amiable man has left us, we renew our appeal made in 1868, that Mr. Walker's material in the British Museum Collection be worked over by a competent hand. In this work reference should be had to the specimens and the descriptions, and every *tenable* name should be fixed, all doubtful names, founded on irrecognizable specimens, should be withdrawn, and in this way Mr. Walker's reputation would be saved from further obloquy, the ends of science furthered and the authorities of the British Museum atone amply for their mistake. Private collectors, who have Mr. Walker's types, would heartily join, doubtless, in a work which would be to their advantage, and a miserable scandal would be done away with forever. This, and so desirable a consummation, remains to be gained by the proper authorities of the institution which allowed the fault to be committed. What greater work have they in prospect that this duty shall be set aside? We close this paper with a kindly remembrance of the dead, and with the words we first used on the occasion of appearing as Mr. Walker's critic, "trusting that nothing we have ever said can be taken as reflecting personally upon a gentleman, whose courtesy and the extent of whose literary labors invite every consideration." A. R. GROTE.

EDWIN LANKESTER.—Dr. Lankester, well known for his zoological publications, died October 30th, at the age of sixty. He was elected a fellow of the Royal Society in 1845. For eighteen years he has edited, in conjunction with Mr. Busk, the Quarterly Journal of Microscopic Science.

Dr. THOMAS ANDERSON, late Professor of Chemistry in the University of Glasgow, died at Chiswick on the 2d of November. He was born in 1819.

SIR WILLIAM JARDINE, the zoologist, and especially distinguished for his labors in Ornithology, died at Sandown, in the Isle of Wight, on the 21st of November, aged 74.

STORM OF JAN. 6-8, 1874

PLATE I.

Punderson & Crisand, New Haven, Conn.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. X.—*Jeffries Wyman. Address of Professor* A. GRAY at the Memorial Meeting of the Boston Society of Natural History, Oct. 7, 1874.*

WHEN we think of the associate and friend whose death this society now deplores, and remember how modest and retiring he was, how averse to laudation and reticent of words, we feel it becoming to speak of him, now that he is gone, with much of the reserve which would be imposed upon us if he were living. Yet his own perfect truthfulness and nice sense of justice, and the benefit to be derived from the contemplation of such a character by way of example, may be our warrant for reasonable freedom in the expression of our judgments and our sentiments, taking care to avoid all exaggeration.

Appropriate and sincere eulogies and expressions of loss, both official and personal, have, however, already been pronounced or published; and among them one from the governors of that institution to which, together with our own society, most of Professor Wyman's official life and services were devoted,—which appears to me to delineate in the fewest words the truest outlines of his character. In it the President and Fellows of Harvard University "recall with affectionate respect and admiration the sagacity, patience and rectitude which characterized all his scientific work, his clearness, accuracy and conciseness as a writer and teacher, and the industry and zeal with which he labored upon the two admirable collections which remain as monuments of his rare knowledge, method and skill. They commend to the young men of the university this signal

* From the "Proceedings" of the Society.

example of a character modest, tranquil, dignified and independent, and of a life simple, contented and honored."

What more can be or need be said? It is left for me, in compliance with your invitation, Mr. President, to say something of what he was to us, and has done for us, and to put upon record, for the use of those who come after us, some account of his uneventful life, some notice, however imperfect, of his work and his writings. I could not do this without the help of friends who knew him well in early life, and of some of you who are much more conversant than I am with most of his researches. Such aid, promptly rendered, has been thankfully accepted and freely used.

Our associate's father, Dr. Rufus Wyman,—born in Woburn, graduated at Harvard College in 1799, and in the latter part of his life physician to the McLean Asylum for the Insane,—was a man of marked ability and ingenuity. Called to the charge of this earliest institution of the kind in New England at its beginning, he organized the plan of treatment and devised the excellent mechanical arrangements which have since been developed, and introduced into other establishments of the kind. His mother was Ann Morill, daughter of James Morill, a Boston merchant. This name is continued, and is familiar to us, in that of our associate's elder brother.

JEFFRIES WYMAN, the third son, derived his baptismal name from the distinguished Dr. John Jeffries, of Boston, under whom his father studied medicine. He was born on the 11th of August, 1814, at Chelmsford, a township of a few hundred inhabitants in Middlesex County, Mass., not far from the present city of Lowell. As his father took up his residence at the McLean Asylum in 1818, when Jeffries was only four years old, he received the rudiments of his education at Charlestown, in a private school; but afterward went to the Academy at Chelmsford, and, in 1826, to Phillips Exeter Academy, where, under the instruction of Dr. Abbot, he was prepared for college. He entered Harvard College in 1829, the year in which Josiah Quincy took the presidency, and was graduated in 1833, in a class of fifty-six, six of whom became professors in the university. He was not remarkable for general scholarship, but was fond of chemistry, and his preference for anatomical studies was already developed. Some of his class-mates remember the interest which was excited among them by a skeleton which he made of a mammoth bull-frog from Fresh Pond, probably one which is still preserved in his museum of comparative anatomy. His skill and taste in drawing, which he turned to such excellent account in his investigations and in the lecture room, as well as his habit of close observation of natural objects met with in his strolls, were manifested even in boyhood.

An attack of pneumonia during his Senior year in college caused much anxiety, and perhaps laid the foundation of the pulmonary affection which burdened and finally shortened his life. To recover from the effects of the attack, and to guard against its return, he made, in the winter of 1833–34, the first of those pilgrimages to the coast of the Southern States, which in later years were so often repeated. Returning with strength renewed in the course of the following spring, he began the study of medicine under Dr. John C. Dalton, who had succeeded to his father's practice at Chelmsford, but who soon removed to the adjacent and thriving town of Lowell. Here, and with his father at the McLean Asylum, and at the Medical College in Boston, he passed two years of profitable study. At the commencement of the third year he was elected house-student in the Medical Department, at the Massachusetts General Hospital,—then under the charge of Doctors James Jackson, John Ware and Walter Channing,—a responsible position, not only most advantageous for the study of disease, but well adapted to sharpen a young man's power of observation.

In 1837, after receiving the degree of Doctor of Medicine, he cast about among the larger country towns for a field in which to practice his profession. Fortunately for science, he found no opening to his mind; so he took an office in Boston, on Washington street, and accepted the honorable, but far from lucrative post of Demonstrator of Anatomy under Dr. John C. Warren, the Hersey Professor. His means were very slender, and his life abstemious to the verge of privation; for he was unwilling to burden his father, who, indeed, had done all he could in providing for the education of two sons. It may be interesting to know that, to eke out his subsistence, he became at this time a member of the Boston Fire Department, under an appointment of Samuel A. Eliot, Mayor, dated Sept. 1, 1838. He was assigned to Engine No. 18. The rule was that the first-comer to the engine-house should bear the lantern, and be absolved from other work. Wyman lived near by, and his promptitude generally saved him from all severer labor than that of enlightening his company.

The turning point in his life, i. e., an opportunity which he could seize of devoting it to science, came when Mr. John A. Lowell offered him the curatorship of the Lowell Institute, just brought into operation, and a course of lectures in it. He delivered his course of twelve lectures upon Comparative Anatomy and Physiology in the winter of 1840–41; and with the money earned by this first essay in instructing others, he went to Europe to seek further instruction for himself. He reached Paris in May, 1841 and gave his time at once to Human Anatomy at the School of Medicine, and Comparative Anatomy and Natural History at the Garden of Plants, attending the lectures of Flourens, Majendie and Longet on Physiology, and of de Blainville, Isidore St. Hilaire, Valenciennes, Dumeril and Milne-Edwards on Zoology and Comparative Anatomy. In the summer, when the lectures were over, he made a pedestrian journey along the banks of the Loire, and another along the Rhine, returning through Belgium, and by steamer to London. There, while engaged in the study of the Hunterian collections at the Royal College of Surgeons, he received information of the alarming illness of his father; he immediately turned his face homeward, but on reaching Halifax he learned that his father was no more.

He resumed his residence in Boston, and devoted himself mainly to scientific work, under circumstances of no small discouragement. But in 1843 the means of a modest professional livelihood came to him in the offer of the chair of Anatomy and Physiology in the medical department of Hampden-Sidney College, established at Richmond, Virginia. One advantage of this position was that it did not interrupt his residence in Boston, except for the winter and spring; and during these months the milder climate of Richmond was even then desirable. He discharged the duties of the chair most acceptably for five sessions, until, in 1847, he was appointed to succeed Dr. Warren as Hersey Professor of Anatomy in Harvard College, the Parkman professorship in the Medical School in Boston being filled by the present incumbent, Dr. Holmes. Thus commenced Prof. Wyman's most useful and honorable connection as a teacher with the university, of which the President and Fellows speak in the terms I have already recited. He began his work in Holden Chapel, the upper floor being the lecture-room, the lower containing the dissecting-room and the anatomical museum of the college, with which he combined his own collections and preparations, which from that time forward increased rapidly in number and value under his industrious and skillful hands. At length Boylston Hall was built for the anatomical and the chemical departments, and the museum, lecture and working-rooms were established commodiously in their present quarters; and Prof. Wyman's department assumed the rank and the importance which it deserved. Both human and comparative anatomy were taught to special pupils, some of whom have proved themselves worthy of their honored master, while the annual courses of lectures and lessons on Anatomy, Physiology, and for a time the principles of Zoology, imparted highly valued instruction to undergraduates and others.

In the formation and perfecting of his museum—the first of the kind in the country, arranged upon a plan both physiological and morphological—no pains and labors were spared, and long and arduous journeys and voyages were made to contribute to its riches. In the summer of 1849,—having replenished his frugal means with the proceeds of a second course of lectures before the Lowell Institute (viz., upon Comparative Physiology, a good condensed short-hand report of which was published at the time),—he accompanied Capt. Atwood of Provincetown, in a small sloop, upon a fishing voyage high up the coast of Labrador; in the winter of 1852, going to Florida for his health, he began his fruitful series of explorations and collections in that interesting district. In 1854, accompanied by his wife, he traveled extensively in Europe, and visited all the museums within his reach. In the spring of 1856, with his pupils, Green and Bancroft, as companions and assistants, he sailed to Surinam, penetrated far into the interior in canoes, made important researches upon the ground, and enriched his museum with some of its most interesting collections. These came near being too dearly bought, as he and his companions took the fever of the country, from which he suffered severely, and recovered slowly. Again, in 1858–9, accepting the thoughtful and generous invitation of Capt. J. M. Forbes, he made a voyage to the La Plata, ascended the Uraguay and the Parana in a small iron steamer which Capt. Forbes brought upon the deck of his vessel; then, with his friend George Augustus Peabody as a companion, he crossed the pampas to Mendoza, and the Cordilleras to Santiago and Valparaiso, whence he came home by way of the Peruvian coast and the Isthmus.

By such expeditions many of the choice materials of his museum and of his researches were gathered, at his own expense, to be carefully prepared and elaborated by his own unaided hands. A vast neighboring museum is a splendid example of what munificence, called forth by personal enthusiasm, may accomplish. In Dr. Wyman's we have an example of what one man may do unaided, with feeble health and feebler means, by persistent and well-directed industry, without eclât, and almost without observation. While we duly honor those who of their abundance cast their gifts into the treasury of science, let us not—now that he cannot be pained by our praise—forget to honor one who in silence and penury cast in more than they all.

Of penury in a literal sense we may not speak; for although Prof. Wyman's salary, derived from the Hersey endowment, was slender indeed, he adapted his wants to his means, foregoing neither his independence nor his scientific work; and I suppose no one ever heard him complain. In 1856 came unexpected and honorable aid from two old friends of his father who appreciated the son, and wished him to go on with his scientific work without distraction. One of them, the late Dr. William J. Walker, sent him ten thousand dollars outright; the other, the late Thomas Lee, who had helped in his early education, supplemented the endowment of the Hersey professorship with an equal sum, stipulating that the income thereof should be paid to Prof. Wyman during life, whether he held the chair or not. Seldom, if ever, has a moderate sum produced a greater benefit.

Throughout the later years of Prof. Wyman's life a new museum has claimed his interest and care, and is indebted to him for much of its value and promise. In 1866, when failing strength demanded a respite from oral teaching, and required him to pass most of the season for it in a milder climate, he was named by the late George Peabody one of the seven trustees of the Museum and Professorship of American Archæology and Ethnology, which this philanthropist proceeded to found in Harvard University; and his associates called upon him to take charge of the establishment. For this he was peculiarly fitted by all his previous studies, and by his predilection for ethnological inquiries. These had already engaged his attention, and to this class of subjects he was thereafter mainly devoted,—with what sagacity, consummate skill, untiring diligence and success, his seven annual Reports—the last published just before he died,—his elaborate memoir on shell-heaps, now printing, and especially the Archæological Museum in Boylston Hall, abundantly testify. If this museum be a worthy memorial of the founder's liberality and foresight, it is no less a monument of Wyman's rare ability and devotion. Whenever the enduring building which is to receive it shall be erected, surely the name of its first curator and organizer should be inscribed, along with that of the founder, over its portal.

Of Prof. Wyman's domestic life, let it here suffice to record, that in Dec., 1850, he married Adeline Wheelwright, who died in June, 1855, leaving two daughters; that in August, 1861, he married Anna Williams Whitney, who died in February, 1864, shortly after the birth of an only and a surviving son.

Of his later days, of the slow, yet all too rapid progress of fatal pulmonary disease, it is needless to protract the story. Winter after winter, as he exchanged our bleak climate for that of Florida, we could only hope that he might return. Spring after spring he came back to us invigorated, thanks to the bland air and the open life in boat and tent, which acted like a charm; —thanks, too, to the watchful care of his attached friend, Mr. Peabody, his constant companion in Florida life. One winter was passed in Europe, partly in reference to the Archæological Museum, partly in hope of better health; but no benefit was received. The past winter in Florida produced the usual amelioration, and the amount of work which Dr. Wyman undertook and accomplished last summer might have tasked a robust man. There were important accessions to the archæological collections, upon which much labor, very trying to ordinary patience, had to be expended. And in the last interview I had with him, he told me that he had gone through his own museum of comparative anatomy, which had somewhat suffered in consequence of the alterations in Boylston Hall, and had put the whole into perfect order. It was late in August when he left Cambridge for his usual visit to the White Mountain region, by which he avoided the autumnal catarrh; and there, at Bethlehem, New Hampshire, on the 4th of September, a severe hemorrhage from the lungs suddenly closed his valuable life.

Let us turn to his relations with this society. He entered it in October, 1837, just thirty-seven years ago, and shortly after he had taken his degree of Doctor in Medicine. He was Recording Secretary from 1839 to 1841; Curator of Ichthyology and Herpetology from 1841 to 1847, of Herpetology from 1847 to 1855, of Comparative Anatomy from 1855 to 1874. While in these later years his duties may have been almost nominal, it should be remembered that in the earlier days a curator not only took charge of his portion of the Museum, but in a great degree created it. Then for fourteen years, from 1856 to 1870, he was the president of this society, as assiduous in all its duties as he was wise in council; and he resigned the chair which he so long adorned and dignified only when the increasing delicacy of his health, to which night-exposure was prejudicial, made it unsafe for him any longer to undertake its duties. The record shows that he has made here one hundred and five scientific communications,* several of them very important papers, every one of some positive value; for you all know that Prof. Wyman never spoke or wrote except to a direct purpose, and because there was something which it was worth while to communicate. He bore his part also in the American Academy of Arts and Sciences, of which he was a Fellow from the year 1843, and for many years a Councillor. To it he made a good number of communications; among them one of the longest and ablest of his memoirs.

Then he was from the first a member of the Faculty of the Museum of Comparative Zoology, where his services and his advice were highly valued. He was chosen president of the American Association for the Advancement of Science for the year 1857, but did not assume the duties of the office.

Some notice—brief and cursory though it must be—of such portion of Dr. Wyman's scientific work as is recorded in his published papers, should form a part of this account of his life

* The Royal Society's Catalogue of Scientific Papers enumerates sixty-four by Prof. Wyman alone, and four in conjunction with others.

His earliest publication, so far as we know, was an article in the Boston Medical and Surgical Journal, in 1837, signed only with the initials of his name. It is upon "The indistinctness of images formed from oblique rays of light," and the cause of it. The handling of the subject is as characteristic as that of any later paper. In January, 1841, we find his first recorded communication to this society, "On the Cranium of a Seal." The first to the American Academy is the account of his dissection of the electrical organs of a new species of Torpedo, in 1843, part of a paper by his friend Dr. Storer, published in the American Journal of Science. In the course of that year, eleven communications were made to our society, besides the Annual Address, which he delivered on the 17th of May. The most important of these was the memoir, by Dr. Savage and himself, on the Black Orang or Chimpanzee of Africa, *Troglodytes niger*, published in full in the Journal of this society, the anatomical part by Professor Wyman. Two other papers of that early year, on the Anatomy of two Mollusca, *Tebennophorus Carolinensis* and *Glandina truncata*, published in the fourth volume of the society's Journal, each with a copper plate, are noteworthy, as showing that he possessed from the first that happy faculty of clear, terse, and closely relevant exposition, and that skill and neatness of illustration with his pencil, which characterize all his work, both of research and instruction.

Another paper of that year, "On the microscopic structure of the teeth of the *Lepidostei*, and their analogies with those of the *Labyrinthodonts*," read to this society in August, and published in this Journal in October, 1843, was important and timely. In it he demonstrated that the labyrinthine structure of the teeth, considered at the time to be peculiar to certain sauroid reptiles, equally belonged to the gar-fishes, and consequently that many fossil teeth which had been referred by the evidence of this character alone to a group of reptiles founded upon this peculiarity, might as well belong to ancient sauroid fishes.

Although not of any importance now to remember, I may here mention his report to this society on the *Hydrarchos Sillimani* of Koch, a factitious Saurian of huge length, successfully exhibited in New York and elsewhere under high auspices, and I think also in Germany, but which Dr. Wyman exposed at sight, showing that it was made up of an indefinite number of various cetacean vertebræ, belonging to many individuals, which (as was afterward ascertained) were collected from several localities.

But the memoir by which Professor Wyman assured his position among the higher comparative anatomists was that communicated to and published by this society in the summer of 1847, in which the Gorilla was first named and introduced to the scientific world, and the distinctive structure and affinities of the animal so thoroughly made out from the study of the skeleton, that there was, as the great English anatomist remarked, "very little left to add, and nothing to correct." In this memoir the "Description of the habits of *Troglodytes Gorilla*" is by Dr. Thomas S. Savage, to whom, along with Dr. Wilson, "belongs the credit of the discovery;" the osteology of the same and the introductory history are by Dr. Wyman. Indeed, nearly all since made known of the Gorilla's structure, and of the affinities soundly deduced therefrom, has come from our associate's subsequent papers, founded on additional crania brought to him in 1849, by Dr. George A. Perkins of Salem: on a nearly entire male skeleton of unusual size, received in 1852, from the Rev. William Walker, and now in Wyman's museum; and on a large collection of skins and skeletons placed at his disposal in 1859 by Du Chaillu, along with a young Gorilla in spirits, which he dissected. It is in the account of this dissection that Professor Wyman brings out the curious fact that the skull of the young Gorilla and Chimpanzee bears closer resemblance to the adult than to the infantile human cranium.

In Professor Wyman's library, bound up with a quarto copy of the Memoir by Dr. Savage and himself, is a terse but complete history of this subject, in his neat and clear hand-writing, and with copies of the letters of Dr. Savage, Professor Owen, Mr. Walker, and M. du Chaillu.

In the introductory part of the Memoir, Professor Wyman states that "the specific name, *Gorilla*, has been adopted, a term used by Hanno in describing the wild men found on the coast of Africa, probably one of the species of the Orang." The name *Troglodytes Gorilla* is no doubt to be cited as of Savage and Wyman, and it was happily chosen by Professor Wyman, after consultation with his friend, the late Dr. A. A. Gould, for the reason just stated. But it is interesting to see, in the correspondence before me, how strenuously each of the joint authors deferred to the other the honor of nomenclature. Dr. Savage from first to last insists, in repeated and emphatic terms, that the scientific name shall be given by Dr. Wyman as the scientific describer, and that he could not himself honestly appropriate it. Professor Wyman, in his MSS. account, after mentioning what his portion of the Memoir was, and that "the determination of the differential characters on which the establishment of the species rests was prepared by me," briefly and characteristically adds: "In view of this last fact, Dr. Savage thought, as will be seen in letter, that the species should stand in my name; but this I declined."

This Memoir was read before this society on the 18th of August, 1847, and was published before the close of the year. But it had not, as it appears, come to Professor Owen's knowledge when the latter presented to the London Zoological Society, on the 22d of February, 1848, a memoir founded on three skulls of the same species, just received from Africa through Captain Wagstaff. When Professor Owen received the earlier Memoir, he wrote to compliment Professor Wyman upon it, substituted in a supplementary note the specific name imposed by Savage and Wyman, and reprinted in an appendix the osteological characters set forth by the latter. "It does not appear, however (adds Dr. Wyman), either in the Proceedings or the Transactions of the (Zoological) Society at what time our Memoir was published, nor that we had anticipated him in our description."

It is safe to assert that in this and the subsidiary papers of Dr. Wyman may be found the substance of all that has since been brought forward, bearing upon the osteological resemblances and differences between men and apes. After summing up the evidence, he concludes:—

"The organization of the anthropoid Quadrumana justifies the naturalist in placing them at the head of the brute creation, and placing them in a position in which they, of all the animal series, shall be nearest to man. Any anatomist. however, who will take the trouble to compare the skeletons of the Negro and Orang, cannot fail to be struck at sight with the wide gap which separates them. The difference between the cranium, the pelvis, and the conformation of the upper extremities in the Negro and Caucasian, sinks into comparative insignificance when compared with the vast difference which exists between the conformation of the same parts in the Negro and the Orang. Yet it cannot be denied, however wide the separation, that the Negro and Orang do afford the points where man and the brute, when the totality of their organization is considered, most nearly approach each other."

Selecting now for further comment only some of the more noticeable contributions to science, we should not pass by his investigations of the anatomy of the Blind Fish of the Mammoth Cave. The series began, in that prolific year, 1843, with a paper published in this Journal, and closed with an article in the same Journal in 1854. Although Dr. Tellkamph had preceded him in ascertaining the existence of rudimentary eyes and the special development of the fifth pair of nerves, yet for whole details of the subject, and the minute anatomy, we are indebted to Professor Wyman. Many of the details, however, as well as the admirable drawings illustrating them, remained unpublished until 1872, when he placed them at Mr. Putnam's disposal, and they were brought out in his elaborate article in the "American Naturalist." Here the extraordinary development of tactile sense, taking the place of vision, and perfectly adapting the animal to its subterranean life, is completely demonstrated.

If Professor Wyman's first piece of anatomical work was the preparation of a skeleton of a bull-frog, in his undergraduate days, his most elaborate memoir is that on the anatomy of the nervous system of the same animal (*Rana pipiens*), published in the "Smithsonian Contributions," in 1852 (51 pages, royal 4to, with 2 plates).

Anything like an analysis of this capital investigation and exposition would much overpass our limits. For, although the special task he assigns to himself is the description of the nervous system of a single Batrachian, chiefly of its peripheral portion, and of the changes undergone during metamorphosis, he is led on to the consideration of several abstruse or controverted questions; such, for instance, as the attempts that have been made to homologize the nervous system of Articulates with that of Vertebrates, upon which he has some acute criticism; the theories that have been propounded respecting the functions of the cerebellum and its relation to locomotion, which he tests in a characteristic way by a direct appeal to facts; the supposition of Cuvier that the special enlargements of the spinal cord are in proportion to the force of the respective limbs supplied therefrom; which he controverts decisively by similar appeal, an extract from which I beg leave to append in a note.*

So, in describing the structure of the optic nerves in the frog, and the development of the eye and optic lobes, he proceeds to remark, that—

"The instances of *Proteus* and *Amblyopsis* naturally suggest the questions, whether one and the same part may not combine functions wholly different in different animals, and whether the

* "If by force is meant the muscular energy and development of the limbs, this statement does not appear to be sustained in the present instance, nor in many other instances brought to notice by comparative anatomy. In man the branchial enlargement is always larger than the crural, though the legs are so much more powerfully developed than the arms, and the same is true of the greater number of mammals. In frogs there is a still greater disproportion between legs and arms, yet there is not a corresponding difference in the size of the bulgings. They cannot, therefore, be said to be in proportion to the muscular force only of the limbs, but correspond far more nearly to the acuteness of the sense of touch, which in man and mammals is more delicate in the hands and arms than in the legs and feet. In bats, it is true that the muscular force of the arms is greater than that of the legs, and that the branchial far surpasses the crural enlargement; but, at the same time, the sense of touch in the membranes of the wings is exalted to a most extraordinary degree. In birds the posterior bulging is almost universally the largest, though this condition is in part dependent upon the presence of the rhomboidal sinus. In these animals, while the muscular energy of the wings is the most developed, the sensibility of the feet is the more acute."

same may not hold true with regard to the cerebral organs which is known to obtain with regard to the skeleton, the teeth, the tongue, and the nose, that identical or homologous parts in different animals may perform functions wholly distinct. If the doctrine here suggested can be admitted (and if this were the place, facts could be cited in support of it), may we not find in it an explanation of many inconsistences which now exist between the results of comparative anatomy and of physiology?"

Then, in his chapter on the philosophical anatomy of the cranial nerves and skull, after showing that there are but three pairs of cranio-spinal nerves, he takes up the controverted question as to the number of vertebræ which compose the skull, and supports the opinion that they also are only three in a characteristic manner.*

Of this whole memoir it is thought that, notwithstanding the great advance which has been made in comparative anatomy during the twenty-five years which have elapsed since it was published, its importance to the student has not at all diminished.

Next to this in extent and value may be ranked Prof. Wyman's paper on the development of the common skate of our waters (*Raia Batis*), communicated to the American Academy in 1864, and published among its Memoirs. It gives an account of the peculiar egg-case of the Selachians, and of the several stages of the development of the embryo skate, expressed in the concise and clear language—as little technical as possible—for which he was distinguished, and leading up to not a few problems in comparative anatomy, morphology, or systematic zoology,—problems which Professor Wyman never evaded when they came directly in his way, and seldom handled without making some real contribution to their elucidation. For instance, in describing the external branchial fringes of the young skate, he notes the agreement in this character with the Batrachians; and in studying the seven branchial fissures of the embryo, he is brought into contact with the view of Huxley, that the formation of the external ear is by involution of

* "The conclusions which have been drawn from the statements made above are as follows: that in frogs the *vagus* comprises the glosso-pharyngeal and accessory nerves; that the *trigeminus* comprises the facial, the abducens, and in the salamanders the patheticus and portions of the motor communis; that other evidence sustains the hypothesis, that the whole of the motor communis is a dependence of the trigeminus; if to these we add the *hypoglossus* (which in frogs is exceptionally a spinal nerve), we shall have three pairs of cranial nerves, each having all the characters of a common spinal nerve, namely, motor and sensitive roots and a ganglion; that there are no nerves to indicate a fourth vertebra, unless the special sense nerves are considered; if these are admitted as indications, then we must presuppose either two pairs of nerves to each vertebra, or the existence of six vertebræ, which is a larger number than can be accounted for on an osteological basis. The functions and mode of development of the special sense nerves we have taken as affording sufficient grounds for considering them as of a peculiar order, and not to be classed with common spinal nerves."

the integument. After confirming the contrary observations of Reichert, on the embryo pig, he concludes that "the first of the seven branchial fissures of the embryo skate is converted into the spiracle, which is the homologue of the Eustachian tube and the outer ear-canal." After a full discussion of the homology of the upper jaw in sharks and skates, under the light afforded by his investigation of the embryo skate, he suggests that the cartilage which extends from the olfactory fossæ toward the pectoral fin is the probable homologue of a maxillary bone, and that in the lobe the homologue of an intermaxillary; that if so, the skates and proteiform reptiles agree in having the nostrils open in front of the dental arch; that while in all Batrachians the nasal groove becomes closed, in the skate it remains permanently open; and finally that this view, if confirmed, "will add another feature which justifies Owen, Agassiz and others, in dissenting from Cuvier so far as to give the Selachians a place in the zoological series higher than that of the bony fishes. But at the same time, it will give corroborative proof of the correctness of Cuvier's view, that 'the rudiments of the maxillaries, and intermaxillaries, ... are evident in the skeleton.'"

[To be continued.]

ART. XI.—*On some Points in the Geology of the Blue Ridge of Virginia;* by WM. M. FONTAINE.

[Concluded from page 22.]

MY next examination was made in the vicinity of Lynchburg, sixty miles southwest of this point. There the James River, and the canal along its banks, cut the strata nearly at right angles to their strike, thus affording unsurpassed facilities for the study of the country. In order that some idea may be had of the nature of the very considerable area lying between Charlottesville and Lynchburg, I give here a section made by Prof. Rogers, across the valley, about twenty miles northeast of Lynchburg. This is the only connected examination, so far as I know, that has ever been made across this part of the valley, which includes a belt sixty miles long and twenty wide. Of course, many variations from this section are to be expected, in such an extended area. Commencing at the western base of the Blue Ridge, at "Tye River Gap," we have—I. Sandstones and slates (Silurian), with high northwest dip; width three-quarters of a mile, extending up the mountain. II. A broad range of granitic rocks; soft, and decomposing, without stratification. These continue three miles to the summit and one mile down the east side. They contain frequent beds of epidotic granite, and a beautiful dark-gray syenite. The latter two are hard and permanent. In this space occur two bands of slaty rocks, one on the west side of the summit, and the other on the east side. That on the west side is one mile below the top, is 200 yards wide and contains gray and reddish slates, with associated greenstone-slate, sometimes amygdaloidal. Dip, moderate, southeast. The other band is half a mile below the summit on the east side. It presents repeated alternations of red and gray slates, white sandstones, and conglomerates, with a high dip, to the southeast, and a width of half a mile. Entire distance four miles. Down the east slope we find gray granitic rocks, with some bands of argillaceous slate, and toward the east have two or three dykes of *greenstone* (pinite porphyry ?). Extent four miles. III. From the last point, on the junction of the north and south forks of Tye River, the country up to two miles beyond Lovingston is mainly gneissic, with frequent beds of true granite near Lovingston. Dip, high, southeast. Extent fourteen miles. IV. Greenish chloritic granite; gneiss; and bluish mica slate. Dip, vertical. Interval occupied, three miles. This last is the position of Buffalo Ridge. V. Findlay's Mountain, one mile wide, composed of coarse quartzite. Dip vertical. After this the dip changes to northwest, and then to southeast, which it retains for a long distance as we pass east.

It will be noticed that in this section the quartzites composing the Ragged Mountains in the central portions of the valley are not found. In No. III the granite mentioned forms the most western ledges of the eruptive rocks to be described near Lynchburg. The chloritic granite is the representative, most probably, of the epidosites of the northeast. If so, this rock, which is *protogine*, is a metamorphic product from argillaceous slates. In the Catoctin Mountains, to the northeast of Lynchburg, various useful minerals occur; among which, copper ores, galena and magnetic iron may be mentioned. These may, however, be of Triassic age, as great masses of Triassic trap occur in them near these deposits.

Coming now to the vicinity of Lynchburg, and commencing with the examination of Buffalo Ridge, three miles southeast of the town, we find massive mica slates and schists composing the ridge and having the form of a closed anticlinal. No metamorphic core is present. Similar rocks occupy the whole distance up to the town. They are disposed in several rather open anticlinals. Near Mt. Athos, four miles down the river from the ridge, we find magnesian limestone associated with some quartzites, mica and talcose slates, containing deposits of magnetic and specular iron. Here occurs the curious rock called "catawbarite," by Lieber. This is an intimate mixture of talcose matter with specular and magnetic iron, containing sometimes enough of the latter to be worked as an ore.

Just opposite the town of Lynchburg occurs the most eastern of the ledges of the syenitic rock, which forms an important feature of the east and central portions of the valley. Since the section given above was made by Rogers, the railroad from Washington to Lynchburg has been made. This runs for sixty miles among these ledges, and exposes by numerous cuts their nature. One of the most striking features presented is the great amount of decay exhibited. Often cuts twenty feet deep fail to give perfectly sound material. It weathers to a rusty brown mass, presenting rounded outlines. Some ledges, however, are almost perfectly fresh. The bedding, and relation to the enclosing mica slates, are well shown both here and at Lynchburg, in the natural section presented along James River.

Returning to the latter place, we find, as we proceed up stream, numerous ledges of this rock succeeding each other at short intervals, being overlaid unconformably by mica slate, which passes occasionally into mica schist. These ledges occupy a belt extending to the west some five or six miles, but diminish in frequency westward until mica slates again occupy the entire surface. These latter continue to the distance of some ten miles from the town, when the coarse granites and syenites of "Tobacco Row," and "No Business" Mountains make their appearance.

The ledges in question often present the appearance of low dykes with rounded summits, over which the slates arch unbrokenly. Then they commonly lie in heavy layers, resembling stratified beds to a certain extent. This, however, I consider to be produced by that concentric structure so often seen in cooling masses, and which, when formed on a large scale and viewed in small segments, is easily mistaken for stratification. The rock sometimes breaks through the slates, and one ledge reverses the dip developed by its neighbor, crumpling back the slates, contorting and crushing them. The width varies greatly. I saw one ledge 600 feet wide near the town, but many are no more than 100 feet wide.

The principal component is hornblende, in pretty large crystalline particles, imbedded in a rather scanty cement of fine granular, white feldspar. This is too fine to show crystalline faces, and hence the species could not be determined. Taking the features all together, it most resembles a syenite, formed by imperfect fusion through metamorphic action on some underlying rock rich in basic compounds. Its texture is rather loose, none of the components are perfectly crystallized, or fused together, and hence perhaps the ease with which it decomposes.

The following accessory minerals occur occasionally: garnet, rutile, rubellan, pyrite.

For much of the distance above Lynchburg mica slate predominates. It shows mostly a dip south-southeast, but several reversals occur, and continue for a considerable distance. The fact is to be noted, that in this region there is no constancy of dip indicating a great succession of closed folds. The mountains some ten miles above Lynchburg, containing the granites and syenites of the central parts of the valley, I had no opportunity to examine. From hand specimens obtained, the granite is an exceedingly coarse-grained, rough-looking rock, composed principally of quartz, with a smaller amount of black mica and white orthoclase. The mica has a tendency to aggregate into lumps, so as to give the rock a rather singular aspect, the white ground of the quartz and feldspar being marked with black spots, sometimes of large size. These rocks are to be regarded as forming one system with the syenites at Lynchburg, as is shown in the cuttings along the railroad, which runs through them in the valley.

My detailed examination was resumed on James River, about three miles from where it issues from the east base of the Blue Ridge. The ridge here is a composite one, being formed of several parallel chains; those on the east being composed of crystalline rocks, and those on the west of Silurian strata. The foot hills on the east often rival in height the main chain.

The first rock seen here is a mica schist, with a dip 30° northwest. This on the west is succeeded by a mass of gneiss 900 feet wide, apparently intruded among the slates. Its dip is so confused by vertical joints that I could not make it out. The composition is principally of uncrystallized feldspar, dark mica in fine lines, and quartz distributed in numberless seams of almost microscopic fineness, showing that the rock is highly altered. This is succeeded by a narrow band of mica slate, dipping southeast, toward the gneiss. The slate is succeeded by a wide belt of coarse syenitic rock, which forms some of the highest foot hills of the ridge here. This rock extends for a half mile, and is overlaid unconformably by mica slates and schists, through which it has evidently been protruded. It is a massive coarse-grained rock, composed principally of red feldspar (orthoclase), quartz, and a smaller amount of hornblende. None of the constituents are well crystallized, or distinctly segregated. The feldspar forms large particles and the hornblende shows a tendency to arrange itself in irregular patches and lines. Some greenish feldspar occurs. The junction with the slates on the west side well shows the relation of the two systems. The slates lean upon the syenite with a dip of 45° to the northwest, showing a sharply distinct line of contact. This mass is plainly an outlier of a larger body of similar rock, which is to be found in the main mountain just west of it. The slates and schists continue 200 yards, when they are thrown into a gentle arch by the protrusion of a ledge of pinite porphyry, 300 feet wide. This in all respects resembles the rock at Harper's Ferry. It occupies here the same position relative to the Silurian strata, being about three miles distant from them. After an interval of 150 yards of slate, we have a second outcrop of pinite porphyry, in a ledge about eighty feet wide. This is followed by several hundred yards of mica slates, showing a moderate southeast dip. For some distance the rock is concealed, and then we have about 400 yards of argillites, the first appearance of this rock on this section. These slates do not have the heavy bedding and chloritic composition of those described farther north, but are thinly laminated and cleave well. Their western edge is thrown into a crushed anticlinal, changing from a previous dip to the southeast. This is caused by the appearance of an extensive ledge of pinite porphyry about 600 feet wide. Succeeding this we have a belt of mica slate, about half a mile wide, extending to the crystalline massive rock of the main ridge. These latter slates dip high to the southeast, being almost vertical and regulated in dip and strike by the course of the massive rock of the Blue Ridge. These dips given as southeast are more properly south-southeast and even south in some places, according to the curves of the crystalline mass which determines the position of the main chain.

A few hundred feet from the main mountain we see a ledge of highly-altered quartzite, about forty feet wide, reaching over toward the ridge. This rock is significant, for it resembles a highly indurated form of the Silurian quartzites, which are to be seen on the opposite side, arching over with a reversed dip to meet it. This ledge, however, is much thinner than the Silurian strata, and is impregnated with chlorite and epidote in places, having its texture perfectly compact. The slates between it and the syenite are much altered, being cut by joints, and having lost their slaty cleavage. They are also impregnated with siliceous and ferruginous matters, causing them to assume a red color on weathering. Their edges, viewed across the chasm cut by the stream, show this change very strikingly. They are seen to arch over the east slope of the crystalline rock in the form of a shell.

Passing through the gorge cut by the river in the most eastern of the principal elevations, we find that the river skirts its west base for a short distance. Turning here so as to front this mountain from the west, we see that its entire face, for more than 1,000 feet, is composed of a rugged, precipitous mass of unstratified crystalline rocks, while a band of reddish rocks, eighty or one hundred feet thick, show their edges skirting the summit. This band is the west edge of the slates which were seen resting on the mountain along the east side.

The Blue Ridge in this part of the State is, as stated before, composed of several parallel ranges of nearly equal height. The one just mentioned is composed of a species of coarse syenite, while the other ranges more to the west are made up of the durable quartzites which here form the Lower Silurian strata.

The entire zone of crystalline, massive rocks here seen is about one mile wide. The most eastern portion, composing the main ridge just described, is a rock in all respects like the coarse syenite mentioned as composing the foot hills farther east. It is truly a protean rock. No two hand specimens will show exactly similar physical features, although the essential constituents are pretty constant. Red orthoclase, in coarse, badly crystallized particles, forms the chief component, but white and green feldspar of the same species also occur. Quartz is next in abundance. The hornblende, which is scanty in amount, never forms distinct crystals. Rutile not well segregated, and films of hematitic matter, are also seen. For some distance next to the slates, on the east, the rock has the fine, well-crystallized texture of a diorite. We have here without doubt an eruption of true igneous rock along the line of junction of the two systems, an occurrence not uncommon.

On the west side we see at the base of the main mass a ledge about 100 feet wide, of a rock of similar composition with the coarse syenite, but of much finer texture; it being in some parts almost compact, and impregnated in spots with chlorite and epidote, so as to give it a bright green color. This again seems to be a modification produced by its position on the border of the principal mass. West of it, the rock changes again, and for about 1,200 feet we have a variety of syenite of fine and more uniform texture, in which the minerals are more individualized, and better crystallized. This extends up to the Lower Silurian strata, which rest against it with a steep northwest dip, the lower beds being so much altered as entirely to lose their characteristic features. This portion of the syenite betrays its more durable character by presenting extensive ledges in the bed of the river, while the coarse rock to the east has been worn down almost entirely. I consider this to be the equivalent of the peculiar syenite to be described as occurring at the Peaks of Otter.

My next examination was made twenty-five miles to the southwest, along a line ten miles in length, extending westward, from Liberty in Bedford County to the Peaks of Otter.

The Catoctin Mountains, as cut by the extension of this line, do not form a continuous range. In its stead, we have isolated elevations, composed of ribs of quartzite standing nearly vertical. To the west of Liberty, for four or five miles, we have mica schists and hornblende schists, much decayed and eroded. Succeeding these come hornblende schists, presenting the same character, and all with moderate southeast dip. On reaching "Big Otter Creek," about two and a half miles from the Blue Ridge, we see a ledge of protogine, showing a width of 600 feet. This has thrown off the hornblende schist nearly vertically to the southeast. This rock, which from its position is the equivalent of the pinite porphyry, is composed of quartz, dull white feldspar, and talc, arranged with granitoid texture. The quartz often appears in shot-like lumps, and sometimes shows quite large irregular masses. It presents in this condition a peculiar sky-blue color and waxy luster. There can be no doubt, I think, that it is the same mass which appears farther north as pinite porphyry, but here like most of the rocks of this region, from more complete metamorphism, having assumed more of the character of a true igneous rock.

Next to this, on the west, we have a belt a quarter of a mile wide of heavy-bedded mica schist, which passes into a bedded syenite or hornblende rock. The exposures here are bad, and the passage from one rock to another cannot be traced, for the surface of all these rocks is much decayed and concealed by clay. Dip of both southeast. This syenite is composed of well segregated hornblende, in large crystals, combined with large crystals of a yellowish-white feldspar, too much decayed to show its true character, but apparently triclinic. This rock is succeeded by a wide belt of massive syenite, which is more igneous-looking in its durability, want of bedding, and apparent protrusion. The latter contains white orthoclase, much hornblende and a little quartz. This extensive belt reaches to within half a mile of the main mountain. It is here succeeded by a very coarse syenite, which exactly resembles that described at Balcony Falls, in the preceding section, with the exception that the red feldspar, which principally composes it, shows distinct cleavage. This extends to within a few hundred yards of the base of the mountain. The interval is occupied by a valley, in which a stream flows, whose alluvial deposits, combined with the vast quantity of transported boulders, conceal the rock. It is apparently the same with the preceding, for the principal mass of the mountain which rises from the valley is composed of the same coarse syenite, showing, however a considerable proportion of white triclinic feldspar. The topography of the locality presents some noteworthy features.

The Blue Ridge is here again a single chain, composed entirely of crystalline rock. There are no considerable hills lying to the east of the main ridge. This latter rises immediately from the valley mentioned, with a rounded, gently swelling slope, bare of surface-earth, but covered profusely with immense boulders derived from the mass composing the Peaks proper.

After attaining the summit of the slope, we find ourselves on a level with a valley lying to the west. This lies along the foot of a chain of mountains situated farther west, which rivals the Blue Ridge in height, and is composed of Silurian strata. The summit of the slope is about 1500 feet above the valley on the east.

On each side of this point rises abruptly a mountain 1600 feet above the pass. That on the right, composed of the same rock with the one on the left, is not an isolated peak, but it is the end of a great mass of mountains which extend northeast as far as the eye can reach, and even surpass in height this *peak*. The elevation on the left, which, with the one just mentioned, forms the Peaks of Otter, is an isolated eminence. It stands up abruptly from the coarse syenitic mass forming its base, like a huge chimney, showing by its bare, abrupt faces, that it is composed of different material from the softly rounded, well-worn base on which it stands. In ascending it we find the coarse syenite accompanying us to within 600 feet of the top of the crag, which forms the highest point. This would seem to indicate that in the pass at least 1000 feet of the older coarse rock has been scooped out, for the two peaks facing each other present similar features. To the southwest, the great elevation seen at the Peaks is soon lost. There the crystalline mass rapidly sinks down into several low finger-like spurs, and farther on no elevation which can be called a mountain occurs. The Virginia and Tennessee railroad passes the Blue Ridge at Buford's Gap without tunnelling, and by moderate grades. In this region, as Rogers has stated, the Silurian range to the west is called the Blue Ridge.

The following then is the structure of the mountain at the Peaks. The main mountain rises in the form of a broad, softly-rounded ridge, composed of coarse syenites, like those described at the east base, and like the rocks on James River west of Lynchburg. From this, as a base, rises abruptly on the west side near the east limit of the Silurian strata, a broad ledge of a totally different rock, which will be presently described. To this latter mass, which is about 900 feet wide, the mountains owe their additional height of 1600 feet.

Many peculiar features of erosion and the transport of matter occur, to adequately describe which too much space would be required. These can best be explained by assuming the action of ice through this gap. In passing over the coarse decomposing syenites, which form the lower part of the mountain, we see several ledges of a much more crystalline rock penetrating them. This, which has all the characters of a true igneous substance, has made its exit principally on the west side, in the broad ledge which forms the two Peaks. It is a dark, greenish rock, very tough, and exceedingly durable. This furnishes the boulders which cover the east slopes. As the more easily decomposing, supporting framework of coarse syenite crumbled away, this more durable substance fell, and made its way down the gradual slope, perhaps aided by ice.

It is composed principally of a peculiar orthoclase of a sea-green color. This by its predominance gives a green color to the entire rock. The other constituent is a granular mixture of hornblende with a notable amount of magnetic iron. All the constituents are well crystallized, and show brilliant cleavage faces. Sometimes the feldspar occurs in quite large masses. Its crystals are always much larger than those of the hornblende and magnetic iron. Some pyrite is present. From some trials, I am inclined to think that the green color of the feldspar is due to finely disseminated hornblende. It is plainly a true igneous rock, of later date than the coarse syenites This then would be a true eruptive syenite, whose emission may have aided in producing the great disturbances seen in the Lower Silurian here and elsewhere in the State.

This belt of rocks passes out of Virginia into North Carolina, and is there continued in the broad area marked by Kerr as Upper Laurentian, in his map of that State. I will defer any remarks on the age of the different rocks here presented until after the presentation of some facts gathered from the study of the Silurian strata which join them, for these have an important bearing on this question.

In this article I have devoted most space to the geological structure of the two mountain chains and to the massive crystalline rocks, since my object in making the examination was to discover whether any igneous rocks existed in them, and, if so, to determine the part they played in their structure.

Morgantown, West Virginia, Oct. 16th.

ART. XII.—*Notice of the Chemical and Geological Essays of T. S. Hunt;** by JAMES D. DANA.

MR. HUNT has brought together, in this volume of Essays, various memoirs which have been published by him in this Journal and elsewhere. The chemical papers are important contributions to science, and show that the author was among the first to appreciate the principles which lie at the basis of what is called modern chemistry. He further applied the principles to the department of mineralogy; and in the view which he presented in 1859 with regard to the molecular relations of the feldspars, he appears to have anticipated Tschermak by ten years. The chapters on chemical geology contain much that is valuable, though not all original, on the origin of igneous and metamorphic rocks, of dolomite and gypsum, of volcanoes, of mountains, and on other topics, yet coupled with opinions, of fundamental importance, especially with reference to the making of mountains, metamorphism and the origin of some kinds of rocks, which science, we think, will never sustain. There is an important chapter on "Bitumen and Pyroschists," † pointing out the relations in chemical constitution between mineral oil and certain vegetable and animal tissues, and throwing light on the origin of the oil. The memoir on the Chemistry of Natural waters is well worthy of study. Another, on the Cambrian and Silurian in North America, is an important historical document—although failing to show that any good would come from separating the Primordial group from the Silurian and calling it Cambrian, when, so far as the fauna and stratification go, there is the closest relation between it and the overlying beds.

The reader of the volume will observe that in the Third Chapter the White Mountain series and Green Mountain series of rocks are made (as had been done by other geologists) Lower Silurian, and Upper Silurian and Devonian, in age, while in the Thirteenth Chapter (as also mentioned in the preface to Chapter III), both are pronounced pre-Silurian. In this, the older view, as I believe I have proved, is the one sustained by the facts. The new view is wholly speculative, being based on no careful stratigraphical study of the regions, but mainly upon the assumption that certain kinds of crystalline rocks are a test of geological age the world over. Since the first announcement of this doctrine by Mr. Hunt, I have spent many months in the

* Chemical and Geological Essays, By Thomas Sterry Hunt, LL.D. 490 pp. 8vo. Boston. 1875. (James R. Osgood & Co.)

† Mr. Hunt's convenient term "pyroschists," applied to shales containing carbonaceous material, is objectionable in that the rocks are shales and not schists; and on this account I have not adopted it in my Geology.

study of the Green Mountain rocks and those of some other parts of New England, in order to ascertain whether there is any virtue in the criterion; and I have found none. Mr. Hunt makes staurolite evidence of pre-Silurian age; while, as I have shown, its crystals occur in crystalline rocks of New England that are not older than Upper Silurian. Such erroneous conclusions make it apparent that in reading the work the judgment should be held in reserve until the other side is heard.

There is also another more serious reason for this reserve. For the volume contains a series of misrepresentations of the views of others wholly unnecessary to the presentation of the author's opinions, and difficult to find excuse for. These misstatements have already been the occasion of various corrections by the writer in this Journal. But, as they are now reproduced, and with additions, a few further words have become necessary.

The controversy between us, which Mr. Hunt here details so far as his side is concerned, relates chiefly to the misrepresentations of my views, as well as those of others, which are contained in his Address before the American Association in 1871, making Chapter XIII of his volume of Essays.

After many years of labor for the progress of truth, it was not a little disappointing to find myself made accountable for views I did not hold, and have them denounced as "sophistries" and "contrary jargon," even though placed under this condemnation in the good company of Gustaf Rose, Haidinger and "many others," all equally innocent of them.* Soon after receiving a copy of the Address, in the autumn of 1871, I informed Mr. Hunt of the incorrectness of his statements in long friendly letters. Obtaining no satisfaction in this, I published my review of his Address in this Journal early in 1872,† and in it denied that I entertained the views he had attributed to me, referring him to my Geology for evidence. Mr. Hunt, notwithstanding my disavowal, repeated the charges in a reply, rejecting the Geology as evidence;‡ and as a specimen of his reasoning, and his way of treating facts, I cite the following from my rejoinder:§

"Mr. Hunt's most extraordinary feat is his making out that the writer has virtually sustained the view of the *metamorphosis of granite or gneiss to limestone*, when, as I said before, it is an idea that never entered my head until the reading of Mr. Hunt's caricature of the subject. The proof which he gives is remarkable. In the first place, he says that my Mineralogy contains the fact that calcite is sometimes found pseudomorphous after quartz; and, in another place, the fact that calcite is found pseudomorphous after feldspar. Hence the conclusion, *granite or gneiss to limestone.* Q. E. D.

* Essays, p. 287. † This Journ., III, iii, 86, 1872. ‡ Ib., iv, 41, 1872. § Ib., iv, 97.

Now, if the facts respecting the pseudomorphs *were facts*, it would still require great constructive powers to make out from the statements the conclusion that I ever held to the 'metamorphosis of granite or gneiss into limestone.' But, as to the facts: (1) The Mineralogy *does not* mention any case of the pseudomorphism of calcite after quartz; and (2) the pseudomorphs of calcite after feldspar are spoken of as examples, not of an *alteration* of the feldspar, but of its removal and the substitution of calcite (4th edit., p. 249, and also 5th edit., p. 361). Now, by this substitution process, the above mentioned metamorphosis would consist (*supposing* fact No. 1 to be a fact, and that mica crystals may be similarly changed to calcite, which Mr. Hunt omits to include) in a removal of all the materials of the granite by a process of solution, and the cotemporaneous or subsequent substitution of calcite!

All will admit that the use of facts and not-facts exhibited in the above charge is most extraordinary; and can judge from it, and from other like cases stated, of Mr. Hunt's ability to appreciate, or do justice to, the views of others."

During the past year he has repeated anew his assertions, in a note before the Boston Natural History Society;* and to this I gave a brief denial in the last volume of this Journal on pages 221, 222.

Among the various other persons persistently misrepresented by him, no one has been more grossly so than the late Dr. Naumann. Mr. Hunt claimed in his Address that Naumann agreed with him in his doctrine that pseudomorphism in the case of certain silicates was simply "envelopment." I showed, by a direct citation of facts from Naumann's work on Mineralogy, that he held, on the contrary, the views of the men Mr. Hunt had denounced, and I proved that the letter from Naumann to Delesse, which Mr. Hunt cited to sustain his opinion, did not refer at all to the point in question. (See page 91 of vol. iii, 1872, of this Journal.) Naumann sustained my statement in an indignant note to the *Jahrbuch für Mineralogie*, of which the following is a translation:

Dresden, November 17, 1872.

Professor Sterry Hunt, in his Address before the American Association of the 16th of August, 1871, has quoted extracts of a letter of mine to Delesse, which were printed in the *Bulletin de la Société Géologique*, vol. xviii, p. 678 of the Second Series, and which seem to show that my views agree with his theory of the formation of serpentine and the allied rocks.

It is certainly true that in that letter I have expressed myself satisfied with this: that my friend Delesse, in his Treatise (*Recherches sur les Pseudomorphoses*, *Ann. des Mines*, V, xvi, 317, et seq.), has separated many examples of what are really cases merely of

* Proceedings for 1874, p. 334.

regular envelopment, (*enveloppemens avec orientation*) from the *pseudomorphs* with which, although having nothing in common with them, they had been associated. In connection, I took occasion to remark that it seemed to me an *analogous* error, when *all* gneisses, amphibolites, and so on, are regarded as metamorphic and not originally-formed rocks; and that the confounding of the two ideas of pseudomorphism and metamorphism has had many unfortunate results; and further that I recognize as pseudomorphs only those cases in which the form of the altered crystal is still retained. The mixture or mutual envelopment of two minerals is generally due indeed to simultaneous crystallization; and yet there are cases of envelopment which may be regarded as pseudomorphs, provided the form of the enveloped crystal is still recognizable.

Although I have several times opposed the exaggerated use of the doctrine of metamorphism, yet it is still incomprehensible to me how Professor Sterry Hunt can consider the portions of my letter to Delesse, quoted by him, as proofs that I regard those cases of pseudomorphism, upon which the theory of metamorphism is based, as for the most part only examples of association and envelopment as well as results of a simultaneous and original crystallization, or that this view of mine is identical with that proposed by himself in the year 1853.*

Nothing but an incomprehensible misunderstanding can explain such an opinion, which, moreover, has been already sufficiently disposed of by Dana in the American Journal of Science for February and August of 1872. CARL NAUMANN.

In Mr. Hunt's new book that letter to Delesse is again appealed to, to show that Naumann holds what he rejects, and what every one who is acquainted with his Mineralogy knows that he has never held; for the work does not contain a word on "envelopment" in the chapter on Pseudomorphism, and both in that chapter and elsewhere he presents the ordinarily accepted view. Naumann's note to the *Jahrbuch* was not called out by anything I had written him; I never addressed a letter on the subject to anyone in Europe.

Mr. Hunt endeavors to make out that Naumann knew the contents of his Address only through my "misleading criticisms," and that therefore his letter is not to be taken as meaning what it says. But Naumann, after giving his view of his own letter, is equally precise in his statement of Mr. Hunt's doctrine. Moreover, Naumann shows that he *did* have Mr. Hunt's writings before him; for he refers to Mr. Hunt's views in "1853," as quoted

*The sentence of Mr. Hunt's, published in 1853, which is here referred to, is as follows: "The generally admitted notions of pseudomorphism seem to have originated in a too exclusive plutonism, and require such varied hypotheses to explain the different cases that we are led to seek for some more simple explanation, and to find it, in many instances, in the association and crystallizing together of homologous and isomorphous species."—*Am. J. Sci.*, II, xvi, 218.—EDS.

in his Address, (see foot-note to the preceding page,) to which date or citation I have at no time until now made any allusion; and the fact that Mr. Hunt, as he admits, omitted part of the letter, is sufficient to explain Naumann's reference to *extracts*, if it be not also true that only *extracts* were published in the *Annales des Mines.* Naumann was too thorough, accurate, and conscientious a man in all his scientific work to have written that criticism of Mr. Hunt without having read carefully Mr. Hunt's writings on the subject. "There is a confusion, not to say contradiction, in these expressed views of the venerable teacher not easy to explain,"* if we take Mr. Hunt as our expositor. But all is clear enough in the words and the works of Naumann.

Mr. Hunt, in his new volume, instead of offering an apology for his misrepresentations, gives the following excuse for his course:

"Nothing has been further from my intention than to misrepresent the views either of Naumann or of Dana; and my error, if I have fallen into one, arises from the difficulty of knowing their real opinions upon the matters in discussion. Let Professor Dana define, as clearly as I have done, his present views as to the origin of magnesian rocks, both those made up of chrysolite and pyroxenic minerals, and those composed of serpentine, steatite and chlorite, which he has supposed to come from an epigenesis of the former; let him tell us whether he holds the doctrine of pseudomorphic metamorphism which he taught in 1845, 1854 and 1858, and which, as I have shown, was held by Delesse as late as 1857, or that doctrine so long maintained by me, which the latter adopted in 1861. Such a definition would be eminently satisfactory to those who look to him as a teacher in science, and would prevent any further misconception or unintentional misrepresentation of his views."

Such questions, after all that I have written on the subjects mentioned, are strangely out of place, and wrong in their implications; for I have expressly stated my present relation to the views I held in 1845, 1854 and 1858, *in my Notices of his Address;* and the difficulty complained of in the opening part of the paragraph is, as shown beyond, wholly a subjective one.

When I referred Mr. Hunt for my present opinions to my Manual of Geology (published in 1862), where they are drawn out at length, and denied that I held, or the book contained, the doctrine that "metamorphism was pseudomorphism on a broad scale," and did the same again in my rejoinder, I supposed that I had been as explicit as possible; and yet I am asked to make another assertion on the subject. In both of my notices of Mr. Hunt's Address (see the citations beyond,) I have stated

* Hunt's Essays, p. 323.

that I had regarded serpentine and some other hydrous magnesian rocks as examples of pseudomorphism on a broad scale, but I have not since 1858 made the principle a general one, or applied it to any other rocks. That statement occurs only in a book-notice in 1858.*

With regard to magnesian rocks, I have stated my views in my first notice of his Address. Again, in my rejoinder to his reply, in August, 1872 (this Journ., III, iv, 103) I observe as follows, after a mention of various facts:

"In view of such facts, the writer still holds, as in 1845, that—

* * * "The same causes that have originated the steatitic scapolites, occasionally picked out of the rocks, have given magnesia to whole rock-formations, and altered throughout their physical and chemical characters. If it be true that the crystals of serpentine are pseudomorphous crystals, altered from chrysolite, it is also true, as Breithaupt has suggested, that the beds of serpentine containing them are likewise altered; though often covering square leagues in extent, and common in most primary formations. The beds of steatite, the still more extensive talcose formations, contain everywhere evidence of the same agents."—*This Journ.*, xlviii, 92, 1845.

"Besides this paragraph, expressive of my views, Mr. Hunt cites also another of the same purport from my Mineralogy of 1854, and in this, also, I see little to modify. It is as follows: that—

"The various examples of pseudomorphism should be understood as cases not simply of alteration of crystals, but in many instances of changes in beds of rock. [Delesse admits this; see p. 99.] Thus all *serpentine*, whether in mountain-masses, or the simple crystal, has been formed through a process of pseudomorphism, or in more general language, of metamorphism; the same is true of *other magnesian* rocks, as steatitic, talcose or chloritic slates.† Thus the subject of metamorphism, as it bears on all crystalline rocks, and of pseudomorphism, are but branches of one system of phenomena."—*Min.*, *4th edit.*, i, 226, 1854.

These statements respecting hydrous magnesian rocks ought to be considered clear and satisfactory; for besides declaring my present relation to the views I had expressed in 1845, 1854 and 1858, I stated, with regard to the origin of these rocks, all that I thought to be warranted in the existing state of the science. I have nowhere attempted an explanation of the precise chemical processes in the production of magnesian rocks, while Mr. Hunt has; but I fully believe that his very clear expositions of the subject, which he presents to me as a model, will prove to be almost worthless when the "real" facts are better understood. Believing much in facts, I have been studying the subject the past year; and the observations which I have made at Brewster, New York, and which are published in the last volume of this

* Amer. Journ. Sci., II, xxv, 445. That the expression was a hasty one on my part is evident from the entire rejection of the opinion from my Geology, which was written in 1859 and 1862, and the additional fact that when I read it in Mr. Hunt's Address I could not at first believe that I was its author, and again and again hunted for it before I found it.

† I would now remove from this list talcose slate, as it has been shown to be mostly hydromica slate, and also chloritic slate, which is an ordinary metamorphic rock.

Journal (see pages 371 and 477) enable us to move a step forward, and, at the same time, leave little room for doubt with regard to the small value of Mr. Hunt's speculations.*

I had no occasion to speak of the origin of chrysolite rocks, nor do I now see that it was necessary. Such rocks are known to be very common among the oldest terranes of the globe, so that this material for making serpentine was then abundantly supplied. Chrysolite rocks and chrysolite altered to serpentine, as Genth has shown, occur in North Carolina "on a broad scale." Hornblende and pyroxene rocks are ordinary metamorphic rocks. A very pure hornblende rock of great thickness occurs in the Helderberg formation of the Connecticut Valley, in Bernardston, Massachusetts, and Vernon, Vermont.

Mr. Hunt keeps up his misrepresentations even when he is saying that "nothing is further from my intention than to misrepresent the views either of Naumann or of Dana." His plea (in the very next sentence to this one about his "intention,") as to the "difficulty of knowing their real opinions upon the matters in discussion" is a subterfuge that can do him no service. Mr. Hunt's persistent neglect to look into the works of Naumann for his opinion on the point in dispute, or to refer to them in any way, is a natural source for the difficulty he complains of. His singular refusal to take my Manual of Geology as evidence with regard to my views since 1862 is also a positive source of difficulty. But difficulty from such sources is no excuse. It may be said that the words "difficulty of knowing their real opinions upon the matters in discussion," referred especially to *one* question—the chemical process in the formation of magnesian rocks. But, as regards Naumann, this question has not been in discussion; and, besides, the expression admits of no such restriction.

In order that the absurdity of the claim of "difficulty" may be still better appreciated, and to prevent, if possible, its repetition, I here state that—

I have never held, and my writings no where sustain, the following opinions which Mr. Hunt has attributed to me and others :—

1. The "possibility of converting almost any silicate into any other."
2. The possibility of converting granite into limestone.
3. The possibility of converting gneiss into limestone.
4. The possibility of converting diorite into limestone.

* Mr. Hunt, in his hypothesis, attributes the origin of beds of serpentine and steatite to the alteration of chemically-deposited beds of different hydrous magnesian silicates related to meerschaum. Serpentine occurs of various ages, and is even found in Cretaceous rocks in California, as shown by Whitney. Certainly if serpentine had been made from the alteration of beds of hydrous magnesian silicates, such beds should now exist somewhere in the *unaltered* strata between the Archæan and Cretaceous; and yet they do not.

5. The possibility of converting granite into serpentine.
6. The possibility of converting granulite into serpentine.
7. The possibility of converting gneiss into serpentine.
8. The possibility of converting diorite into serpentine.
9. The possibility of converting limestone into granite.
10. The possibility of converting limestone into gneiss.

Again, with the exception of the year 1858, I have never held nor taught that metamorphism is pseudomorphism on a broad scale. My Geology gives a very different definition of metamorphism.

I regret that I have been compelled to return to this unpleasant subject. Charged with holding views which I did not entertain, it became a duty to the cause of scientific truth to put in a disclaimer. And now that Mr. Hunt's misstatements have been given new currency by a republication of them, with additions, in his volume of Essays, and since his repeated assertions have led to my being quoted for the views attributed to me, a new explanation and denial seemed to be demanded.

The case is a strange one in the annals of science. Four years have not sufficed to secure a recognition of the facts. Any other person, with hardly an exception, if he had had my denial, and had been referred to publications of mine that gave my views and fully sustained the denial, would have accepted the statement, and made a public correction. The misrepresentations are a blot on the volume of Essays, and one which might have easily been avoided.

Art. XIII.—*Do Varieties wear out, or tend to wear out?* By Professor Asa Gray.

The following article was published in the N. Y. Tribune, (the Semi-weekly, of Dec. 8,) in response to some questions referred to the author. Although cast in a popular form, for general readers, we deem it well worthy of reproduction in this Journal.—Eds.

This question has been argued from time to time for more than half a century, and is far from being settled yet. Indeed, it is not to be settled either way so easily as is sometimes thought. The result of a prolonged and rather lively discussion of the topic about forty years ago in England, in which Lindley bore a leading part on the negative side, was, if we rightly remember, that the nays had the best of the argument. The deniers could fairly well explain away the facts adduced by the other side, and evade the force of the reasons then assigned to prove that varieties were bound to die out in the course of time. But if the case were fully re-argued now, it is by no means certain that the nays would win it. The most they could expect would be the Scotch verdict, "not proven." And this not because much, if any, additional evidence of the actual wearing out of any variety has turned up since, but because a presumption has been raised under which the evidence would take a bias the other way. There is now in the minds of scientific men some reason to expect that certain varieties would die out in the long run, and this might have an important influence upon the interpretation of the facts that would be brought forward. Curiously enough, however, the recent discussions to which our attention has been called seem, on both sides, to have overlooked this matter.

But, first of all, the question needs to be more specifically stated if any good is to come from a discussion of it. There are varieties and varieties. They may, some of them, disappear or deteriorate, but yet not wear out— not come to an end from any inherent cause. One might even say, the younger they are the less the chance of survival unless well cared for. They may be smothered out by the adverse force of superior numbers; they are even more likely to be bred out of existence by unprevented cross-fertilization, or to disappear from mere change of fashion. The question, however, is not so much about reversion to an ancestral state, or the falling off of a high-bred stock into an inferior condition. Of such cases it is enough to say that, when a variety or strain, of animal or vegetable, is led up to unusual fecundity or of size or product of any organ, for our good, and not for the good of the plant or animal itself, it can be kept so only by high feeding and exceptional care; and that with high feeding and artificial appliances come vastly increased liability to disease, which may practically annihilate the race. But then the race, like the bursted boiler, could not be said to wear out, while if left to ordinary conditions, and allowed to degenerate back into a more natural, if less useful state, its hold on life would evidently be increased rather than diminished.

As to natural varieties or races under normal conditions, sexually propagated, it could readily be shown that they are neither more nor less likely to disappear from any inherent cause than the species from which they originated. Whether species wear out, i. e., have their rise, culmination, and decline from any inherent cause, is wholly a geological and very speculative problem, upon which, indeed, only vague conjectures can be offered. The matter actually under discussion concerns cultivated domesticated varieties only, and, as to plants, is covered by two questions.

First, *will races propagated by seed*, being so fixed that they come true to seed, and purely bred, (not crossed with any other sort,) continue so indefinitely, or *will they run out in time*—not die out, perhaps, but lose their distinguishing characters? Upon this, all we are able to say is that we know no reason why they should wear out or deteriorate from any inherent cause. The transient existence or the deterioration and disappearance of many such races are sufficiently accounted for otherwise; as in the case of extraordinarily exuberant varieties, such as mammoth fruits or roots, by increased liability to disease, already adverted to, or by the failure of the high feeding they demand. A common cause, in ordinary cases, is cross-breeding, through the agency of wind or insects, which is difficult to guard against. Or they go out of fashion and are superseded by others thought to be better, and so the old ones disappear.

Or, finally, they may revert to an ancestral form. As offspring tend to resemble grand-parents almost as much as parents, and as a line of close-bred ancestry is generally prepotent, so newly originated varieties have always a tendency to reversion. This is pretty sure to show itself in some of the progeny of the earlier generations, and the breeder has to guard against it by rigid selection. But the older the variety is—that is, the longer the series of generations in which it has come true from seed—the less the chance of reversion: for now, to be like the immediate parents, is also to be like a long line of ancestry; and so all the influences concerned—that is, both parental and ancestral heritability—act in one and the same direction. So, since the older a race is the more reason it has to continue true, the presumption of the unlimited permanence of old races is very strong.

Of course the race itself may give off new varieties: but that is no interference with the vitality of the original stock. If some of the new varieties supplant the old, that will not be because the unvaried stock is worn out or decrepit with age, but because in wild nature the newer forms are better adapted to the surroundings, or, under man's care, better adapted to his wants or fancies.

The second question, and one upon which the discussion about the wearing out of varieties generally turns, is, *Will varieties propagated from buds, i. e., by division, grafts, bulbs, tubers and the like, necessarily deteriorate and die out?* First, Do they die out as a matter of fact? Upon this, the testimony has all along been conflicting. Andrew Knight was sure that they do, and there could hardly be a more trustworthy witness.

"The fact," he says, fifty years ago, "that certain varieties of some species of fruit which have been long cultivated cannot now be made to grow in the same soils and under the same mode of management, which was a century ago so perfectly successful, is placed beyond the reach of controversy. Every experiment which seemed to afford the slightest prospect of success was tried by myself and others to propagate the old varieties of the apple and pear which formerly constituted the orchards of Herefordshire, without a single healthy or efficient tree having been obtained; and I believe all attempts to propagate these varieties have, during some years, wholly ceased to be made."

To this it was replied, in that and the next generation, that cultivated vines have been transmitted by perpetual division from the time of the Romans, and that several of the sorts, still prized and prolific, are well identified, among them the ancient Græcula, considered to be the modern Corinth or Currant grape, which has immemorially been seedless; that the old Nonpariel apple was known in the time of Queen Elizabeth; that the White Beurré pears of France have been propagated from the earliest times; and that Golden Pippins, St. Michael pears, and others said to have run out, were still to be had in good condition.

Coming down to the present year, a glance through the proceedings of pomological societies, and the debates of farmers' clubs, brings out the same difference of opinion. The testimony is nearly equally divided. Perhaps the larger number speak of the deterioration and failure of particular old sorts; but when the question turns on "wearing out," the positive evidence of vigorous trees and sound fruits is most telling. A little positive testimony outweighs a good deal of negative. This cannot readily be explained away, while the failures may be, by exhaustion of soil, incoming of disease, or alteration of climate or circumstances. On the other hand, it may be urged that, if a variety of this sort is fated to become decrepit and die out, it is not bound to die out all at once, and every where at the same time. It would be expected first to give way wherever it is weakest, from whatever cause. This consideration has an important bearing upon the final question, are old varieties of this kind on the way to die out on account of their age or any inherent limit of vitality?

Here, again, Mr. Knight took an extreme view. In his essay in the Philosophical Transactions, published in the year 1810, he propounded the theory, not merely of a natural limit to varieties from grafts and cuttings, but even that they would not survive the natural term of the life of the seedling trees from which they were originally taken. Whatever may have been his view of the natural term of the life of a tree, and of a cutting being merely a part of the individual that produced it, there is no doubt that he laid himself open to the effective replies which were made from all sides at the time, and have lost none of their force since. Weeping willows, bread-fruits, bananas, sugar-cane, tiger-lilies, Jerusalem artichokes, and the like, have been propagated for a long while in this way, without evident decadence.

Moreover, the analogy upon which his hypothesis is founded will not hold. Whether or not one adopts the present writer's conception, that individuality is not actually reached or maintained in the vegetable world, it is clear enough that a common plant or tree is not an individual in the sense that a horse or man, or any one of the higher animals, is—that it is an individual only in the sense that a branching zoophyte or mass of coral is. *Solvitur crescendo:* the tree and the branch equally demonstrate that they are not individuals, by being divided with impunity and advantage, with no loss of life, but much increase. It looks odd enough to see a writer like Mr. Sisley reproducing the old hypothesis in so bare a form as this: "I am prepared to maintain that varieties are individuals, and that as they are born they must die, like other individuals." "We know that oaks, Sequoias and other trees live several centuries, but how many we do not exactly know. But that they must die, no one in his senses will dispute." Now what people in their senses do dispute is, not that the tree will die, but that other trees, established from cuttings of it, will die with it.

But does it follow from this that non-sexually propagated varieties are endowed with the same power of unlimited duration that are possessed by varieties and species propagated sexually—i. e., by seed? Those who think so jump too soon at their conclusion. For, as to the facts, it is not enough to point out the diseases or the trouble in the soil or the atmosphere to which certain old fruits are succumbing, nor to prove that a parasitic fungus (*Peronospora infestans*) is what is the matter with potatoes. For how else would constitutional debility, if such there be, more naturally manifest itself than in such increased liability or diminished resistance to such attacks? And if you say that, anyhow, such varieties do not die of old age—meaning that each individual attacked does not die of old age, but of manifest disease—it may be asked in return, what individual man ever dies of old age in any other sense than of a similar inability to resist invasions which in earlier years would have produced no noticeable effect? Aged people die of a slight cold or a slight accident, but the inevitable weakness that attends old age is what makes these slight attacks fatal.

Finally, there is a philosophical argument which tells strongly for some limitations of the duration of non-sexually-propagated forms, one that probably Knight never thought of, but which we should not have expected recent writers to overlook. When Mr. Darwin announced the principle that cross-fertilization between the individuals of a species is the plan of nature, and is practically so universal that it fairly sustains his inference, that no hermaphrodite species continually self-fertilized would continue to exist, he made it clear to all who apprehend and receive the principle, that a series of plants propagated by buds only must have weaker hold of life than a series reproduced by seed. For the former is the closest possible kind of close breeding. Upon this ground such varieties may be expected ultimately to die out; but "the mills of the gods grind so exceeding slow" that we cannot say that any particular grist has been actually ground out under human observation.

If it be asked how the asserted principle is proved or made probable, we can here merely say that the proof is wholly inferential. But the inference is drawn from such a vast array of facts that it is well nigh irresistible. It is the legitimate explanation of those arrangements in nature to secure cross-fertilization in the species, either constantly or occasionally, which are so general, so varied and diverse, and we may add so exquisite and wonderful, that, once propounded, we see that it must be true. What else, indeed, is the meaning and use of sexual reproduction? Not simply increase in numbers; for that is otherwise effectually provided for by budding propagation in plants and many of the lower animals. There are plants, indeed, of the lower sort, in which the whole multiplication takes place in this way, and with great rapidity. These also have sexual reproduction; but in it two old individuals are always destroyed to make a single new one! Here propagation diminishes the number of individuals 50 per cent. Who can suppose that such a costly process as this, and that all the exquisite arrangements for cross-fertilization in hermaphrodite plants, do not subserve some most important purpose? How and why the union of two organisms, or generally of two very minute portions of them, should re-enforce vitality, we do not know and can hardly conjecture. But this must be the meaning of sexual reproduction.

The conclusion of the matter from the scientific point of view is, that sexually propagated varieties, or races, although liable to disappear through change, need not be expected to wear out, and there is no proof that they do; but, that non-sexually propagated varieties, though not liable to change, may theoretically be expected to wear out, but to be a very long time about it.

ART. XIV.—*Communications from the Laboratory of Williams College;* by IRA REMSEN.

I. *Formation of Paratoluic Acid from Parasulphotoluenic Acid.*

IN an article published a short time ago in this Journal * I stated that when potassic parasulphobenzoate is fused with sodic formate, according to the method of V. Meyer for the synthesis of aromatic acids, terephtalic acid is formed. The reaction was a very clean one, not a trace of the isomeric phtalic acids being produced. I also called attention to the fact that a certain degree of importance was connected with this result, in as much as it showed, more conclusively than had been shown up to that time, that the reaction of Meyer takes place in a normal manner, and is hence adapted to the determination of the constitution of aromatic bodies, notwithstanding the doubts that had been expressed by chemists as to its value for this purpose.

Since the publication of the above article, V. v. Richter † has attempted to prove that Meyer's reaction does not take place in a normal manner, by showing that, when benzoic acid alone is fused with sodic formate, both isophtalic and terephtalic acids are produced. He had evidently not read my article, as it appeared in this Journal, but only a brief preliminary notice which I had previously published ‡ in Germany, in which, however, I had distinctly stated that pure terephtalic acid is formed from parasulphobenzoic acid. As this notice was a *brief* one, v. Richter takes the liberty of doubting the assertion clearly made in it. After remarking that the direct replacement of the brom- and sulpho-groups in benzoic acid, by means of the questionable reaction, can only then be looked upon as proved, after it has been shown that the isomeric substituted benzoic acids may be converted into the corresponding dicarbonic acids by the same reaction, he says: "Dieses ist aber trotz verschiedener Versuche nicht gelungen; es existirt nur eine kurze Anzeige von I. Remsen dass er aus der Parasulfobenzoesäure reine Terephtalsäure erhalten;" and he then proceeds to reason exactly as if this brief notice did not exist. Subsequently, V. Meyer § answered Richter in an entirely satisfactory manner, upholding the correctness of my assertion, and employing it as an argument in favor of his views. I have hence not felt called upon to say a word in my own defense, and I now only take this opportunity to remark that *a priori* I attach as much weight to

* Vol. v, 179, 274, 354.
† Berliner Berichte, vi Jahrgang, 876, 879.
‡ Ibid, v Jahrgang, 379.
§ Berliner Berichte, vi Jahrgang, 1146.

an assertion made in a brief notice as to one made in a long article, and I shall continue to do so hereafter, whatever deviation from this principle the custom of a few chemists may appear to sanction.

In view of the importance of the question under discussion, I have endeavored to furnish further proofs of the value of Meyer's reaction, by employing it for the purpose of effecting new conversions of known compounds into known compounds the constitutions of which are established. Of one of these conversions, viz., that of parasulphotoluenic acid into paratoluic acid, I wish to speak here.

Pure potassic parasulphotoluenate was mixed with an equal quantity of sodic formate, and the mixture then gradually heated to fusion, the mass being constantly stirred. All the phenomena mentioned by Meyer, and afterward noticed by myself, were repeated. Vapors of an exceedingly disagreeable odor were given off, and the mass turned darker and darker until it became almost black. Toward the end of the operation, inflammable gases escaped and took fire at the top of the crucible. The whole was now allowed to cool and then treated with water. With the exception of a small black residue, the mixture dissolved entirely, forming a clear solution. This was treated with sulphuric acid until it showed an acid reaction; and the solution was then agitated with ether until the latter no longer extracted any solid substance. On now evaporating the ether, an almost colorless solid residue remained which exhibited the properties of an acid. It was comparatively easily soluble in boiling water, and separated from this solution, on cooling, in the form of microscopic needles. These were found to sublime with ease, and were thus obtained in the form of beautiful, flat needles. The pure substance fused instantly at 176°. It was converted into the barium salt, and from this reprecipitated. Its fusing point was again found to be 176°.

These properties suffice to characterize the substance as paratoluic acid; but another and more positive proof of its nature was given. The acid was treated with the ordinary oxidizing mixture of potassic dichromate, sulphuric acid and water, and, after boiling for a short time, an insoluble powder was thrown down. This was filtered off, washed and dried, and was then found to have all the properties of terephtalic acid. It was insoluble in water, hot as well as cold, and did not fuse, but sublimed in a capillary tube before an applied flame.

Now as parasulphotoluenic acid is known to yield a cresole, which in turn yields paraoxybenzoic acid, and as paraoxybenzoic and paratoluic acids are conceded to belong to the same series, it follows that, in the instance here considered, the sulpho-group is replaced directly by carboxyl. But, further, paratoluic acid was the only product of the reaction. I was unable to discover a trace of any other acid, although special precautions were taken to prevent errors of observation in this respect. The quantity of the product, too, was sufficient to warrant the conclusion that it was not formed by any secondary reaction.

The results of this experiment then serve to strengthen the conclusion already drawn with reference to Meyer's reaction, and to weaken the arguments of v. Richter. I shall next attempt to convert orthosulphotoluenic acid into orthotoluic acid by the same method, though success is hardly to be anticipated, as Meyer himself failed to convert chlorsalylic acid into the corresponding orthocarbonic acid, the substituting group being replaced by hydrogen instead of by carboxyl.

Another experiment with which I have been occupied, closely allied to that described, has not yet led to decisive results. I stated, in the article already referred to, that having failed to obtain orthosulphobenzoic acid from orthosulphotoluenic acid by oxidation with potassic dichromate and sulphuric acid, I intended to use potassic permanganate in alkaline solution for the purpose of effecting this oxidation. My main object in preparing orthosulphobenzoic acid was, through it, to reach phtalic acid by means of Meyer's reaction. It appears up to the present that orthosulphotoluenic acid is destroyed entirely by potassic permanganate in alkaline solution, though I do not feel prepared to assert this positively. W. Weith * has lately shown that orthotoluic acid may be readily converted into phtalic acid by potassic permanganate in alkaline solution. Though this interesting discovery renders the preparation of phtalic acid, by the method proposed by me, unnecessary from one stand-point, I shall, nevertheless, endeavor to accomplish this.

II. *On Nitroparasulphobenzoic Acid.*

In continuing my investigations on parasulphaminbenzoic acid, I have reached some new results which are herewith communicated.

I first attempted to introduce the group SO^2OH into parasulphaminbenzoic acid in order thus to obtain a sulpho acid which, were it susceptible to ordinary reagents, might lead to definite conclusions concerning the dioxybenzoic acids and the tricarbonic acids of benzine. Common concentrated sulphuric acid dissolves parasulphaminbenzoic acid when heated with it, but does not change it, for, on diluting with water the solution thus obtained, the original acid is precipitated in its characteristic acicular crystals. The same is true in regard to the

* Berliner Berichte, vii Jahrgang, 1057.

action of sulphuric anhydride; solution is effected, but from this solution parasulphaminbenzoic acid is precipitated unchanged on the addition of water. On boiling the acid with Nordhausen sulphuric acid, however, a change is accomplished, though not that which was expected and desired. The change consists simply in a regeneration of parasulphobenzoic acid from the amine-acid. In other words, the group NH^2 is converted into OH. The parasulphobenzoic acid was recognized by diluting with water, neutralizing with baric carbonate, evaporating, adding chlorhydric acid and allowing to cool. Thus were deposited the characteristic flat needles of the acid barium salt. This possessed all the properties of the salt, and its identity was further proved by the following analysis:

0·2475 grams salt lost 0·022 grams on being heated to 200°; and gave 0·0963 grams $BaSO^4$ = 0·05662 grams Ba.

	Calculated.		Found.
$2(C^7H^5SO^5)$	402	67·79	——
Ba	137	23·10	22·88
$3H^2O$	54	9·11	8·88
	593	100·00	

I next endeavored to introduce the group NO^2 into parasulphaminbenzoic acid. Fuming nitric acid was first employed for this purpose. When this is boiled with the amine-acid, solution takes place, and, on diluting this solution with water, nothing is precipitated. The change effected is, however, the same as that effected by Nordhausen sulphuric acid, viz: the NH^2 group is simply converted into OH, and parasulphobenzoic acid thus regenerated. The latter acid was in this instance also readily recognized. The solution was evaporated to dryness on the water bath and all nitric acid thus removed. On now dissolving in water, neutralizing, as above, with baric carbonate, adding chlorhydric acid and allowing to cool, the acid barium salt was deposited. It was identified beyond a doubt by the aid of the following analysis:

0·5325 grams salt lost 0·0483 grams on being heated to 200°; and gave 0·2095 grams, $BaSO^4$ = 0·1232 grams Ba.

	Calculated.		Found.
$2(C^7H^5SO^5)$	402	67·79	——
Ba	137	23·10	23·11
$3H^2O$	54	9·11	9·07
	593	100·00	

These experiments then only show that parasulphobenzoic acid is an exceedingly stable compound, as it resists the action of Nordhausen sulphuric acid and fuming nitric acid at the boiling temperatures, no matter how long the boiling may be continued. It may, further, be looked upon as an interesting result that the Nordhausen acid should cause a conversion of the NH^2 group into OH; a fact which at least indicates a remarkable predisposition on the part of the amine-acid to conversion into the corresponding sulpho-acid.

Finally, by employing a mixture of the two agents already employed, I was enabled to obtain a substitution-product of parasulphobenzoic acid. The boiling was continued until red fumes ceased to be given off, and the solution became perfectly clear. On now diluting with water, neutralizing with baric carbonate, etc., a new salt was obtained. This was comparatively easily soluble in hot water, though less so in cold water. It crystallized in long, lustrous needles, arranged concentrically in groups which might be termed fan-shaped. They were colored yellow, and repeated recrystallizations failed to remove this color. The analyses gave the following results, showing the salt to be the neutral barium salt of nitroparasulphobenzoic acid:

I. 0·2345 grams salt lost 0·0147 grams at 200°; and then gave 0·1320 grams $BaSO^4$ = 0·077616 grams Ba.

II. 0·2335 grams salt lost 0·0155 grams at 200°; and then gave 0·1325 grams $BaSO^4$ = 0 0779 grams Ba.

	Calculated.		Found.	
$C^7H^3SNO^7$	245	59·90	——	——
Ba	137	33·50	33·10	33·37
$1\frac{1}{2}H^2O$	27	6·60	6·27	6·64
	409	100·00		

The formula of this salt is thus seen to be

$$C^6H^3(NO^2)\begin{cases}SO^2.O\\CO.O\end{cases}\!\!>Ba + 1\tfrac{1}{2}H^2O.$$

A nitrosulphobenzoic acid has already been prepared by Limpricht and Uslar.* But, as this was obtained from metasulphobenzoic acid, it is not at all probable that the two are identical. Nothing is known concerning the relative position of the nitro-group in either of these acids, nor have we as yet any data that will enable us to draw conclusions of value with reference to this point. In this connection, the following method of investigation suggests itself. Three isomeric nitrobenzoic acids are known, and the series to which each belongs is also known. Now, if it be possible to introduce into these nitro-acids the sulpho-group, compounds would be obtained

* Annalen der Chemie u. Pharmacie, cvi, 27.

which would probably be identical with the two known forms of nitrosulphobenzoic acid. According to the conditions then, we would have data which would enable us to determine the constitution of these latter acids; for we should thus fix the position, first, of the sulpho-group with reference to the carboxyl, and second, that of the nitro-group in one and the same compound.

I shall endeavor to prove the feasibility of this method of investigation, as soon as possible. It is well to remember, however, that Mulder* has already tried to obtain a nitrosulphobenzoic acid by the action of sulphuric acid on ordinary (meta) nitrobenzoic acid, and that no such product resulted. Possibly the isomeric nitrobenzoic acids may yield more satisfactory results.

III. *On the Action of Potassium on Ethyl succinate.*

Several years ago Fehling† described a peculiar compound which he had obtained by the action of potassium on ethyl succinate. This compound, according to the discoverer, crystallizes in yellowish laminæ which are insoluble in water, difficultly soluble in cold alcohol, easily in hot alcohol. The formula deduced from the analyses was $C^6H^8O^3$, or ethyl succinate minus the constituents of one molecule of alcohol. The exact nature of this body was not determined, nor was much more than its existence and composition proved. Its peculiar nature led me to desire a more thorough knowledge of its relations to other known compounds, and I have hence undertaken its study in the hope of being able to discover its constitution by the aid of appropriate experiments. It appears possible that it may be the representative of a new class of bodies of an interesting nature, which may be prepared under similar circumstances from the various ethers of bibasic fatty acids.

Its preparation is comparatively simple, and the yield is satisfactory. I have prepared a considerable quantity, and have found the statements of Fehling concerning it essentially correct. In a pure condition, it forms long, flat, beautiful needles of a slightly yellowish color, instead of yellow laminæ. It may be boiled with alcohol or water without undergoing change. When sodium-amalgam is added to the alcoholic solution, a very rapid change takes place. A bright red precipitate is formed, which is insoluble in alcohol but easily soluble in water. From the aqueous solution of this new substance chlorhydric acid throws down a white precipitate, which is insoluble in water and difficultly soluble in alcohol. Dilute caustic potassa produces a similar change. The substance dissolves in this very

* Annalen der Chemie u. Pharmacie, xxxiv, 297.
† Ibid, xlix, 192.

easily, and the solution conducts itself in the same manner as that above mentioned. The action of the amalgam is then due alone to the formation of caustic soda, and not to the action of nascent hydrogen.

In order to obtain the red substance above referred to, the original body was dissolved in warm alcohol, and to this solution an alcoholic solution of caustic soda was added. In this manner a bright red voluminous precipitate was obtained, which consisted of very fine lustrous needles. This was filtered off, well washed out with alcohol, pressed with bibulous paper and allowed to dry. In drying, the red color changes to yellow, but the needles remain otherwise unchanged. An addition of alcohol to the yellow substance restores the red color, so that there seems to be no chemical change connected with that of color. Further, this yellow body after being dried may be preserved in the air. Analyses gave as a result 12·37 per cent sodium, but I shall not attempt to deduce a formula until this result has been confirmed by other means.

The precipitate that is produced by chlorhydric acid in the aqueous solution of the red substance proved to be the body $C^6H^8O^3$, so that it would seem that this body plays the part of an acid. Alkaline carbonates, however, do not act in the same manner as the hydroxides. Without the aid of heat, indeed, they do not act at all. When the body $C^6H^8O^3$ is boiled with sodic carbonate, succinic acid is regenerated and is precipitated on the addition of chlorhydric acid to the cooled solution. The same is true when in the case of the hydroxides the solutions are boiled. Very concentrated aqueous ammonia does not act upon the substance $C^6H^8O^3$, even when the two are boiled together.

I intend to study the action of phosphoric chloride and acetyl chloride, and, further, of nascent hydrogen in acid solution, produced by tin and alcoholic chlorhydric acid, upon the body under investigation, and expect in this manner to reach definite results which will lead to a knowledge of its constitution.

October, 1874.

Art. XV.—*On the Detection of Hydrocyanic Acid*; by M. Carey Lea, Philadelphia.

1. *New Test.*

If a little pure protosalt of iron (I have used ferrous ammonia sulphate) be dissolved together with a little uranic nitrate, we have a solution which, with a soluble cyanide, gives a purple precipitate, or in very dilute solutions of the cyanide, a greyish purple.

This test is very delicate. Used in the manner to be presently described, a solution of potassic cyanide, containing only $\frac{1}{5000}$ of a grain of anhydrous hydrocyanic acid, gives a perfectly distinct reaction. It is therefore not exceeded in delicacy by any known test for that substance.

The solution of iron and uranium must not be acidulated, but on the contrary should be quite neutral, and so dilute as to be nearly colorless. A grain or two of each salt may be dissolved in a half ounce of water. Two or three drops of the mixed solution are to be placed in a clean white porcelain capsule, and a drop or two of the liquid to be tested should be made to slip slowly down, that the reaction at the point of contact may be carefully noted.

Cobaltous nitrate may be substituted for the uranium salt, and gives an almost equally delicate reaction, but the color of the cobalt salt is an objection.

2. *Prussian Blue Test.*

The delicacy of the Prussian blue reaction for the detection of hydrocyanic acid has been much understated. Thus Taylor (quoted in Watts' Dict., ii, 219) affirms that whilst the sulphocyanide reaction is capable of distinctly indicating the presence of $\frac{1}{3930}$ of a grain of anhydrous prussic acid, the Prussian blue test will not detect less than $\frac{1}{780}$ of a grain. A much greater delicacy than this can be obtained by using appropriate precautions.

There must not be too much iron salt present, and the solution of iron salt must not be too strong: these two points are essential. For ferric salt, the ammonia citrate is to be preferred to ammonia ferric alum or ferric chloride. The best mode of proceeding is as follows:

A weak solution of iron is to be made, containing a ferrous salt, to which a little ferric ammonia citrate is to be added. Of this solution, acidified with hydrochloric acid, two or three drops only are to be placed in a white porcelain capsule. A drop of the liquid to be tested is then allowed to slip down the side of the capsule, and this meeting the iron solution will give rise to the production of a blue cloudiness.

If a grain of potassic cyanide be dissolved in four ounces of pure water, rendered slightly alkaline with caustic alkali, and a single drop of the solution be allowed to flow down the capsule in the manner just described, a distinct blue coloration will result. This drop will have contained about $\frac{1}{2000}$ of a grain of cyanide, or about $\frac{1}{5000}$ of a grain of anhydrous prussic acid, a degree of delicacy very far surpassing that found by Mr. Taylor; surpassing, indeed, that claimed by him for the sulphocyanhydric test.

The advantage of using ferric ammonia citrate over ferric ammonia alum may be curiously shown as follows:

Place in a small white porcelain basin about an ounce of a solution containing a few grains each of ferrous ammonia sulphate and ferric ammonia sulphate acidulated with hydrochloric acid. Take about a milligramme of cyanide of potassium, or about as much dust of that substance as can be distinctly perceived and shake it into the basin. Each infinitesimal particle will produce a blue coloration as it touches the liquid, but on agitating, the blue (if the quantity of cyanide has been small enough) will disappear. If now the same experiment be repeated with a solution of ferrous ammonia sulphate and ferric ammonia citrate, also acidulated, the blue color produced does not disappear on shaking, but presently settles or becomes more conspicuous.

For the same reason, ferric ammonia citrate will detect infinitesimal traces of potassic ferrocyanide in the ferridcyanide when ferric chloride and ferric ammonia alum will not, and therefore it should have the preference for testing the purity of potassic ferridcyanide.

Art. XVI.—*Brief Contributions to Zoology from the Museum of Yale College.* No. XXX.—*The Gigantic Cephalopods of the North Atlantic*; by A. E. Verrill.

The existence of several distinct species of gigantic ten-armed cephalopods, belonging to more than one genus, has been well established by the researches of Steenstrup, Harting and others.

More recently attention has been repeatedly called to the frequent occurrence of these remarkable animals in the waters of Newfoundland. In an article on this subject, in this Journal, vol. vii, p. 158, Feb., 1874, I was able to enumerate five specimens from American waters, concerning which we had some reliable information.* Since that time much more material has been accumulated, and I am now able to cite twelve American examples. I have also had opportunities to study portions of five of these specimens. These evidently represent two distinct species, both of which belong to the genus *Architeuthis* of Steenstrup (or *Megaloteuthis* of Kent). The largest of these is represented only by the jaws of two specimens, one of which (No. 1 in my former article) was found floating at the Banks of Newfoundland, and the other (which

*See articles on this subject by the writer, in the American Naturalist, vol. ix, Jan., 1875; and vol. viii, p. 167; and letters from Mr. Alexander Murray in the Naturalist, vol. viii, p. 120, Feb., 1874.

we will designate as No. 10) was taken from the stomach of a sperm whale. The upper jaw of the latter was imperfectly figured by Dr. Packard in his article on this subject.* It is the largest jaw yet known. These belong to an apparently undescribed species, which I propose to name *Architeuthis princeps*,† and shall describe more fully farther on.

The second species, which I consider identical with the *Architeuthis monachus* of Steenstrup, is represented by parts of three individuals, and seems to be the species most commonly met with on the coasts of Newfoundland and Labrador.

The most complete specimen that has ever come under scientific observation was captured in November, 1873, at Logie Bay, near St. John's, Newfoundland. It became entangled in herring-nets and was secured by the fishermen with some difficulty, and only after quite a struggle, during which its head was badly mutilated and severed from the body, and the eyes, most of the siphon-tube, and the front edge of the mantle were destroyed. Fortunately this specimen was secured by the Rev. M. Harvey of St. John's. After it had been photographed and measured, he attempted to preserve it entire in brine, but this was found to be ineffectual, and after decomposition had begun to destroy some of the most perishable parts, he took it from the brine and, dividing it into several portions, preserved such parts as were still undecomposed in strong alcohol. These various portions are now in my possession, and with the photographs have enabled me to present a restoration, believed to be quite accurate, of the entire creature (plate II, fig. 1). In this figure the eyes, ears, siphon-tube, and front edge of the mantle have been restored from a small squid (*Loligo pallida*), to which this gigantic species seems to be nearly allied in many respects. The other parts have been drawn directly from the photographs and specimens.‡

Mr. Harvey has published popular accounts of this specimen and the previously captured arm of a still larger one, in the Maritime Monthly Magazine of St. John, N. B., for March, 1874, and in several newspapers.§ To him we are, therefore,

* American Naturalist, vol. vii, p. 91.

† This species was named and characterized in a communication made to the Connecticut Academy of Sciences, Nov. 18, 1874, and will be described in greater detail in its Transactions. See also American Naturalist, Feb., 1875.

‡ The figure was originally made, from the photographs only, by Mr. P. Rœtter, of the Museum of Comparative Zoology, but after the arrival of the specimens it had to be altered in many parts. These necessary changes were made by the writer, after a careful study of the parts preserved, in comparison with the photographs and original measurements.

§ Acknowledgments are also due to Mr. Alexander Murray, Provincial Geologist, who coöperated with Mr. Harvey in the examination and preservation of these specimens, and who has also written some of the accounts of them that have been published. See also the American Naturalist, vol. viii, p. 122, February, 1874; American Journal of Science, vol. vii, p. 160; Nature, vol. ix, p. 322, February 26, 1874; and Appleton's Journal, Jan. 31, 1874.

mainly indebted for the latest and most important additions to our knowledge of these remarkable animals. The preserved parts of this specimen (No. 5) which I have been able to examine are as follows: the anterior part of the head, with the bases of the arms, the beak, lingual ribbon, etc.; the eight shorter arms, but without the suckers, which dropped off in the brine, and are now represented only by the strong marginal rings; the two long tentacular arms, which are well preserved, with all the suckers in place; the tail; portions of the "pen" or internal shell; the ink-bag; and pieces of the body.

The general appearance and form of this species * are well shown by plate II. From the great size of the large suckers on the long arms, I judge it to be a male. The body was relatively stout, and according to the statement of Mr. Harvey, it was, when fresh, about seven feet long and five and one-half feet in circumference. The "tail" or caudal fin (plate IV, fig. 9) is said by Mr. Harvey to have been 22 inches across, but the preserved specimen is considerably smaller, owing, undoubtedly, to shrinkage in the brine and alcohol. It is remarkable for its broad sagitate form. The posterior termination is unusually acute and the lateral lobes extend forward considerably beyond their insertion. In the preserved specimen the total length, from the anterior end of the lateral lobes to the tip of the tail, is 23 inches; from the lateral insertions to the tip 19 inches; from the dorsal insertion 13·5 inches; total

* Mr. W. Saville Kent, from the popular descriptions of this species, has seen fit to give it new generic and specific names, viz: *Megaloteuthis Harveyi*, in a communication made to the Zoological Society of London, March 3, 1874 (Proceedings Zool. Soc., p. 178; see also Nature, vol. ix, p. 375, March 12, and p. 403, March 19). My identification is based on a comparison of the jaws with the jaws of *A. monachus*, well figured and described by Steenstrup in proof-sheets of a paper which is perhaps still unpublished, though printed several years ago, and referred to even by Harting. Their agreement is very close in nearly all respects, but the beak of the lower jaw is a little more divergent in Steenstrup's figure. His specimen was a little larger than the one here described and was taken from a specimen cast ashore in 1853. Mr. Kent was probably unaware of that specimen when he said (Nature, ix, p. 403) that *A. monachus* "was instituted for the reception of two gigantic Cephalopods, cast on the shores of Jutland in the years 1639 and 1790, and of which popular record alone remains."

His statement that *Architeuthis dux* Steenstrup is known from the beak alone appears to be erroneous, for Steenstrup, Harting, and Dr. Packard, in their articles on this subject, all state that the suckers, parts of the arms, and the internal shell or pen were preserved, and they have been figured by Prof. Steenstrup; Harting has also given a figure of the lower jaw, copied from a figure by Steenstrup. Steenstrup also mentions having the arm-hooks (Tandvæbningen), which would indicate a genus distinct from our species; in the proof-sheets which I have seen, this specimen is referred to as "*A. Titan*," but Harting cites it as *A. dux* Steenstrup. Possibly two distinct species are confounded under this name.

Should the *Architeuthis dux* prove to belong to a genus distinct from this, it might perhaps be taken as the type of *Architeuthis*, and in that case the generic name given by Kent could be retained, and the two species here described would then be called *Megaloteuthis monachus* and *M. princeps*, if my identification of the former species be correct.

breadth about 15 inches; width of lateral lobes 6 inches. The eight shorter arms, when fresh, were, according to Mr. Harvey's measurements, six feet long and all of equal length, but those of the different pairs were respectively ten, nine, eight and seven inches in circumference. They are three-cornered or triquetral in form and taper very gradually to slender acute tips. Their inner faces are occupied by two alternating rows of large obliquely campanulate suckers, with contracted apertures surrounded by broad, oblique, marginal rings, armed with strong, acute teeth around their entire circumference, but largest and most oblique on the outside (plate III, fig. 10). These suckers gradually diminish in size to the tips of the arms, where they become very small, but are all similar in form and structure. The largest of these suckers are said by Mr. Harvey to have been about an inch in diameter, when fresh. The largest of their marginal rings in my possession are ·65 of an inch in diameter at the serrated edge, and ·75 beneath. The rings of the smaller suckers are more oblique and more contracted at the aperture, with the teeth more inclined inward, those on the outside margin being largest. The two long tentacular arms are remarkable for their slenderness and great length when compared with the length of the body. Mr. Harvey states that they were each 24 feet long and 2·75 inches in circumference when fresh. In the brine and alcohol they have shrunk greatly, and now measure only 13·5 feet in length, while the circumference of the slender portion varies from 2·25 to 3 25 inches. These arms were evidently highly contractile, like those of many small species, and consequently the length and diameter would vary greatly according to the state of contraction or relaxation. The length given (24 feet) probably represents the extreme length in an extended or flaccid condition, such as usually occurs in these animals soon after death. The slender portion is three-cornered or triquetral in form, with the outer angle round, the sides slightly concave, the lateral angles prominent, and the inner face a little convex and generally smooth.

The terminal portion, bearing the suckers, is 30 inches in length and expands gradually to the middle, where it is 4·5 to 5 inches in circumference (6 inches when fresh), and 1·5 to 1·6 across the inner face. The sucker-bearing portion may be divided into three parts. The first region occupies about seven inches, in which the arm is triquetral, with margined lateral angles, and gradually increases up to the maximum size, the inner face being convex and bearing about forty irregularly scattered, small, flattened, saucer-shaped suckers, attached by very short pedicels, and so placed in depressions as to rise but little above the general surface. They have narrow marginal rings, with the thin edges nearly smooth, or minutely denticulate, and ·10 to ·12 of an inch in diameter, surrounded by a thick and prominent marginal membrane. These suckers are at first distantly scattered, but become more crowded, finally covering the whole width of the inner face, which becomes here 1·6 inches broad. Scattered among the suckers are about as many low, broad, conical, smooth, callous verrucæ, or wart-like prominences, rising above the general surface, their central elevation corresponding in form and size to the apertures of the adjacent suckers. These, without doubt, are intended to furnish secure points of adhesion for the corresponding suckers of the opposite arm, so that, as in some other genera, these two arms can be fastened together at this wrist-like portion, and thus they can be used unitedly. By this means they must become far more efficient organs for capturing their prey than if used separately. Between these smooth suckers and the rows of large ones there is a cluster of about a dozen small suckers, with serrate margins, mostly less than a quarter of an inch in diameter, attached by slender pedicels.

The second division, 14 inches in length, succeeds the small suckers. Here the arm is well rounded on the back and flattened on the face, where it bears two alternating rows of very large serrate suckers, and an outer row of small ones on each side, alternating with the large ones. The inner edge is bordered by a rather broad, regularly scalloped, marginal membrane, the scallops corresponding to the large suckers. On the other edge there is a narrower and thinner membrane, which runs all the way to the tip of the arm. In one of the rows of large suckers there are eleven, and in the other ten, above half an inch in diameter, but each row has at either end one or two smaller ones, from half an inch to a quarter of an inch in diameter. The largest suckers (plate IV, fig. 11, *a*) are from 1 to 1·15 inches in diameter at the margin. These are attached by strong, though slender, pedicels, so that their margins are elevated about an inch above the surface of the arm. Each one is situated in the center of a pentagonal depressed area, about an inch across, bounded by ridges, which alternate regularly, and interlock on the two sides, so as to form a zigzag line along the middle of the arm. These large suckers are obliquely campanulate; the marginal ring is strong, and sharply serrate all around. The small marginal suckers (fig. 11, *b*) are similar in structure, but more oblique, and mostly only ·3 to ·4 of an inch in diameter; they are attached by much longer and more slender pedicels, and their marginal teeth are relatively larger and more incurved, especially on the outer margin. The terminal division of the arm is 9 inches long. It gradually becomes much compressed laterally, and tapers regularly to the tip, which is flat, blunt, and slightly incurved. Just beyond the large suckers, where this region begins, the circumference is 3·5 inches. The face is narrow and bears a large number of small serrate and pedicellate suckers, arranged in four regular alternating rows, and gradually diminishing in size to the tip of the arm, where the rows expand into a small cluster. These suckers are much like the marginal ones of the previous division, and at first are about ·25 of an inch in diameter, but decrease to about ·10 of an inch near the tip of the arm. The color, where preserved, is pale reddish, with thickly scattered small spots of brownish red.

The form of the jaws of this specimen is well shown by plate III, figs. 3 and 4. When in place, these jaws constitute a powerful beak, looking something like that of a parrot or hawk, except that the upper jaw shuts into the lower, instead of the reverse, as in birds. The color is dark brown, becoming almost black toward the tip, where its substance is thicker and firmer, and smoothly polished externally. The upper jaw (plate III, fig. 3) measures 3·85 inches in total length; 1 inch in greatest breadth; and 2·50 from front to back. The lower jaw (fig. 4) is 3 inches long, 2·75 broad, and 2·65 from front to back.

The small squids of our coast have a very similar pair of jaws. Those of *Loligo pallida* (plate IV, figs. 5, 5a) are here figured twice the natural size, for comparison and to explain the terms used in describing the large jaws.

The most remarkable anatomical character observed in this specimen is found in the form and arrangement of the teeth on the "lingual ribbon," or *odontophore*, for in this respect it differs widely from all other known Cephalopods.

The ordinary squids and cuttle-fishes all have these teeth arranged in seven regular longitudinal rows; those of the three middle rows being generally two or three-pronged, as in *Loligo pallida* (plate IV, fig. 7), while the lateral rows have long, simple, fang-like teeth. But in this species (fig. 6) the teeth are very irregularly scattered over the surface of the broad thin membrane, and it is difficult to trace the rows, if such they can be called, for the arrangement seems to be somewhat in irregular quincunx. The number of rows, however, cannot be less than twenty. These teeth are all simple, but vary considerably in size and form. They are all attached by a more or less rounded, flattened base, and all are considerably curved; some are broad and tapering; others are slender and acute; but the different forms and sizes are irregularly intermingled across the whole breadth of the membrane. Irregular granules of silica are also scattered in great numbers over the membrane among the teeth, and similar grains are embedded in the membrane lining the mouth. This peculiar type of dentition must be regarded as an extremely generalized one.

The portions of the pen in my possession belong mostly to the two ends, with fragments from the middle region, so that although neither the actual length nor the greatest breadth can be given, we can yet judge very well what its general form and character must have been. It was a broad and thin structure, of a yellowish brown color, and translucent. Its anterior portion (plate III, fig. 2) resembles that of *Loligo*, but its posterior termination is entirely different, for instead of having a regular lanceolate form, tapering to a point at the posterior end, as in *Loligo*, it expands and thins out toward the posterior end, which is very broadly rounded or irregularly truncate, fading out insensibly, both at the edges and end, into soft membrane. The anterior end, for about an inch and a half, was rapidly narrowed to a pen-like point, as in *Loligo;* from this portion backward the width gradually increases from 1·2 inches to 5 inches, at a point .5 inches from the end, where our specimen is broken off; at this place the marginal strips are wanting, but the width is 5 inches between the lateral midribs (*d*, *d''*), which were, perhaps, half an inch from the margin. Along the center of the shell, there is a strong, raised, rounded midrib, which fades out a short distance from the posterior end, but is very conspicuous in the middle and anterior sections. On each side of the midrib is a lateral rib of smaller size. These at first diverge rapidly from the central one, and then run along nearly parallel with the outer margin and about ·4 of an inch from it, but beyond 11 inches from the point the margins are torn off. Like the midrib the lateral ribs gradually fade out before reaching the posterior end; near the place where they finally disappear, they are about six inches apart.

The pen of our *Architeuthis* seems to resemble that of the ancient genus *Teudopsis*, found fossil in the Jurassic formations.

From the above description it will be seen that the most important and most characteristic features of this species, or rather of the *genus* to which it belongs, are to be found in the *lingual dentition*, in the *internal shell*, in the *form of the caudal-fins*, and in the cluster of small suckers and tubercles on the long arms. As already stated, the first three of these peculiarities indicate a low or generalized structure, and therefore a low rank in our system of classification, unless it should be found to have some other characters not yet known and of greater importance, which might outweigh those here given. It will appear, therefore, that this genus of huge squids should be classed below *Loligo*, which, in its turn, would go below *Ommastrephes*, to which genus the common small squids of our northern coasts belong, for the latter genus has distinct eyelids, which are not found in *Loligo*, and the internal shell is also more specialized.

I have received through Professor Baird, of the Smithsonian Institution, a pair of jaws and two large suckers of the long arms, which were taken from a specimen (No. 4), cast ashore in Bonavista Bay, Newfoundland. These jaws agree precisely in form and size with those described above, so that the size of these two individuals must have been about the same. The suckers (plate IV, figs. 12, 13) had been dried, and have lost their true form, but the marginal rings are perfect, and only ·92 of an inch in diameter, and though somewhat smaller than in the specimen just described, they have the same kind of denticulation around the margin. Their smaller size may indicate that the specimen was a female, but they may not have been the largest of those on the arm.

Explanation of Plates.

Plate II.—Figure 1. *Architeuthis monachus* Steenstrup (No. 5); $\frac{1}{12}$ natural size.

Plate III.—Figure 2. Anterior part of the "pen" of the same; $\frac{1}{5}$ natural size. The dotted lines indicate parts that are wanting.
- Figure 3. Upper jaw of the same; natural size.
- Figure 4. Lower jaw of the same, lacking a small piece at *a*.

Plate IV.—Figures 5 and 5a Jaws of *Loligo pallida; a*, the rostrum or beak; *a b*, the cutting edge, with a notch at *b; b c*, the anterior edge of the alæ or wings; *d*, the frontal lamina in the upper jaw, or chin-portion (*mentum*) in the lower jaw; *e*, the palatine lamina in the upper jaw, or gular lamina in the lower jaw; twice the natural size.
- Figure 6. Part of the lingual ribbon of *A. monachus;* enlarged.
- Figure 7. Ditto of *Loligo pallida;* much more enlarged.
- Figure 8. Ditto of *Loligo Hartingii*, copied from Harting; enlarged.
- Figure 9. Caudal fin of *A. monachus* (No. 5); $\frac{1}{10}$ natural size.
- Figure 10. Marginal ring of a sucker from one of the sessile arms; enlarged two diameters.
- Figure 11. *a*, A large sucker; and *b*. a small marginal sucker from the tentacular arms of same; natural size.
- Figure 12. Large sucker from tentacular arm of No. 4; natural size.
- Figure 13. Part of the marginal ring of the same; enlarged.

[To be continued.]

Art. XVII.—*On the Mechanical Work done by a Muscle before Exhaustion;* by F. E. Nipher, Assistant Professor of Physics in Washington University.

The work done by a muscle may be classed under two heads: 1st. The exerting of any force (F) through any distance (D). To distinguish this kind of work from the other, we may call it dynamical work. It is measured by the product F D. 2d. Suppose an experimenter to hold a weight on his outstretched arm, and suppose furthermore that the experimenter is one of the weights of a large Atwood's machine, and is moved vertically with an accelerated motion. The dynamical work done by the arm before exhaustion is easily obtained from the equations of dynamics. If now the acceleration becomes zero, and the weight be simply held on the arm at a constant level, the arm very soon tires, showing that work is still done. This kind of work, which Prof. Haughton has called "statical" work, is purely molecular, and we hope to be able to show that it may be referred to and easily measured by the ordinary unit of mechanical work—the kilogram-meter.

In the supposed case,* if the acceleration becomes negative, the time of fatigue increases, until for an acceleration of minus (g), the time required to wholly fatigue the arm is infinite.

These considerations show, not only the reality of "statical" work, but also that it is an important element in all kinds of muscular work.

As the unit of statical work, we shall adopt the work done by the horizontally outstretched arm in sustaining a weight of one kilogram for one second upon a lever-arm of one meter. This work is evidently equivalent to the lifting of this same weight through a certain height.

As the unit of dynamical work, we shall take the dynamical work done by the horizontally outstretched arm, in lifting a weight of one kilogram, through a height of one meter, with an acceleration of one meter per second, on a lever-arm of one meter. The solution of the problem evidently consists in finding the relation between these two units.

In 1871 I published two series of experiments on this subject,† which consisted in lifting a weight w through a height h, in a time t, the intervals t being separated by equal intervals, during which the weight was allowed to drop, being caught on a cushion attached to the leg. In one series w was made variable, in the other series t varied. These experiments were repeated by Mr. Haughton, and in spite of my warnings in regard to the inaccuracy of the method, he has given them a "theoretical" reduction in his Principles of Animal Mechanics; London, 1873, pp. 462 and 475.

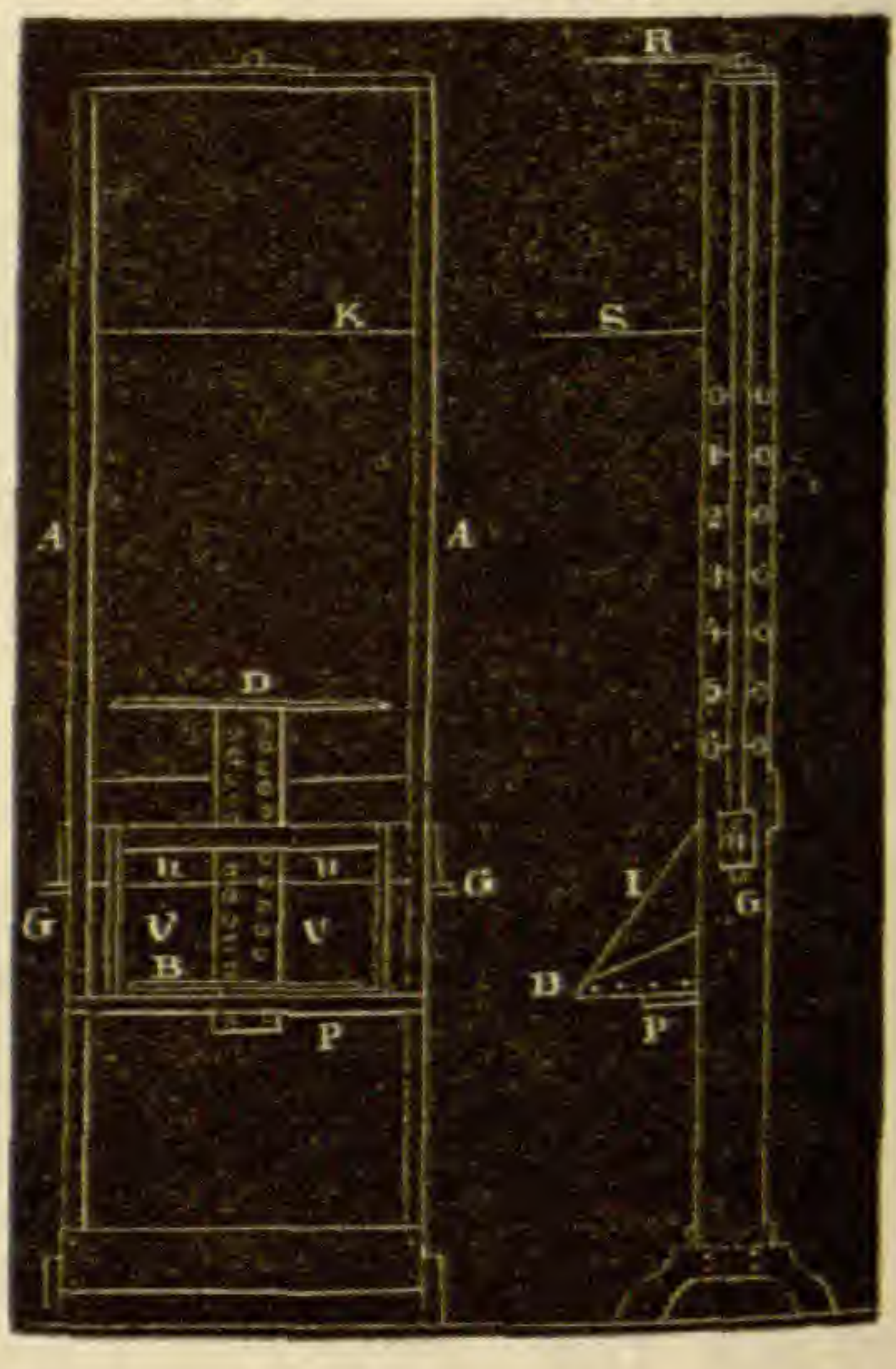
In order to eliminate the fatigue caused by the downward-plunging weight, the apparatus shown in figs. 1 and 2 was devised. B is a shelf armed with a plate of car-spring caoutchouc, for the support of the weight. This shelf is fastened by the iron bands I and a vertical back-piece V, to the slide U, being further supported by a cross-piece P. By using suitable blocks, G, the slide, may be raised to any desired height, which height is read off on a scale marked on the upright pieces A. D is used as a support for the arm during the interval of rest, and it can be adjusted to any desired height. S (fig. 2) is a horizontal string attached to the wire K, and to the wall of the

* We hope soon to be able to commence the series of experiments here indicated, the apparatus for which has been already devised.

† Hinrichs' "School Laboratory." 1871. p. 108.

room. R is an iron rod for holding the apparatus in position. The weight is a bucket of shot, provided with a stiff bail and wooden handle, so that during the lifting of the weight the line passing through the center of the hand and the center of gravity of the weight is a vertical. The experimenter stands to the right of the apparatus (as in fig. 2) and lifts the weight from the shelf B until his knuckles touch the cord S. (Back of hand turned upward.) The beginning and close of this interval of work is marked by the sharp click of a metronome, the time of whose beat is t. At the instant when the weight has reached the highest point, it is grasped by an assistant and lowered to the shelf, the arm of the experimenter being wholly relaxed, and resting upon the stiff bail of the bucket and the support D. The arm of the experimenter moves in the vertical plane which makes an angle of 45°, with the vertical plane passing through the centers of the shoulder joints.

Fig. 1. Fig. 2.



This process is kept up until the arm can no longer lift the weight to the required height. The determination of the number of lifts, n, should *never* be made by the experimenter, who should, furthermore, try to lose all estimate of time during the process. Only in this way can the mind be kept unbiased, so that the determinations are independent of each other.

In the earlier experiments it became evident that the arm not only grew gradually stronger, but also that it varied exceedingly in strength from day to day. In order to get some measure of the strength of the arm, I exhausted the arm each day of experiment with a 5·0 kgrs. weight, and reduced all of the experiments to the mean strength, as shown by the constant experiment. In this series, a weight, w, was lifted through a height, $h=0·70$ meters, in a time, t, of 1·25 sec. The interval of rest was also 1·25 sec. The experiments were so arranged as to make the constant experiment come, alternately, at 11 A. M. and 4 P. M., the other experiments alternating in like manner. The weight, w, was changed each day of experiment, so that in the table below the numbers on the horizontal lines are arranged as observed, the order of time being indicated by the indices in the first vertical column.

The columns headed c are the number of lifts n' for the constant experiment $w=5·00$. The mean value of c for the weights 3·0, 3·5, etc., 7·5, in all 100 experiments, is 35·79. The determinations of n for $w=7·5$ and 8·0 were consciously bad, as the arm was unable to manage such weights at such velocity, so that I was obliged to stop *before the arm was exhausted.**

RIGHT ARM. w variable. $h = 0·70$ meters. $t = 1·25$ sec.

w	2·00	c	2·50	c	3·00	c	3·50	c	4·00	c	4·50	c	5·00	c	5·50	c	6·00	c	6·50	c	7·00	c	7·50	c	8·00	c
☞	239	34	140	33	124	31	69	27	53	34	36	25	32	27	26	32	19	31	16	30	15	36	11	37	7	28
✍	479	35	186	30	144	32	62	32	57	28	32	25	26	28	25	28	19	30	16	24	11	25	7	26	6	26
☞	445	35	239	33	138	42	79	37	61	34	38	28	33	32	26	33	19	31	17	30	17	36	10	33	7	28
✍	707	39	271	33	158	38	79	34	66	35	45	30	38	37	27	30	24	38	19	39	16	40	10	32	8	26
☞	---	--	208	33	128	37	97	35	80	35	47	39	44	45	25	33	25	37	20	40	14	33	12	37	9	37
✍	---	--	221	31	122	33	89	31	55	33	44	37	28	28	28	36	23	32	20	36	14	34	12	31	9	37
☞	---	--	245	30	177	31	124	38	103	48	61	48	41	40	34	39	26	43	19	39	15	35	10	35	7	46
✍	---	--	520	38	180	39	117	42	71	36	71	42	46	37	34	43	26	42	18	43	15	41	11	37	6	37
☞	---	--	340	34	216	42	129	39	87	44	67	37	31	34	25	38	23	38	18	47	16	43	8	45	5	39
✍	---	--	---	--	178	44	100	34	66	46	52	33	43	44	32	44	23	36	16	36	13	41	9	37	7	33

The values of n' for $w < 3·00$, were also rejected in the calculation of the constants, as with such light weights the work varies greatly with a slight variation of strength. [This will be fully discussed hereafter.] Taking the constant c as the measure of the strength, and assuming that the work done with any weight at different times is proportional to the strength, (which we will show to be true for the weights not rejected), and we have

Calling n'= observed number of lifts before exhaustion,
and n=the same, reduced to the basis the mean strength 35·79

$$n = \frac{35·79}{c} n'$$

from which formula we have the following values of n. The mean values of n are given in the eleventh line, and the prob-

	2·00	2·50	3·00	3·50	4·00	4·50	5·00	5·50	6·00	6·50	7·00	7·50	8·00
	251	152	143	91	56	51·5	42·4	29·1	21·9	19·1	14·9	10·7	8·9
	489	222	161	69	73	45·8	33·2	32·0	22·7	23·9	15·8	9·6	8·2
	454	259	118	76	64	48·5	36·9	28·2	21·9	20·3	16·9	10·8	8·9
	648	294	149	80	67	53·7	36·8	32·2	22·6	17·4	14·3	11·2	11·0
		225	124	99	82	43·1	35·0	27·1	24·2	17·9	15·2	11·6	8·7
		255	132	103	60	42·6	35·8	27·8	25·7	19·9	14·7	13·9	8·7
		292	204	117	77	45·5	36·7	31·2	21·6	17·4	15·3	10·0	5·4
		488	165	100	71	60·5	44·5	28·3	22·2	15·0	13·1	10 6	5·8
		358	184	118	71	64·8	32·6	23·6	21·7	13·7	13·3	6·4	4·6
			145	105	51	56·4	35·0	26·0	22·9	15·9	11·3	8·7	7·6
Mean	----	----	152·5	95·8	67·2	51·2	36·9	28·6	22·7	18·1	14·5	10·4	7·8
e	----	----	5·7	3·5	2·0	1·7	0·9	0·6	0·3	0·2	0·1	0·1	0·4

* This point is important. Try to lift 20 kgrs. in a second through 0·70 meters. You will fail to lift it once, and *yet not be exhausted.* The question of maximum velocity attainable with different weights is wholly different from the one under consideration. I think Mr. Haughton has overlooked this influence on his own experiments.

able error (e) of this mean is given in the twelfth line, and is calculated from the formula $e=\frac{2}{3}\sqrt{\frac{[d.d]}{v(v-1)}}$, where v = the number of observations and d= difference from the mean.

Assuming the arm to be a uniform cylinder, and denoting by α one-half the weight of the arm, and we have for any weight w the total dynamical work done before exhaustion.

$$\text{Total work} = (w+\alpha)h\,.\,n. \qquad (1)$$

The value of α can be determined by direct weighing, as follows: Exhaust the arm thoroughly, then holding it in the same position as when lifting, extend the arm horizontally, resting the hand in the scale-pan of a spring-balance, the dial of which is turned from the experimenter. The reading off of the weight is done by an assistant. After a few minutes the muscles tire so that a practical experimenter can then gradually relax them fully. Untrained muscles, when thus tried, act involuntarily, and precise results can not be obtained. The value of α was thus determined twenty times, the values being here given.

a (obs.)

1·46	1·42	1·63	1·42	1·46
1·42	1·58	1·42	1·48	1·40
1·42	1·52	1·48	1·58	1·50
1·50	1·49	1·62	1·58	1·57
				α=1·50

The mean is 1·50 kgr. with a probable error of 0·01 kgr. Hence (calling the total work=W), (1) becomes

$$W=(w+1{\cdot}50)\,0{\cdot}70n.$$

Coördinating the values of W and w and the relation appears plainly hyperbolic. Hence the two most probable cases are

$$(w+\alpha)hn=\frac{c'}{(w+\alpha)^{v'}} \text{ ------------ } (2) \text{ and}$$

$$(w+\alpha)hn=\frac{c}{w^{v}} \text{ ------------ } (3)$$

where c and v are constants.

From these we readily have

$$\log(w+\alpha)+\log n=k'-v'\log(w+\alpha) \text{ --------- } (4)$$

$$\log(w+\alpha)+\log n=k-v\log w \text{ -------------- } (5)$$

These equations are of the form $y=k+vx$.

where y and x can be determined from the observations. They are given in the table below.

These values of x and y for eq. (4) and (5) are coördinated on the chart and a straight line, drawn as nearly as possible through the points, shows the functions to be linear in each case. v is the change in y, for each unit of change in x, and is for eq. (4), 2·58. For eq. (5) it is 1·99, which is essentially 2·0.

w	$(w+a)$	n	$\log w$	$\log(w+a)$	$\log n$	$(\log w+a)+\log n$
3·0	4·5	152·5	0·4771	0·6532	2·1833	2·8365
3·5	5·0	95·8	0·5441	0·6990	1·9814	2·6804
4·0	5·5	67·2	0·6021	0·7404	1·8274	2·5678
4·5	6·0	51·2	0·6532	0·7782	1·7093	2·4875
5·0	6·5	36·9	0·6990	0·8129	1·5670	2·3799
5·5	7·0	28·6	0·7404	0·8451	1·4564	2·3015
6·0	7·5	22·7	0·7782	0·8751	1·3560	2·2331
6·5	8·0	18·1	0·8129	0·9031	1·2577	2·1608
7·0	8·5	14·5	0·8451	0·9294	1·1614	2·0908

As will be hereafter shown, the observations are most nearly represented by eq. (3). It is, however, impossible to decide between equations (2) and (3) with absolute certainty, until the experiments are repeated with other values of h and t. For the present we assume the equation

$$(w+\alpha)hn=\frac{c}{w^2} \text{ - - - - - - - - - - - - - - - } (6)$$

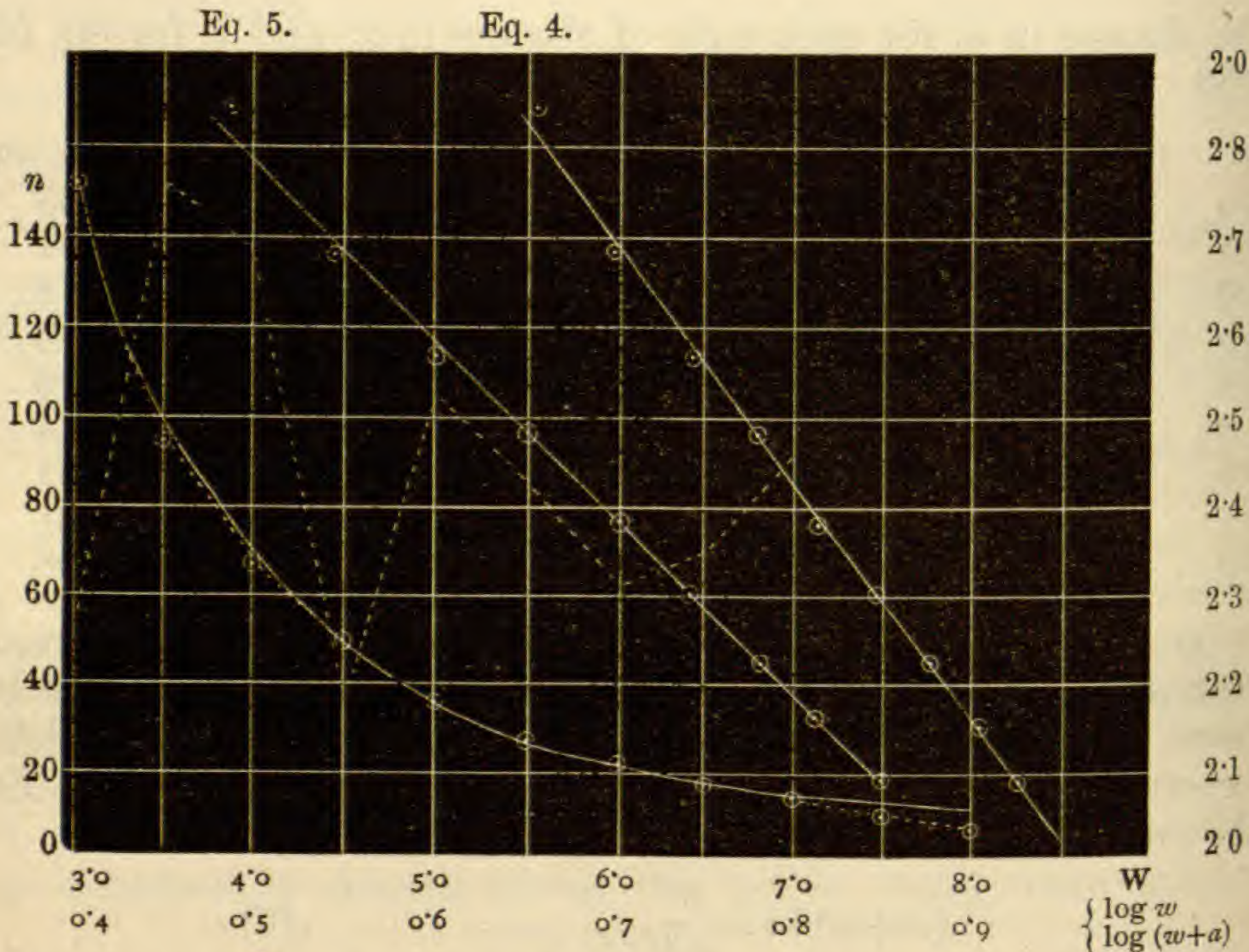
from which we readily have $w^3hn=c-\alpha w^2hn$,
which is of the form of $y=c+\alpha u$.

By the method of least squares, the values of the constants are more accurately determined, and are found to be

$$\alpha=1{\cdot}52 \qquad c=42{\cdot}61.$$

Solving (6) for n, and substituting the proper values, and we have the following comparison of the observed and calculated values of n. δn is n (calc.)—n (obs.). e is the probable error of n (obs.), also in per cent.

w	n (obs.)	n (calc.)	δn (%)	e (%)
2·50	283	242	—14·4	7·5
3·00	152·5	150·3	− 1·4	3·7
3·50	95·8	99·4	+ 3·6	3·6
4·00	67·2	69·2	+ 2·9	2·9
4·50	51·2	50·1	− 2·1	3·3
5·00	36·9	37·4	+ 1·3	2·4
5·50	28·6	28·7	+ 0·3	2·9
6·00	22·7	22·5	− 0·9	1·3
6·50	18·1	18·0	— 0·5	1·1
7·00	14·5	14·6	+ 0·7	0·7
7·50	10·4	11·9	+14·4	0·9
8·00	7·7	9·9	+28·5	5·2



The comparison of the calculated and observed values of n is very satisfactory. This is shown graphically on the chart, the small circles representing the observations. The values of δn, with the proper sign, are also there represented by the broken dotted line, the zero line being the horizontal line, which it repeatedly crosses. The observed value of α is 1·50. The calculated value is 1·52. The difference, 0·02 kgr., being 1·3 per cent of α observed.

Instead of eq. (6), Prof. Haughton has found the relation for the case here discussed, to be represented by the equation.*

$$(w+\alpha)^2 n = A \quad\ldots\ldots\ldots\ldots(7)$$

where for my right arm he finds the values of the constants to be $A=1000$ and $\alpha=1·0$. The experiments from which this formula was obtained are, as before said, unreliable, and the calculated value of α is 33 per cent less than the observed value. This relation would also demand that v', in equation (2), should equal unity. It was found to be 2·58.

In order to test the matter, experimentally, I performed two experiments as follows:

1. The arm alone ($w=0$) was lifted through 90° (from vertical to horizontal) in the time 1·25 seconds, the experiments being conducted exactly as described in my later experiments.

According to (7) for complete exhaustion $n=1000$
" (6) " " $n=\infty$

* Principles of Animal Mechanics. London, 1873. p. 463.

The arm was lifted 2000 *times without feeling any appreciable exhaustion.*

2. A weight $w=0{\cdot}50$ kgr. was lifted, as before, except that the weight was allowed to *drop* during the interval of rest, as in my earlier experiments.

It was lifted 1500 *times with very little of fatigue.*

According to (7) for complete exhaustion $n=$ 440
" (6) " " $n=12000$

In the latter case the time of exhaustion would be $8\frac{1}{3}$ hours. The work done before exhaustion would be 17,000 kgr.-meters. The daily labor of a working man is about 100,000 kgr.-meters. Considering these facts, and also the slight fatigue experienced by me, in experiment 2, I am convinced that my arm could work 8 hours and 20 minutes at the above rate, care being taken to avoid fatigue from other sources (standing on the feet in one position, etc.). It would, however, be a dangerous experiment.

Experiment 2 was also performed with a time $t=1{\cdot}164$ (the time taken in my earlier experiments, reduced by Prof. Haughton) with the same result.

This experiment also shows that eq. (2) does not represent this kind of work, for we deduce, from the chart, for the values of the constants

$$(w+\alpha)h \,.\, n=\frac{21240}{(w+\alpha)^{2{\cdot}58}}\text{-}$$

making $w=0{\cdot}5$, and we have (since $\alpha=1{\cdot}5$ and $h=0{\cdot}7$) $n=2500$. The arm would be exhausted for 2500 lifts, which is hardly possible.

Anyone who will take the trouble to coördinate the corresponding values of c and n' as given in the first table, will see clearly that we were justified in retaining those values of n, and only those, which we there reduced. Each curve, however, gives evidence of the fact, that for any weight, n varies as some power of the strength.

We have made several series of experiments to investigate this point, determining the strength (s) of the muscle, by means of a dynamometer. Calling τ, the time of exhaustion I have found that

$$\tau=\alpha(s-\beta)^{v},$$

where v is a function of the weight, α and β being also constant for the same weight. If the dynamometer really gave the absolute strength of the muscle, β would be equal to w. Precise values of these constants have not yet been obtained, and we therefore decline to discuss this equation any farther at present.

St. Louis, Oct. 31, 1874.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Constitution of Sulphurous Acid and Sulphites.*—Michaelis and Wagner have made some experiments to determine whether sulphurous acid possesses the constitution assigned to it by Strecker, $H \, . \, SO_2 \, . \, OH$, or has the more usual formula $HO \, . \, SO \, . \, OH$. Since, if the former formula be correct, the two hydrogen atoms have different positions in the molecule, it is obvious that the replacement of one of them by another atom or atomic group must give rise to two isomers; while only one compound is possible when they are both replaced by the same radical. By this reasoning, only a single ethyl-ether of sulphurous acid can exist, its formula being $C_2H_5 \, . \, SO_2 \, . \, OC_2H_5$. But in fact two bodies having the composition of ethyl sulphite are known; one boiling at 161° and the other at 207°. The former is the true ethyl-ether of sulphurous acid. The latter, prepared by the action of sodium ethylate upon ethyl-sulphon-chloride, must from its mode of preparation be $C_2H_5 \, . \, SO_2 \, . \, OC_2H_5$. Since the two bodies are not identical, it follows that the only possible formula for the former is $C_2H_5O \, . \, SO \, . \, OC_2H_5$, corresponding to an acid of the formula $HO \, . \, SO \, . \, OH$. This view the authors confirmed by acting with phosphoric chloride upon the sulphurous ether produced when sulphur chloride acts on alcohol. Ethoxyl-thionyl chloride, $Cl \, . \, SO \, . \, OC_2H_5$, was obtained; and this, as shown by Carius, for thionyl chloride, treated with alcohol, yields ethyl sulphite. This result proves that the equivalence of sulphur is different in sulphuric and sulphurous acids, being in the latter a tetrad.—*Ber. Berl. Chem. Ges.*, vii, 1073, Sept., 1874. G. F. B.

2. *On the Organic acids of crude Petroleum.*—Hell and Medinger have examined an acid liquid, obtained by agitating the second running (specific gravity 0·875) in the distillation of heavy Wallachian petroleum with caustic soda, and treating the flocculent precipitate thus formed, after solution in water, with sulphuric acid. This oily acid liquid, which collects on the surface, called mineral-oil acid by the workmen, is a mixture of probably homologous acids, whose separation was exceedingly difficult, fractional precipitation yielding semi-fluid products, and distillation producing decomposition. Finally, an ethyl-ether boiling constantly at 236°–240°, was obtained as a colorless oily liquid, highly refractive, and having an agreeable fruity odor and burning taste. Upon saponification, and subsequent decomposition by sulphuric acid, a colorless acid of specific gravity 0·982 at 0° was obtained, which boiled constantly at 258°–261° without decomposition. It is a weak acid, its ammonium salt being decomposed by water in excess. The sodium and potassium salts closely resemble soft-soaps and could not be obtained in the solid form. Analysis gave as the probable molecular formula of the acid $C_{11}H_{20}O_2$. Its reactions show that it does not belong to either

of the three series of fatty acids at present known, and the authors believe it to be a member of a new series characterized by a peculiar mode of union of the carbon atoms.—*Ber. Berl. Chem. Ges.*, vii, 1216, Sept., 1874. G. F. B.

3. *On the Direct Synthesis of Methyl aldehyde.*—BRODIE has succeeded in effecting a direct synthesis of methyl aldehyde by passing the induction spark through a mixture of carbonous oxide and hydrogen. In his earlier experiments, in which equal (or nearly equal) volumes of the two gases were used, the only other product obtained was marsh gas; and this equally whether carbonous oxide or carbon dioxide was used. By a modification of the conditions of the experiment with carbon dioxide, he has effected the expected synthesis, the 188·6 volumes of gas remaining after the removal of the nitrogen, oxides of carbon, and a trace of oxygen, being composed of 183·2 of hydrogen, 0·2 of marsh gas and 5·2 of methyl aldehyde. This latter amount being equivalent to 2·76 per cent. The reaction appears to be as follows:

$$CO_2+(H_2)_2=COH_2+H_2O$$

Brodie believes that methyl aldehyde was formed in his former experiments, but was subsequently decomposed thus:

$$(COH_2)_2=CO_2+CH_4$$

Ann. Ch. Pharm., clxxiv, 284, Nov., 1874. G. F. B.

4. *Synthesis of an Isomer of Cane-sugar.*—The relation of the glucoses, or simple sugars, to the saccharoses, or compound sugars, is very obvious from their formulas; two molecules of the former by the loss of a molecule of water being united into one molecule of the latter. While it is quite possible by means of ferments, acids, and the like, to reverse this operation and produce the simple sugars from the compound ones, it has not hitherto been possible to build up the latter from the former. GAUTIER has now succeeded in withdrawing a molecule of water from two molecules of dextrose, one of the simple sugars, and thus forming a body having the composition of a compound sugar. The result was effected by dissolving perfectly pure dextrose in nearly absolute alcohol, cooling the solution by means of ice, and then passing very slowly through it a current of dry hydrochloric acid gas. After saturation, the liquid is evaporated in a vacuum, neutralized by barium carbonate and hydrate, treated with strong alcohol, again evaporated, treated with ether to remove a bitter substance, and finally dried in vacuo at 100°. A colorless body is thus obtained, analogous to gum and dextrin in appearance and taste, very soluble in water, and very hygroscopic. Upon analysis, its composition was found to be $C_{12}H_{22}O_{11}$. It has no sweet taste, is not precipitated by ammoniacal lead acetate, reduces the copper test only with difficulty and is dextrogyrate. It is not fermentable, and is decomposed again on heating its aqueous solution to 160°, into two molecules of a simple sugar; but this sugar appears not to be identical with the primitive dextrose, but to be analogous though not identical with inosite, reducing the

copper test but not being fermentable. The author suggests that the acetylic derivative of dextrose obtained by Schützenberger, $C_{12}H_{14}(C_2H_3O)_8O_{11}$, is the octacetylic derivative of this new compound.—*Bull. Soc. Ch.*, II, xxii, 145, Sept., 1874.

5. *On Maltose.*—SCHULZE has re-investigated and confirmed the statement of O'Sullivan that the action of malt-extract upon starch produces, not dextrose as had been supposed, but a compound sugar having the formula $C_{12}H_{22}O_{11}$, which he called maltose. This sugar reduces the copper test only two-thirds as actively as dextrose, but possesses a much greater rotatory power. Schulze's experiments were conducted with diastase, precipitated from malt-extract by alcohol. Starch paste treated with this, at a temperature of 60°, was rapidly saccharified. After concentration and precipitation of the dextrin by alcohol, the solution was evaporated to a syrup treated with alcohol, the clear solution poured off and evaporated over sulphuric acid. Crystals first appeared on the walls of the vessel, and finally the whole solidified to a crystalline mass. Recrystallized from water or alcohol, maltose retains crystal water, which is readily given up at 100°. In appearance, maltose resembles dextrose but is distinguished from it by its composition, its reducing power, and its action on a polarized ray. By boiling with dilute acids it is converted into dextrose. It is therefore an intermediate product between dextrin and dextrose.—*Ber. Berl. Chem. Ges.*, vii, 1047, Sept., 1874.

G. F. B.

6. *Synthesis of Leucic acid by means of its Nitrile.*—ERLENMEYER and SIGEL, by acting on amyl aldehyde—obtained from the alcohol produced by fermentation—with hydrocyanic acid, have produced the true nitrile of leucic acid, as a colorless, peculiarly smelling oil, insoluble in water. It cannot be distilled, being decomposed into the bodies from which it was formed. Potassium and sodium hydrates also decompose it similarly. Analysis gave it the formula $C_6H_{11}NO$. Fuming hydrochloric acid decomposes it, producing ammonium chloride and leucic acid. On the addition of water the latter product separates as an oil, sinking to the bottom. It is removed by means of ether, which leaves it on evaporation as a syrup, from which after a time large transparent crystal plates of the acid separate, having the composition $C_6H_{12}O_3$. There can be no doubt therefore that leucic acid is thus constituted :—

$$\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right\}CH\text{--}CHOH\text{--}COOH.$$

Ber. Berl. Chem. Ges., vii, 1109, Sept., 1874. G. F. B.

7. *Relation of Phthalic acid to Anthraquinone.*—During the preparation of sulpho-anthraquinonic acid in a Basle alizarin manufactory a considerable quantity of a crystallized sublimate was obtained in large colorless needles, which was soluble in water and crystallized therefrom in brilliant plates. WEITH and BINDSCHEDLER examined it and proved it to be phthalic acid, by conversion into the anhydride and into calcium and barium phthalates,

as well as into phthalimide. Further investigation showed that anthraquinone carefully purified from phthalic acid, heated with four parts of fuming sulphuric acid for six hours to 270°, gave colorless needles of phthalic anhydride, nearly an inch in length. Hence anthraquinone must be regarded as the ketone of phthalic acid, the decomposition taking place as follows:

$$C_6H_4\left\{\begin{matrix}CO\\CO\end{matrix}\right\}C_6H_4+2SO_2\left\{\begin{matrix}OH\\OH\end{matrix}\right.=C_6H_4\left\{\begin{matrix}COOH\\COOH\end{matrix}\right.+C_6H_4\left\{\begin{matrix}SO_2OH\\SO_2OH\end{matrix}\right.$$

Ber. Berl. Chem. Ges., vii, 1106, Sept., 1874. G. F. B.

8. *Simple preparation of Uræmatin from Hæmatin.*—Hoppe-Seyler has identified the coloring matter which he had produced by acting upon hæmatin, the coloring matter of the blood, with reducing agents, especially tin and hydrochloric acid, with that obtained from the urine by Jaffe and called urobilin, and that produced from bilirubin by Maly by the action of sodium amalgam. Hence it follows that the coloring matter of normal fæces, and of urine, is only a reduction derivative of the coloring matter of the blood, and that the biliary coloring matters bilirubin and biliverdin are intermediate stages in this reduction. The principal normal coloring matter of the urine, however, is not urobilin but uræmatin; but Hoppe-Seyler states that this is easily derived from urobilin, and that too, by reduction. This discovery opens the way for the solution of interesting questions on the disintegration of the blood-corpuscles under pathological conditions.—*Ber. Berl. Chem. Ges.*, vii, 1065, Sept., 1874. G. F. B.

9. *Asparaginic acid as a product of Pancreatic digestion.*—Since asparaginic acid has been proved to be a product of the splitting up of the albuminates, both vegetable and animal, it occurred to Radziejewski and Salkowski to ascertain whether natural ferments such as that of the pancreatic juice, produced asparaginic acid in their action upon blood-fibrin. Fresh blood-fibrin was digested at 40°–50° with the pancreas of the ox for several hours. Upon testing the solution obtained, asparaginic acid was detected; its identity being established by conversion into the copper salt and by elementary analysis. The formula $C_4H_7NO_4$ requires 36·09 of carbon and 5·26 hydrogen. Analysis gave 35·76 carbon and 5·68 hydrogen.—*Ber. Berl. Chem. Ges.*, vii, 1050, Sept., 1874. G. F. B.

10. *Sympathetic Vibrations*.—M. E. Gripon has studied at length the influence exercised on the vibrations of a column of air by neighboring sonorous bodies. He concludes that the pitch of a vibrating mass of air is raised by bringing near its orifice an elastic membrane or a second mass of air which alone would give the same note. A similar effect is produced, but in a less marked manner if the second mass of air or membrane, has a higher pitch than the first. The pitch of a membrane, on the other hand, is lowered by bringing a solid body near it. In order that a layer of air, bounded on one side by a membrane and on the other by a plane parallel to it formed by a solid free around its edge, may be reinforced by a given sound, its thickness must be proportional to its length;

further, this thickness depends on the ratio which exists between the sound proper to the membrane and the given sound, and also on the nature and dimensions of the membrane.

We can, with sounding tubes with flute embouchure, reproduce the principal phenomena obtained with singing flames.

The pitch of a pipe falls when we bring a solid body near its orifice. This flattening is still produced when the pipe is the center of a solid plane which extends indefinitely around the pipe. The change in pitch is proportional to the number of vibrations of the pipe, and within certain limits nearly proportional to the breadth of the solid rim surrounding the pipe; it is, on the contrary, constant starting from a certain breadth, and then proportional to the diameter of the pipe.—*Ann. Chem. et Phys.*, iii, 343–390. E. C. P.

11. *Electrical Resistance.*—M. Benoit has measured with great precision the electrical resistance of various metals at temperatures from 0° to 860°. He employed both the method of the differential galvanometer and of the Wheatstone's bridge, and for each metal has measured several specimens. The mean of these is given in the following table, the second column giving the resistance of a wire one meter long and having a cross section of one mm. in Ohms, and column three the same quantity in Siemens units. Column four gives the resistance compared with silver:

Metal.	Ohms.	Siemens.	
Silver, A	·0154	·0161	100·
Copper, A	·0171	·0179	90·
Silver, A (1)	·0193	·0201	80·
Gold, A	·0217	·0227	71·
Aluminum, A	·0309	·0324	49·7
Magnesium, H	·0423	·0443	36·4
Zinc, A., at 350°	·0565	·0591	27·5
Zinc, H	·0594	·0621	25·9
Cadmium, H	·0685	·0716	22·5
Brass, A (2)	·0691	·0723	22·3
Steel, A	·1099	·1149	14·0
Tin	·1161	·1214	13·3
Aluminum Bronze, A (3)	·1189	·1243	13·0
Iron, A	·1216	·1272	12·7
Palladium, A	·1384	·1447	11·1
Platinum, A	·1575	·1647	9·77
Thallium	·1831	·1914	8·41
Lead	·1985	·2075	7·76
German Silver, A (4)	·2654	·2775	5·80
Mercury	·9564	1·0000	1·61

A, annealed; H, hardened; (1) silver ·75; (2) copper 64·2, zinc 33·1, lead 0·4, tin 0·4; (3) copper 90, aluminum 10; (4) copper 50, nickel 25, zinc 25.

These results, which are all taken at 0°, agree closely with those obtained by other observers. M. Benoit has extended his observations to a range of temperature much greater than those previously employed for this purpose. He wound the wire around a clay pipe enclosed in a muffle and immersed the whole in a bath of water, mercury, sulphur or cadmium, which was kept at the boiling point by a Perret furnace. Constant temperatures of 100°, 360°, 440° and 860° were thus obtained. Various temperatures below 360° were also obtained by a mercury bath. The measures were also corrected for expansion. Plates annexed to his memoir, presented to the Faculty of Sciences of Paris, show the results graphically. They show that the resistance increases regularly for all metals like tin, lead and zinc up to their point of fusion. This increase, however, differs for different metals. We notice that tin, thallium, cadmium, zinc, lead, are found together in the upper part of the plate; at 200° to 230° their resistance has doubled. Below them are iron and steel; for the last the resistance doubles at 180°, quadruples at 430°, and at 860° is about nine times that at 0°. Palladium and platinum, on the other hand, increase much less and only double their resistance at 400° to 450°. Gold, copper and silver form an intermediate group. In general the conductibility decreases more rapidly in a metal the lower its point of fusion. Iron and steel are an exception to this rule. In alloys the variation is always less than in their constituents, and this is especially the case with German silver.—*Bib. Univ.*, cciii, 284.

E. C. P.

12. *Reflection by Glass.*—Dr. P. GLAN has measured the amount of light reflected by a plate of glass and compared the results with those given by theory. The apparatus employed consisted of a doubly-refracting prism attached to the collimating lens of an optical circle, so that its principal section was parallel to the slit. The objective of the observing telescope carried a Nicol with a divided circle reading to minutes; and the spectral analysis of the light was effected by the prisms of a Hoffman spectroscope set on the table of the apparatus. The slit was divided into two parts by a strip of tinfoil, whose breadth was such that the ordinary image of one-half and the extraordinary image of the other were in exact contact, consequently by turning the Nicol the two adjacent spectra could always be brought to precisely the same degree of brightness. Owing to the dispersion of the doubly-refracting prism, perfect contact was only possible for one color, but the spectra were of such a length as to render the contact close enough over a space of considerable width; by turning the doubly-refracting prism this contact could be effected in any part of the spectrum. A rectangular prism was placed over the lower half of the slit and reflected through it the light of a petroleum flame, while in front of the upper half a small spectrometer was placed, by which the light reflected from the glass was passed through the apparatus. By turning the Nicol the two images were rendered equal, and each observation was repeated five times, using the light of wave-length equal to that of thallium.

In the following table the first column gives the angle of incidence, the second the mean of twelve observations of the amount reflected by a prism of crown glass, the third the amount reflected according to Fresnel's formula, and the fourth and fifth the observed and computed reflections for a similar prism of flint glass. The incident beam is in all cases taken as 100.

	Crown glass.		Flint glass.	
I.	Obs.	Calc.	Obs.	Calc.
30°	5·5	5·9	7·0	7·1
40	7·2	7·3	8·4	9·3
50	10·4	11·4	12·0	13·3
55	13·3	14·1	16·1	16·2
60	17·4	17·9	20·3	20·3
65	23·1	22·9	25·4	25·7
70	29·3	30·2	32·7	33·0

The indices of refraction were found from the angle of total polarization, since Seebeck has shown that the density and, therefore, the refraction of the surface may be considerably altered by grinding. For the crown glass this method gave $n=1·507$, and for the flint glass $n=1·577$. It is evident that the agreement with theory is all that could be expected, since the individual observations differ in some cases as much as four per cent from one another.—*Monats. Acad.*, *Berlin*, 1874, p. 511; *Phil. Mag.*, xlviii, 475.

E. C. P.

13. *Electrical Polarization.*—M. G. QUINCKE describes in detail a great number of experiments on the electrical currents accompanying the non-simultaneous immersion of two mercury electrodes in various liquids, and has arrived at the following conclusions:

If two mercury electrodes, connected by the wire of a multiplier, be immersed one after the other in any liquid which is a conductor of electricity (water, alcohol, saline solutions, etc.), an electric current is observed passing from the freshly wetted mercury surface through the liquid to the other mercury surface. The strength of the current diminishes as the resistance of the liquid column between the electrodes is increased. The electromotive force varies with the nature of the liquid and increases as the concentration diminishes, in some cases amounting to 0·6 of a Volt. The electromotive force increases if the boundary surface of mercury with the surrounding liquid in the last immersed electrode is more quickly produced. It soon, however, reaches a maximum, especially in the case of viscous liquids like glycerine. The cause of these currents is probably the alteration in molecular condition (change of density or concentration), which is gradually accomplished in the liquid near the surface of contact after the wetting. Similar effects are obtained with solid metals, as with mercury. The currents formed with acids are due chiefly to chemical action, and are, therefore, secondary phenomena. The surface tension may be either increased or diminished and may change its sign with the direction and duration of the current. The disturbances in capillarity can not be accounted for by electrolysis.—*Pogg. Annal.*, cliii, 161–203; *Phil. Mag.*, xlviii, 479. E. C. P.

II. Geology and Natural History.

1. *On the Cosmical dust which falls to the earth with atmospheric precipitation;* by A. E. Nordenskiöld.—In the early part of December, 1871, the region about Stockholm was visited by a snow fall of unprecedented magnitude. Nordenskiöld availed himself of this opportunity to investigate whether the apparently pure snow did not contain particles of foreign matter. A cubic meter of the snow was collected and melted with all possible precautions: it was taken, moreover, during the latter part of the storm (which lasted several days), when the atmosphere must have been purified from all accidental dust. Notwithstanding this, a residue was obtained consisting of a black powder, from which, when heated in a matrass, a fluid product was distilled off, and which gave, on being ignited, a reddish-brown ash. It contained also magnetic particles, which gave the reaction for iron.

The experiment was not in all respects satisfactory, as it was at least supposable, notwithstanding the precautions taken, that the organic matter might have had its origin from the thousands of chimneys about Stockholm, and that the metallic iron might have been derived from the roofings of the houses, covered up though they were at the time by several feet of snow. In order to obtain more positive results, the experiment was repeated in a remote forest district of Finland. A large body of snow was collected with care and melted. The result in this case also was a sooty powder, consisting of a black coal-like mass with minute magnetic particles, which proved to be metallic iron. The quantity of material obtained was too small to allow of its being tested for cobalt or nickel.

Still more conclusive evidence to the same point was obtained in the winter of 1872, when Nordenskiöld, in connection with the polar expedition, spent the winter on the northern coast of Spitzbergen. At this point (lat. 80° N.) most remote from all human habitations, the investigations were further carried on. The snow which covered the drift ice, which itself had come from much higher latitudes, was found to be thickly dusted with minute black particles; they rested in part on the surface, and were in part enclosed in the icy snow mass some inches below. The dust was black when collected, but became gray on drying. It proved to contain metallic particles which, with sulphate of copper, gave a precipitate of metallic copper. The experiment was repeated later, the material being obtained from a layer consisting of a granular crystalline mass of altered snow, covered by eight millimeters of old hardened snow, and that in turn by 50 mm. more, which was loose and had recently fallen. At this place it was estimated that about 0·1 to 1· milligram of the magnetic particles were contained in a square meter. Enough of the material was obtained to allow of some qualitative experiments, and it was proved to contain, beside metallic iron, also phosphoric acid, cobalt and probably nickel. The portion insoluble in acids consisted of a firm, angular, colorless powder, in which some fragments of diatoms were observed.

This material has much resemblance to the remarkable dust found by Nordenskiöld scattered on the surface of the ice in the interior of Greenland, as also at a distance of 30 miles from the coast, and to which he gave the name *cryoconite.* This consisted for the most part of minute angular crystalline grains, which were colorless and transparent, with fragments possibly of feldspar and augite crystals, and some black magnetic particles. In an analysis the cryoconite was proved to consist of silica, alumina, oxide of iron, manganese, magnesia, potash, soda, with traces of chlorine and organic matter, and to give the oxygen ratio for the protoxyds, alumina, silica and water, 2 : 3 : 14 : 1. Its specific gravity is 2·63, and the crystalline form is monoclinic.

Nordenskiöld shows that the cryoconite must have had either a cosmical origin, or have come from Jan Mayen, or else some unknown volcanic region in the interior of Greenland, while the presence of cobalt, and probably nickel, would seem to prove that a part of the dust at least had a cosmical origin. He finally comes to this conclusion—that small quantities of a cosmical dust, containing metallic iron, cobalt, nickel, and phosphoric acid and also a carbonaceous organic matter, falls upon the earth along with atmospheric precipitation.—*Pogg. Ann.*, cli, 154, 1874.

[The dust, or cryoconite, has nearly the composition of an oligoglase-trachyte.—E. S. D.]

2. *On Middle Park Mineral Coal;* by E. J. Mallett. (From the *Rocky Mountain News,* Denver, Colorado, of Nov. 19, and dated Territorial School of Mines, Nov. 17, 1874.)—I have examined specimens of coal from Middle Park, and herewith communicate the results, which may be of interest to your readers.

The coal presents somewhat the appearance of bituminous coal of the older epochs, and does not have much tendency to slack or break to pieces. When pulverized, it loses its jet-black color, assuming a dark vandyke-brown. * * * * * *

Although it might be classed as caking bituminous coal, it differs in the following respects from coals of that class:

First. In the nature of the residue left after distillation—a true coke, something similar to that which would be derived from distilling sugar, but too porous and crumbling to support burden in a furnace.

Second. In the large amount of gas and tarry oil produced.

Third. In the brown color of its powder.

English cannel coal was placed in another retort and heated simultaneously with the Middle Park coal, in order to compare roughly the relative amounts of gas. Apparently the domestic coal gave about thirty per cent more gas, of high illuminating power, and very much more liquid distillate than the English coal. When the coal is boiled with concentrated solution of potash, it does not affect the color of the solution. Lignitic or brown coal colors potash solution brown.

Considering all of its properties, I may say that it possesses much in common with the recently discovered mineral called *albertite*, a species of solidified petroleum, and also with what is known as *torbanite.* These two varieties are highly valued by gas manufacturers, who mix from five to twenty per cent of these bituminous compounds with less bituminous coal, thereby greatly increasing the yield and quality of the gas. It resembles the former in the large amounts of gas and tarry oil it yields (which may prove as valuable as that derived from albertite), but differs from it in being heavier—the specific gravity of the albertite being 1·090, while this is 1·323,—also in yielding no soluble products when treated with bisulphide of carbon, spirits of turpentine, ether, etc. From torbanite it differs, in not crackling in the fire, in being much heavier, and in melting and intumescing when heated. Analysis shows it to contain in one hundred parts 6·02 per cent of water and moisture, 39·95 per cent of volatile matter (gas and tarry oil), 54·03 per cent of fixed residue, consisting of coke and ash.

As much confusion exists in the nomenclature of the mineral fuel of Colorado, I would propose, as I recently did to Professor Hayden, to give up entirely the term lignite as a special class name. If we call our mineral fuel lignite, we must conclude that lignite can be either bituminous-caking, bituminous-non caking, anthracite, or possess an organic structure. The term lignite should be dropped, as being inapplicable when applied to our mineral fuel as a class.

The coal from Middle Park is of the class caking-bituminous, and being a peculiar variety, might be distinguished as "Byerite."

3. *Volcanic Phenomena of County Antrim and adjoining Districts, Northeastern Ireland;* by Prof. EDWARD HULL. (Proc. Brit. Assoc., Aug., 1874.)—The Antrim igneous rocks, which include those of the Giant's Causeway, are referred to the closing part of the Eocene period and the whole of the Miocene. The earlier of the ejected rocks—probably later Eocene—are stated to be trachytic lavas; they have a feldspathic base and contain crystals of sanidin and also grains of quartz. They come from many vents and have a thickness in some places of 600 feet. Over these there are sheets of augitic lavas (which are separated often by layers of reddish clayey or soil-like material), and also beds of volcanic ashes. The ash-beds of Ballypalidy, the Causeway and other places contain fossil plants of Miocene character. Following the ash depositions, after a considerable interval, there were other augitic eruptions in vast sheets, covering in some places beds of lignite and others of pisolitic limonite. The whole thickness of the basaltic sheets of Antrim is estimated to be 1100 feet; or 1300 feet for the basaltic and the underlying trachytic sheets. This, though so large, is far short of the thickness on Mull, which is made by Geikie to be 3,000 to 4,000 feet. In both regions the thickness has been reduced by denudation. Mr. Hall states that the thousands of dikes in northeastern Ireland—whose aggregate breadth would be several thousand feet—were made without any crumpling of the strata.

The augitic rock consists of crystalline grains of augite and labradorite with grains of titano-ferrite [a titaniferous magnetite?], and often also of chrysolite. Owing to the amount of iron in the rock, its decomposition has produced beds of pisolitic limonite. No distinct remains of volcanic cones can now be distinguished in the region.

4. *Report of the Geological Survey of Missouri, including field-work of* 1873–4, with 91 Illustrations and an Atlas; by GARLAND C. BROADHEAD, State Geologist. 734 pp. 8vo. Jefferson City, 1874.—We cite the following from this valuable Report.

The "Historical Notes," with which the Report opens, show that lead-mining was begun in Missouri in 1719, but was prosecuted only on a small scale for many years. In 1823 the annual yield was reported at 3,000,000 pounds; in 1873 it reached 27,676,320 pounds. The first iron was made in 1816; the first zinc, in 1867.

The Lower Drift includes large boulders of granite, red quartzyte, greenstone, etc., which increase in quantity and size as we go north. In Sullivan County, a granite boulder measures 20 by 24 feet. The Missouri River seems to limit their southern extension; for only small and scattered ones are seen farther south, and these mostly rounded, as if by stream action. It is very probable that, anterior to the deposit of this rounded drift, but subsequent to the age of deposit on the highest land, an immense lake covered the larger part of the State, including all of North Missouri, St. Louis County, the counties on the Missouri River above Moniteau County, and a portion of the border counties, while all Central and Southern Missouri formed an extensive area of dry land. We have evidence in North Missouri of great erosion previous to the existence of this immense lake.

The total area of the Missouri coal-field is estimated at 23,100 square miles.

The term Choteau Group is used as the equivalent of Kinderhook, on the ground of priority; but, since it was originally applied to but one of the three beds now included, while the "Kinderhook," from the first, was used to include all three—Choteau Limestone, Vermicular Sandstone and Lithographic Limestone—with their equivalents elsewhere, this use seems liable to cause needless confusion. The "greater thickness and better development" of the group in Missouri does not appear to us sufficient reason for replacing a name in itself unobjectionable.

After brief summaries of facts concerning caves, water-supply, soils, economic minerals and rocks, and topographical features of the southwest coal field, there follow over three hundred pages of county reports. The following chapters, on lead, zinc and iron ores, by Schmidt and Leonhard, give many interesting details concerning the occurrence and relations of these ores. At Joplin and Oronogo, the galenite is frequently associated with bitumen, which sometimes entirely impregnates the ore. This bituminous galenite has a darker appearance than the common ore, being often deep black in color. Bitumen is of quite common occurrence in the

Joplin mines. Analyses of galenite, from nine different localities, show an average of a little over an ounce of silver to the ton.

At the Oronogo mines, specimens have been obtained, which show very plainly the gradual change from galenite to cerussite. Crystals or masses of galenite, imbedded in altered and softened limestone, seem to have been coated at first by a compact layer of cerussite. Through this layer, solutions containing carbonic acid penetrated and gradually dissolved the galenite, precipitating a part of the lead as carbonate on the inside of the coating, but carrying most of it out of the shell, either to deposit it immediately or to carry it away. When this process has been continued for some time, we find a round or oval shell of compact and generally crystalline cerussite, of the size of a walnut, or sometimes much larger, containing a dark, transparent, watery fluid, in which a piece of galenite, smooth and rounded, but irregular in shape, is lying loose. If this process continues, the galenite dissolves entirely, and a cavity lined with cerussite crystals is the final result.

In Southwest Missouri, chert (of Subcarboniferous age) occurs in heavy beds. The greatest observed thickness is 105 feet. This is here one of the principal ore-bearing rocks, containing galenite in numerous sheets or seams. It is evident, in all places, that the galenite was formed after the chert had been formed and hardened and in many places broken up. The limestone has undergone, in many places, a process of dolomization. Solutions penetrating it have dissolved the carbonate of lime and partly replaced it with carbonate of magnesia. With this change a contraction is connected; cracks are opened in the mass, and filled with crystallized dolomite. The change was always begun either in fissures or on the surfaces of layers or of broken off blocks, and gradually proceeded toward the interior of the rock. It seems to have preceded the formation of the ore, and to have continued during the whole process. The deposition of zinc ores, especially calamine, and of galenite, is evidently intimately connected with the dolomization. At Granby, the alteration extends through horizontal zones of irregular outline, generally from two to six feet high, above which the solid beds are undisturbed. In the Joplin districts, the ore-deposits are mostly in the form of "runs," extending principally in one horizontal direction, rarely more than five feet wide, and limited in height by the layers of chert above and below the limestone layer, in the crevice of which the run originated. Another mode of alteration of these rocks consists in a gradual solution and removal of the limestone, either unaltered or more or less dolomized. This was undoubtedly effected by water containing carbonic acid. Large caves are produced by this dissolving process, whenever the layers of chert above do not happen to break down.

The lead ores of Central Missouri are mostly in the Lower Silurian limestones, though partly, also, in the Subcarboniferous, as are all those of the southwest portion of the State. None of the deposits as yet worked have proved to be paying to a greater depth than about 80 feet below the surface. This fact is independent of the geological position of the deposits. It is a remarkable fact, also, that while barite is entirely missing in the southwestern region, this mineral is, in this central region, a nearly constant associate of the galenite in the Carboniferous as well as in the Silurian rocks. These facts suggest the idea, as Mr. Schmidt observes, that the occurrence of lead ore, with its associates, is not exclusively dependent on the geological formation, but that its deposition may have taken place simultaneously in similar rocks belonging to different geological periods, which rocks happened to be under similar conditions at the time of deposition. If this suggestion is correct, it would throw the origin of all the galenite of the central and southwestern lead regions into a later period than the Subcarboniferous. As galenite is also found in the seams and partings of the coal strata in Simpson's coal-mine, situated in the lead district of southern Moniteau County, which strata, although belonging to a separate basin, must be supposed to have been formed simultaneously, or nearly so, with the North Missouri coal-field, we may conclude that the galenite is of much later origin, even, than the Coal-measures.

The Atlas accompanying the Report contains geological maps of Cedar, Barton, Vernon, Bates, Howard, Madison, Jasper and Newton Counties, with uncolored maps of the lead districts, and three sheets of parallelized sections of the Coal-measures. These last seem to us objectionable, in that they give but little information, while involving great expense. The *field-notes* thus published might better be reserved for the special study of their author, and only the *thoroughly digested general section* sent to the printer.

5. *Geological Survey of Victoria.* Melbourne, 1874. (London: Trübner & Co.).—Two volumes of Reports on the Geology of Victoria have recently been issued: one, a Report of Progress, by R. Brough Smyth, Secretary for Mines for the Colony, with additional reports on the mineral resources of Ballarat, by R. A. F. Murray, and on certain Coal-fields; and the other, Decade I, on the Paleontology of Victoria, by Frederick McCoy. The plants of the Coal-fields are mostly similar to those of Australia; but no species of *Glossopteris*, the very common Australian genus, have yet been found, and three are mentioned of the genus *Zamites*. *Glossopteris Browniana*, the most abundant Australian species, has, however, been reported from Southeastern Tasmania, along with *Pecopteris Australis*, a plant of both the Australian and Victoria Coal-fields. Professor McCoy makes all these Coal-measures Mesozoic. While no Lepidodendrids occur in these Coal-measures, a species is reported from a sandstone of Gippsland, which is very similar to the European Carboniferous *Lepidodendron tetragonum* Sternb. These beds are supposed to be Subcarboniferous.

The most interesting discovery mentioned in the Reports is that of the occurrence of many American species of Graptolites in the slates of Victoria. Mr. McCoy has identified 12 to 14 species of this group; and, of these, Decade I contains descriptions and figures of the following, which are described by Hall from the

Quebec group of the Lower Silurian: ***Phyllograptus typus*** Hall, ***Didymograptus mucronatus*** Hall, ***Diplograptus pristis*** (***Prionotus pristis***, var. B., Hall), ***D. bicornis*** Hall, ***Graptolites fruticosus*** Hall, ***G. quadribrachiatus*** Hall, ***G. bryonoides*** Hall, ***G. octobrachiatus*** Hall, ***G. Logani*** Hall. The last four are very common species both in Canada and Victoria, though rare in Europe.

6. *Report upon Vertebrate Fossils discovered in New Mexico, with descriptions of new species;* by Prof. E. D. COPE, Paleontologist. 18 pp. 8vo. Geogr. Expl. and Surveys west of the 100th Meridian, First Lieut. G. M. WHEELER, Corps of Engineers, U. S. Army, in charge.—Professor Cope states that the Eocene discoveries show that an Eocene lake extended over the part of New Mexico now drained by the tributaries of the Chama River on the east and the San Juan on the west. The Mammalian remains differ from those of the Fort Bridger Eocene in the absence of species of the genus *Palæosyops*, and its replacement by *Bathmodon* Cope, and by the presence of only one small *Hyrachyus*. Four new species of Toxodonts are among the discoveries reported; they are referred to the new genera *Ectoganus* and *Calamodon*.* The teeth of six or seven species of sharks and one *Ostrea* have been found with the Mammalian remains.

7. *Twenty-sixth Annual Report on the New York State Museum of Natural History;* by the Regents of the University of the State of New York. Transmitted to the Legislature, May 2, 1873. 192 pp. 8vo. Albany, 1874.—The series of Reports on the New York State Museum, which has now reached its 26th number, is of great value to science on account of the descriptions of new species contained in it, and especially of species of fossils by Professor JAMES HALL. The volume just issued contains descriptions of over 50 species of Bryozoans and Corals of the Lower Helderberg group, by Professor Hall; besides, also, Entomological Contributions, No. III, by J. A. LINTNER, including notes on the larves or transformations of various insects, and descriptions of some new species; and also a report of the Botanist, C. H. PECK, containing among its tables a list of plants hitherto unreported from the State, with various notes.

8. *Wind-drift erosion: Note by* G. K. GILBERT. (Communicated.)—At the Hartford meeting of the American Association for the Advancement of Science, a paper was presented by the writer upon "Erosion by Sand in the Western Territories," and an abstract of the same is already in type for the forthcoming volume of the Proceedings. One of the topics discussed was the degradation of desert plains by drifting sand—a degradation evinced by the peculiar worn surfaces of the pebbles which strew the plains. The hard pebbles exhibit a high polish; the softer parts of the heterogeneous are deeply scored; and pebbles of limestone are carved with an arabesque plexus of furrows. These phenomena were briefly noted by Dr. J. S. Newberry in 1861 (Geol.

* According to Professor Marsh, this genus is identical with his *Stylinodon*, described in this Journal in vol. vii, p. 532, May, 1874, where its resemblances to *Toxodon* were mentioned.—EDS.

Ives' Exped., pp. 17 and 24), and his observation was cited as the first on record. I have recently had my attention called to the fact that the phenomena were earlier observed by Prof. W. P. Blake, who published descriptions in this Journal and elsewhere in 1855, prior to the organization of Lieut. Ives's Expedition. (Pacific Railroad Rept., v, 108, 230 and 232; Am. Jour. Sci., 2d ser., xx, 180; Proc. Amer. Assoc. Adv. Sci., 1855, p. 218.) His description, which is more extended than Dr. Newberry's, touches the majority of the features to which I called the attention of the Association at Hartford; and to him belongs the credit of having first discovered and truly explained the facts.

9. *Zircon-syenyte of the Canaries.*—M. Meunier mentions in the Comptes Rendus (lxxix, p. 594, Sept., 1874) the occurrence of zircon-syenyte in the Canary Islands, the rock being identical with that long known from Scandinavia.

10. *Text-book of Geology, designed for Schools and Academies;* by JAMES D. DANA. 2d edition, 358 pp. 8vo. Illustrated by 400 woodcuts. New York and Chicago, 1874. (Ivison, Blakeman, Taylor & Co.)—This Geological Text-book of Professor Dana has been thoroughly revised, and thereby adapted to the arrangement of the new edition of the Manual and to the present state of geological science. The work is somewhat enlarged by the addition of new facts and illustrations, but without adding to the number of pages, the page having been increased in size to balance the additions, and also—as is true equally of the much-enlarged Manual—without an increase of price. The book is well printed on good paper.

11. *New American Geological Reports.*—The following Reports have been received, and will be noticed in another number of this Journal.

The Geology of New Hampshire, C. H. HITCHCOCK, State Geologist, and J. H. HUNTINGTON, Principal Assistant. Part I, Physical Geography. 668 pp. royal 8vo, with many plates and wood-cuts.

Contributions to the Fossil Flora of the Western Territories: Part I, *The Cretaceous Flora;* by LEO LESQUEREUX. 136 pp. 4to, with thirty lithographic plates, constituting volume VI of the quarto Reports of the United States Geological Survey of the Territories, F. V. Hayden, U. S. Geologist in charge. Department of the Interior.

First Annual Report of the Geological and Agricultural Survey of Texas; by S. B. BUCKLEY, A.M., Ph.D., State Geologist. 142 pp. 8vo. Houston, Texas, 1874.

Geological Survey of California, J. D. WHITNEY, State Geologist. *Contributions to Barometric Hypsometry*, with tables for use in California. 88 pp. roy. 8vo. 1874. Also map of California and Nevada. 1874.

The Surface Geology of Ohio: from vol. ii, of the Reports of the Geological Survey of Ohio; by J. S. NEWBERRY.

12. *Memoirs of the K. K. geologische Reichsanstalt.*—The following very fully illustrated memoirs in 4to, have been recently published by the K. K. geologische Reichsanstalt, Vienna.

Die Fauna der Schichten mit *Aspidoceras acanthicum;* by Dr. M. Neumayr. 1873.

Ueber einen neuen fossilen Saurier aus Lesina; by Dr. A. Kornhuber. 1873. The species is named the *Hydrosaurus Lesinensis.*

Ueber die triadischen Pelecypoden-Gattungen *Daonella* & *Halobia;* by Dr. E. M. v. Mojsvár. 1874.

Ueber die palæozoischen Gebilde Podoliens und deren Versteinerungen; by Dr. A. v. Alth. 1874.

Die Cephalopodenfauna der Gosauschichten in den nordöstlichen Alpen; by A. Redtenbacher. 1873.

13. *Manual of Determinative Mineralogy, with an Introduction on Blow-pipe Analysis;* by George J. Brush, Professor of Mineralogy in the Sheffield Scientific School. 8vo. New York, (John Wiley & Son.)—Professor Brush calls his work a compilation based on the tenth edition of Von Kobell's Tables. But, while this is true of it, he has contributed largely to the work from his own long labors in blowpipe mineralogy. Moreover, the species, with their blowpipe characters, and also, in additional columns, the several physical characters, have been arranged in a series of extended tables, which will be found exceedingly convenient by the student and sure of leading him, if he faithfully uses it, to the name of any mineral in hand. All species are included in it, even those recently announced.

This volume, as the Preface states, constitutes the Determinative Part of Dana's System of Mineralogy.

14. *Pharmacographia: a History of the Principal Drugs of Vegetable origin met with in Great Britain and British India;* by F. A. Fluckiger, Ph.D., Professor in the University of Strassburg, and Daniel Hanbury, F.R.S., &c. London: Macmillan & Co., 1874. pp. 704, 8vo.—A standard work like this has long been wanted; and to Mr. Hanbury, botanists and druggists have been looking for it. The part taken by his German colleague is not specified; but the result is in every way satisfactory. It is not a treatise on Materia Medica, at least in the modern sense; the therapeutical applications of the drugs are indicated only in a general way; still less is it concerned with pharmaceutical details and manipulations. Nor is it a Medical Botany, although accurate botanical knowledge is turned to the best account; and the arrangement follows the natural orders of the plants yielding the drugs. It is the drugs themselves that are identified and described, rather than the plants that produce them. Their botanical origin is briefly discussed; their history is next given, generally with fulness and freshness, condensing the results of much research and literary labor; chemical composition is noted, but with no superfluity of symbolic formulas; under "Production and Commerce" much statistical and trade information is given; medical and economical uses are indicated; the nature of the principal adulterations noted, and the means of detecting them pointed out; and, finally, occasional substitutes, not of the nature of adulteration, are specified. In describing a root, bark, or the like, the microsopic

structure plays an important part, and is duly attended to. It has well been said that this can be made clear and explicit only by means of figures; but figures in sufficient number to be of much account would greatly increase the size and enhance the price of the work. A hand-book like this must do without them. A. G.

15. *Hymenomycetes Europæi, sive Epicriseos Systematis Mycologici editio altera;* scripsit ELIAS FRIES (Sumptibus auctoris). Upsaliæ, 1874.—The preface to this classical volume (of 755 8vo pages) is dated August 15, 1874, upon the venerable author's eighty-first birthday. He began to publish upon these *Fungi* sixty years ago, has all along been the acknowledged head and master of this recondite department, as well as one of the most learned and critical of Phanerogamous botanists; and his wonderful powers and sure judgment appear to be almost unabated. The full index fills nearly 50 pages. A. G.

16. *Miocene Fossil Plants of Greece.*—In the *Revue Bibliographique* of the Bull. Bot. Soc. France, 1874, p. 114, an abstract is given of a critical examination of Fossil Plants of Koumi, in Eubæa, by Count Saporta, a paper contributed to the *Ann. Sci. de l'Ecole Normale Supérieure*, ser. 2, t. 2. The main interest lies in the discovery of a Miocene flora, rich in peculiar species, and allied on one hand to the present Mediterranean vegetation, on the other to that of South Africa. It has *Widdingtonia*, *Podocarpus*, *Cussonia*, *Myricæ*, and *Anacardiaceæ*, &c., of the Cape types, and an *Encephalartos*, the first fossil *Cycadea* clearly made out as of an existing genus. It contains, moreover, *Glyptostrobus Europæus* of Heer, which passes insensibly into the existing representative, *G. heterophyllus* of China; and a *Sequoia* (*Fournalii*), which so closely approaches *S. sempervirens* of California, "que l'on ne saurait marquer aucune divergence sensible entre ces deux espèces." A. G.

17. *Mace.*—The mace of nutmeg, once taken as the type of an *arillus*, was, a good while ago, distinguished as a *arillode*, or false aril, by Planchon, on finding that it developed from the micropyle, while a true aril is a growth from the hilum or summit of the funiculus. Hooker and Thomson's statement, that the mace develops from both the micropyle and the hilum, has been confirmed by Baillon (*Comptes Rendus*, 78, p. 779, abstracted in *Rev. Bibliogr.* of Bull. Bot. Soc. France, l. c.). The consequence is that the distinctions between *arillus* and *arillode*, *caruncle* and *strophiole* become not exactly superfluous, but systematically unimportant. A. G.

18. *Organogeny of the Andrœcium and its bearings upon natural affinities*, by M. CHATIN.—A long and important series of papers in the Comptes Rendus, t. 78, 1874, of which a full and clear abstract is given in the Revue Bibliographique, above cited, occupying six pages. A. G.

19. JOHN TRAHERNE MOGGRIDGE's name was misprinted *Maggridge* in the January number, p. 69. He was, as we learn, a grandson of *Dillwyn* of Swansea; and so his taste for natural history came by inheritance. A. G.

20. *On the effects of certain Poisons on Mollusks;* by WILLIAM NORTH RICE, of Middletown, Conn. (From the Proceedings of the American Association for the Advancement of Science, Portland Meeting, August, 1873.)—Professor Rice closes his paper on this subject with the following paragraph:

Among the most interesting results of the experiments was the observation that certain poisons which act with extreme violence upon the mammalia, are very feeble in their action on the mollusca. This is especially true of hydrocyanic acid and woorara. Specimens of *Ilyanassa obsoleta*, immersed in dilute hydrocyanic acid on Friday, showed somewhat feeble signs of life on the following Tuesday. A specimen of *Lunatia heros*, into which a quantity of woorara had been injected, was found the next day to show no sign of any injury. Indeed, both of these poisons seemed to produce death very little sooner than the animals would have died in stale water. The sudden introduction of a large amount of carbonic acid in the manner which has been described, seemed to produce no decided effect. On the other hand, chloral hydrate seems to be very suddenly fatal, the animals treated with it becoming instantly contracted, and not resuming their activity when kept for a number of hours in sea water. Cyanide of potassium is similar in its effects, though not quite so instantaneously fatal. The effects of quinine are similar, though less energetic. Chloroform produces instantaneous contraction, and probably death; but, as the animals treated with this poison were not afterward kept for a time in pure sea water to give them an opportunity to revive, it is not certain that they were really dead.

21. *On the mode in which Amœba swallows its Food.*—Professor LEIDY remarked that he had supposed that Amœba swallows food by this becoming adherent to the body, and then enveloped, much as insects become caught and involved in syrup or other viscid substances. He had repeatedly observed a large Amœba, which he supposes to be *A. princeps*, creep into the interstices of a mass of mud and appear on the other side without a particle adherent. On one occasion he had accidentally noticed an Amœba, with an active flagellate infusorium, a Urocentrum, included between two of its finger-like pseudopods. It so happened that the ends of these were in contact with a confervous filament, and the glasses above and below, between which the Amœba was examined, effectually prevented the Urocentrum from escaping. The condition of imprisonment of the latter was so peculiar that he was led to watch it. The ends of the two pseudopods of the Amœba gradually approached, came into contact, and then actually became fused—a thing which he had never before observed with the pseudopods of an Amœba. The Urocentrum continued to move actively back and forth, endeavoring to escape. At the next moment a delicate film of the ectosarc proceeded from the body of the Amœba, above and below, and gradually extended outwardly so as to convert the circle of the pseudopods into a complete sac, inclosing the Urocentrum. Another of these crea-

tures was noticed within the Amœba, which appeared to have been inclosed in the same manner.

This observation would make it appear that the food of the Amœba ordinarily does not simply adhere to the body, and then sink into its substance, but rather, after becoming adherent or covered by the pseudopods or body, is then inclosed by the active extension of a film of ectosarc around it.—*Proc. Acad. Nat. Sci. Philad.*, p. 143.

22. *On the Motive Power of Diatoms.*—Professor LEIDY made some remarks on the moving power of Diatoms, Desmids, and other Algæ. While the cause of motion remains unknown, some of the uses are obvious. The power is considerable, and enables these minute organisms, when mingled with mud, readily to extricate themselves and rise to the surface, where they may receive the influence of light and air. In examining the surface-mud of a shallow rain-water pool, in a recent excavation in brick clay, he found little else but an abundance of minute diatoms. He was not sufficiently familiar with the diatoms to name the species, but it resembled *Navicula radiosa.* The little diatoms were very active, gliding hither and thither, and knocking the quartz sand grains about. Noticing the latter, he made some comparative measurements, and found that the Naviculæ would move grains of sand as much as twenty-five times their own superficial area, and probably fifty times their own bulk and weight, or perhaps more.—*Ibid*, p. 113.

23. *The Common Frog;* by ST. GEORGE MIVART. Nature series. Macmillan & Co., 1874.—This little treatise contains not only a large amount of information concerning the comparative anatomy of frogs, but also numerous illustrations of the anatomy of other animals, and of man, introduced for the sake of comparison with the corresponding parts of the frog. It is illustrated by eighty-eight cuts, most of them excellent. V.

24. *Animal Mechanism: a Treatise on Terrestrial and Aerial Locomotion;* by E. J. MAREY. With one hundred and seventeen figures. International Scientific series. D. Appleton & Co., New York, 1874.—In this work the Subject of animal locomotion is treated in a very clear, analytical and concise manner, while the numerous illustrations render even the most complicated mechanisms easily understood. The first part of the book treats of the various forces and organs concerned in locomotion; the second treats of terrestrial locomotion; the third, of the flight of insects and birds. The author presents in this work the results of his own extensive investigations of this subject, and gives full accounts of the numerous mechanical contrivances by which the wings, legs, and bodies were made to record their own motions. Many of the tracings are reproduced in the cuts. Several machines, so constructed as to imitate faithfully the essential motions and effects of the wings of insects, are described and figured. The entire subject is so well explained and illustrated that the book cannot fail to be interesting and instructive, even to non-scientific readers. V.

III. Astronomy.

1. *The Transit of Venus, Dec.* 8, 1874.—The following notices present a summary of the stations at which successful observations of the Transit were made so far as information has yet been received. The stations are arranged in the order of latitude :

In the Northern Hemisphere.

1. *Tschita.* Lat. 52° 0′ N., long. 7h. 34m. E. Russian station. Contacts observed and four series of measures with heliometer.
2. *Nertchinsk.* Lat. 51° 18′ N., long. 7h. 58m. E. Russian station. Three contacts observed, and two diameters and twenty distances of the planet measured with heliometer.
3. *Kiachta.* Lat. 50° 20′, long. 7h. 6m. E. Russian station. Eight photographs taken.
4. *Habarovka.* Lat. 48° 16′, long. 8h. 58m. E. Russian station. First two contacts and some chords observed.
5. *Jassy.* Lat. 47° 3′, long. 1h. 50m. E. German station. Last external contact observed.
6. *Wladiwostok.* Lat. 43° 7′, long. 8h. 47m. E. American and Russian station. First and second contacts observed, 13 photographs taken, and numerous distances of the two limbs were measured.
7. *Port Possiet.* Lat. 42° 42′, long. 8h. 43m. E. Russian station. Two interior contacts observed and 38 photographs taken.
8. *Orianda.* (North of the Crimea?) Russian station. Satisfactory observation of last two contacts.
9. *Pekin.* Lat. 39° 54′, long. 7h. 46m. E. American and French station. First and second contacts observed and photographs taken.
10. *Tschifu.* Lat. 37° 30′, long. 8h. 5m. E. German station. The observation of contact, the heliometer measurement, and the photographs succeeded splendidly.
11. *Teheran.* Lat. 35° 37′, long. 3h. 25m. E. Russian station. Observations successful.
12. *Yokohama.* Lat. 35° 36′, long. 9h. 19m. E. Russian station. Observation successful.
13. *Kobe.* Lat. 34° 40′, long. 9h. 1m. E. French station. Successful observations.
14. *Nagasaki.* Lat. 32° 45′, long. 8h. 39m. E. American and French station. Second contact observed well, first and third contacts observed through clouds. 60 good photographs. 150 micrometric measurement of cusps, separation of limbs and diameter of Venus.
15. *Ispahan.* Lat. 32° 40′, long. 3h. 27m. E. German station. 19 photographs taken.
16. *Cairo.* Lat. 30° 6′, long. 2h. 5m. E. English station. Last two contacts well observed.
17. *Suez.* Lat. 29° 58′, long. 2h. 10m. E. English station. Last two contacts observed satisfactorily.
18. *Roorkee.* Lat. —, long. —. East India Co. station. 100 photographs taken.
19. *Thebes.* Lat. 25° 43′, long. 2h. 10m. E. English station. Last two contacts well observed. 50 photographs taken. Russian station. Splendid weather; very important observations.
20. *Honolulu.* Lat. 21° 18′, long. 10h. 31m. W. English station. First two contacts well observed. Photographs unsatisfactory. The complete disc of Venus was seen twelve minutes before the internal contact. The first contact was observed at 3h. 7m. 1s.; the time computed in the Eng. Naut. Alm. was 3h. 5m. 18s; O—C = +1m. 43s. Second contact obs. 3h. 35m. 55·7s.; comp. 3h. 33. 0s; O—C= +2m. 55·7s.

In the Southern Hemisphere.

1. *Sydney.* Lat. 33° 31′ S., long. 10h. 5m. E. English Observatory. Observations satisfactory.
2. *Adelaide.* Lat. 34° 40′, long. 9h. 15m. E. English Observatory. Last two contacts well observed. The third contact was observed at 3h. 4m. 43·4s.; the time computed by the American Commission was 3h. 5m. 49s.; O−C = − 1m. 6s. Fourth contact obs. 3h. 34m. 7·5s.; comp. 3h. 35m. 39s.; O−C=−1m. 32s.
3. *Melbourne.* Lat. 37° 49′, long. 9h. 40m. E. English Observatory. Observations successful.
4. *Queenstown,* New Zealand. Lat. ——, long. ——. American station. Observations successful. Ingress observed and 237 photographs taken.
5. *Hobart Town.* Lat. 43° 0′, long. 9h. 49m. E. American station. 113 photographs taken.
6. *Christ Church,* New Zealand. Lat. 43° 20′, long. 11h. 31m. E. English station. Failure from clouds.

2. *Aurora Australis at Melbourne, Victoria.*—Traces of the aurora were seen on the evenings of the 7th and 8th of March; there were a few faint pink streamers on the 7th at 7.30 P. M. It was also seen on the 8th at Cape Otway and Port Albert, and on the evening of the 10th at Mount Macedon.—*Monthly Record during March,* 1874, *under the Superintendence of R. L. J. Ellery, Government Astronomer, Melbourne.*

IV. Miscellaneous Scientific Intelligence.

1. *Royal Society.*—The Copley medal of the Royal Society has been awarded to Prof. Louis Pasteur, "for his researches on Fermentation and Pebrine;" and the Rumford medal to J. Norman Lockyer, "for his spectroscopic researches on the Sun and on the Chemical elements."

2. *Proceedings of the Centennial of Chemistry.*—Numbers 2, 3 (for August and September) of volume v of the American Chemist are occupied with the proceedings of the Centennial meeting at Northumberland. They contain the address of Prof. H. H. Croft, on the life and labors of Priestley; of Dr. H. Coppée at the grave; of T. Sterry Hunt, on the century's progress in chemical theory; of J. Lawrence Smith, on the century's progress in industrial chemistry, and of B. Silliman, on American contributions to chemistry. To the last the author has added, with much labor, a list of papers published by American authors, bearing on chemistry, physics, and the chemical composition of minerals, and including also references to many papers on other topics.

Report of the Commissioners of Agriculture for 1873. 496 pp. 8vo. Washington, 1874.

Half-hour Recreations in Popular Science. No. 11. The Transmission of Sound by the Atmosphere, by John Tyndall. Gigantic Cuttle-fish, by W. S. Kent. 32 pp. 8vo. Boston. (Estes & Laureat.)

Half-hours with Insects. Part 5. Insects of the Pond and Stream, by A. S. Packard, Jr. pp. 129–160, 12mo. Boston. (Estes & Laureat.)

Tidal Researches, by William Ferrel, A.M., Assistant U. S. Coast Survey. Appendix to the U. S. Coast Survey Report for 1874. A profound work, the result of many years labor.

Topographical Survey of the Adirondack Wilderness of New York for the year 1873; by Verplanck Colvin. Transmitted to the New York Legislature, April 21, 1874. 306 pp. 8vo, with many valuable maps. Albany, 1874.

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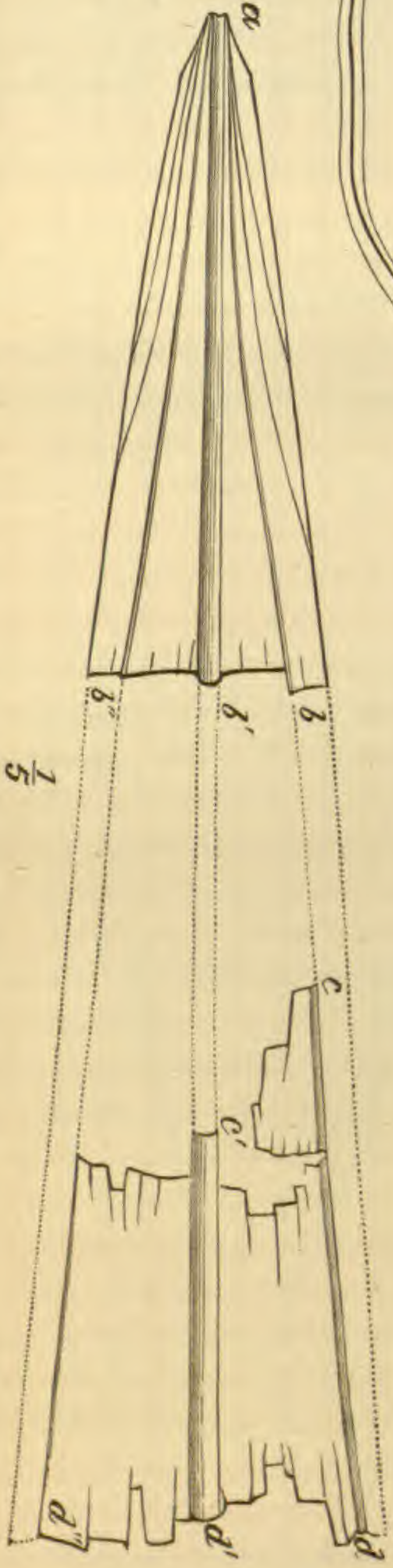

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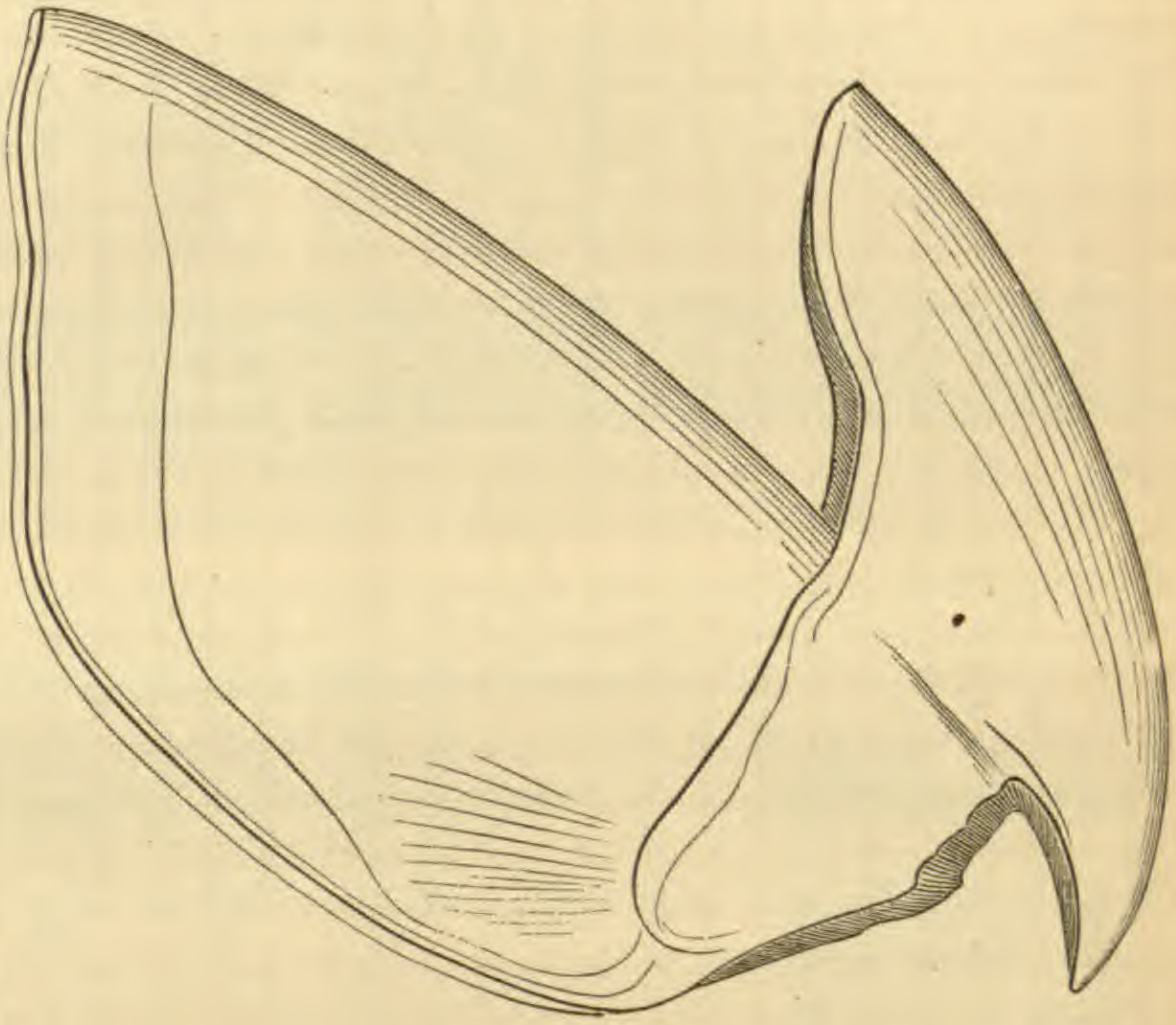

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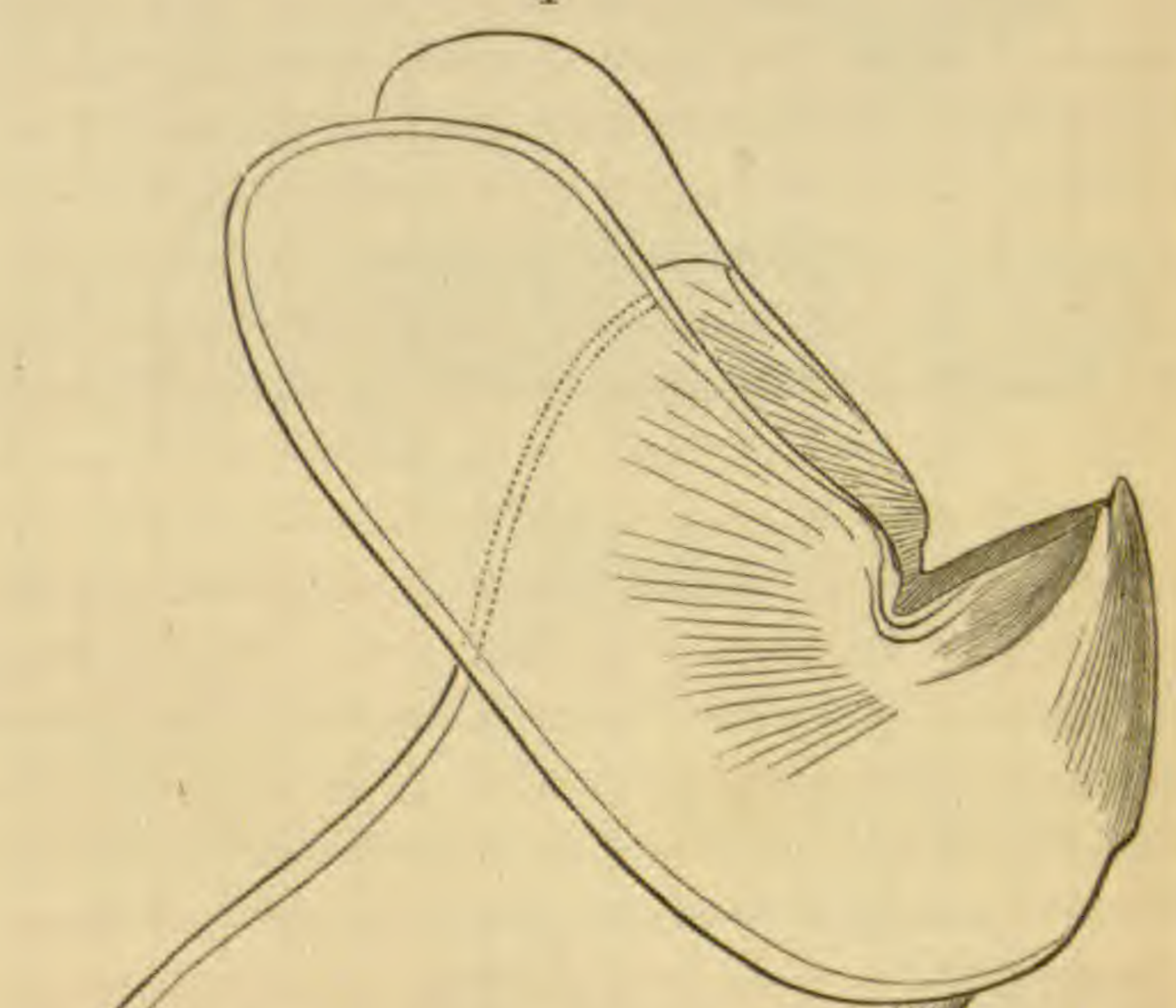


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THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XVIII.—*On some Phenomena of Binocular Vision;* by JOSEPH LECONTE, Professor of Geol. and Nat. Hist., University of California.*

VII. *Position of the eyes in sleepiness.*

IT is usually taught, and I think universally believed by physiologists, that in sleep and also in extreme drowsiness, when control over the ocular muscles is lost, the optic axes turn upward and *inward.* Müller says:† "During sleep the eyes have a peculiar position. At that time, as well as in a *state of mere sleepiness*, both eyes are turned *inward* and upward." I find similar statements by other writers on this subject; but I cannot find any experiments or observations upon which this conclusion is based. I think it probable that it has been reached indirectly thus: It is known that in a state of sleepiness the images of objects double. This double vision may arise either from convergence on divergence of the optic axes. It is very naturally attributed to the former, because in sleep the iris is contracted, and contraction of the irides is usually consensual with convergence of the optic axes. Thus Müller says (p. 535): "The contracted state of the irides in sleep is *a consensual motion dependent on the position of the eyes*, which are turned upward and inward by the inferior oblique muscles." The experiments I am about to describe, however, prove conclusively that, if not in sleep, at least *in sleepiness* or the act of falling to sleep, *the optic axes diverge.*

* For preceding articles on this subject, see this Jour., Ser. II, vol. xlvii, pp. 68 and 153; and Ser. III, vol. i, p. 33, vol. ii, p. 1, vol. ii, pp. 315 and 417.

† Müller's Physiology, Baly's Translation, Am. ed., p. 810.

There are few persons, I suppose, who have not experienced an unconquerable drowsiness while listening to a dull speaker on a warm summer afternoon. Every one at such times must have observed that as the control over the ocular muscles is lost, the head of the speaker, whom he is vainly attempting to regard with attention, becomes double; the two heads separating more and more, until, at the distance of 30 feet, they may seem 10 to 15 feet apart. In my own case the control over the eyes is lost even while the consciousness is perfect, and the mind in a condition to make a scientific experiment. Often, although, by an effort, the control over the eyes could be retained, I have chosen to abandon it, in order to make the experiments related below.

In accordance with the usual doctrine, I had long supposed that this doubling of images in sleepiness was due to optic convergence. On testing it, however, I found I was mistaken. I tested it as follows:

It is well known that the images of all objects nearer or farther off than the point of optic convergence (point of sight) are double. But there is this difference in the two cases: if the object be beyond the point of sight, i. e. if the optic convergence be *too great*, the images *are homonymous*; but if the object be nearer than the point of sight, i. e., if the optic convergence be *too small* (and *a fortiori, if there be optic divergence*) *the images are heteronymous.* Now I have found it perfectly easy, even in the state of drowsiness already mentioned, to perform an experiment to test the position of the optic axes. As soon as the head of the speaker doubles and the two images are well separated, I wink the *right* eye. Invariably the *left* image disappears. The images are therefore heteronymous, and *heteronymous images in this case prove optic divergence.* For even with the point of sight at infinite distance, i. e., the optic axes parallel, the doubling of an object at the distance of 30 or 40 feet would be almost imperceptible (the distance between the centers of the two images being only equal to the interocular distance, or $2\frac{1}{2}$ inches), while in the experiments the images were widely separated, in some cases 10 to 15 feet, indicating therefore an optic divergence of 15° to 20°.

I am sure, in the course of 15 or 20 years I have performed this experiment many hundred times, and always with the same result. But thinking it possible that my own case might be exceptional, I asked Professor E. P. Alexander, one of my colleagues in the University of South Carolina, who had been troubled with similar drowsiness, to make the same experiments. He did so, and his results were identical with my own.

In every case, of course, the experiment rouses the mind and quickly re-unites the images, but not so quickly but that the result is perfectly obvious. But lest some may regard this speedy re-union of the images as an objection to the reliableness of this mode of experimenting, I devised another method, which is not open to this objection.

While gazing on vacancy, objects near at hand are very perceptibly double, the images being heteronymous. Now if while thus gazing, perhaps in profound thought, the observer should happen to be overcome with drowsiness and lose control over the eyes, *the already heteronymous images will separate more and more widely.* I have made this experiment many times while lying abed in the morning and always with the same result. But this result is impossible except by optic *divergence*, for by convergence the images would approach each other, unite and then cross over and become homonymous.

Thus, then, it is certain, that *in the act of falling to sleep the eyes diverge.* Whether this position is retained in profound sleep, I have tried in vain to determine. The attempt to make observations on the eyes of sleepers, for this purpose, invariably introduces disturbing influences which vitiate the result. I have also attempted observations on sick infants, who often, in a weak condition, drowse with the eyes half open ; but I have always found, under these circumstances, the action of the ocular muscles irregular and the position of the optic axes, therefore, unsteady. Nevertheless it seems highly probable that in profound sleep, also, the position of the optic axes is divergent.

I will now bring forward several facts which point to the conclusion reached by these experiments, viz: that the *optic axes diverge when completely relaxed.*

1. Double vision is a well-known phenomenon of the state of drunkenness. Accompanying the double vision there is always observable an unnatural appearance of the eyes, resulting from a want of the perfect parallelism or the very slight convergence of the optic axes, which is a necessary condition of single vision. Double vision may result from too much convergence (squinting) or from divergence; but I think every one who has observed persons in this state will agree with me that the eyes do not squint but *diverge* as in sleepiness, and from the same cause, viz: a loss of control and consequent relaxation of the normal tonic contraction of the muscles of the eyes.

2. The axes of the conical eye-sockets, if produced, would meet each other about the occiput. This gives a divergence, in passing forward, of about 25°. It is probable that in a state of absolutely perfect relaxation, the optic axes coincide with the axes of the eye-sockets, and it requires, therefore, some contraction to bring the optic axes to a condition of parallelism and still more to a condition of convergence, as in every volun-

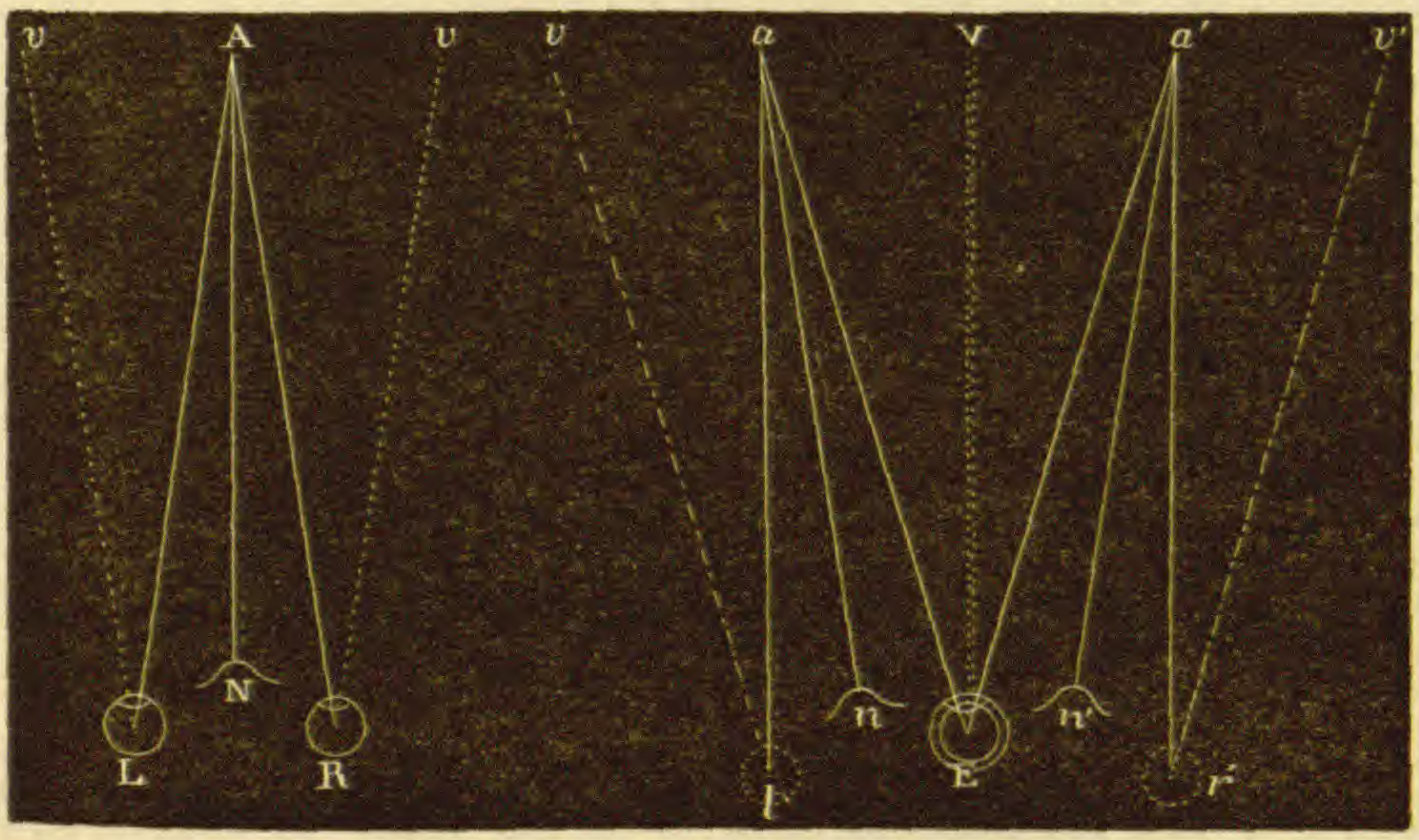
tary act of sight. In the human eye, therefore, and also in that of the highest animals, there are three conditions of the optic axes: 1st, convergence, when we look at a near object; 2d, parallelism, when we look at a distant object or gaze on vacancy; 3d, divergence, when we lose control of the eyes, as in sleep, in drunkenness and probably in death. The 1st requires a distinct voluntary effort—a distinct voluntary contraction of the ocular muscles; in the 2d there is no *voluntary* contraction, but only that tonic contraction characteristic of the waking state; in the 3d the relaxation is complete. The 1st is the *active* state of the eye; the 2d the *waking* passive state; the 3d the *absolutely* passive state.

3. In most normal eyes, in the waking passive state, the optic axes are perfectly parallel, and it is impossible to carry the relaxation so far as to produce divergence. Hence it is easy to double a near object either by looking at a *nearer* or at a *more distant* point—either by *too great* or too small convergence; but it is impossible to double an infinitely distant object, like a star, except in one way, viz: by convergence—by crossing the eyes. For the same reason it is impossible for most normal eyes, *without the use of instruments*, to combine stereoscopically two similar objects or two similar pictures, *beyond the plane of the object or the pictures*, unless the distance between identical points of the objects or pictures be, at most, not greater than the interocular distance. Yet I have known, at least, one man, a gentleman of rare intelligence and much interested in binocular experiments, and whose eyes were to all appearance perfectly normal, in whom the waking passive state, as in gazing on vacancy, was one of slight optic *divergence*—in whom therefore the relaxation was more complete than in most eyes. This gentleman could double a star by gazing vacantly, and as it were beyond it. I thought at first that the doubling was the result of optic convergence, but by placing a screen alternately before the one and the other eye and asking which image disappeared, I completely satisfied myself that his eyes, while gazing on vacancy, were really slightly divergent instead of parallel.

I proved this, however, still more satisfactorily in another way. I have stated that it is impossible for most persons of normal eyes to combine two similar pictures *with the naked eyes*, so as to form a stereoscopic image *beyond the plane of the pictures*, unless the distance between identical points in the pictures be, at most, not greater than the interocular distance. But this gentleman could thus combine ordinary stereoscopic pictures with the naked eyes beyond the plane of the pictures, even when the distance between identical points was greater than the distance between the centers of his pupils. His ocular divergence was very small, and therefore, as might have been expected, in proportion as the distance between identical points of the pictures was greater, the distance from the eyes at which the pictures must be placed must also be greater. For instance: when the distance between identical points was three inches the pictures were held at arm's length; when the distance was six inches the pictures were placed on the other side of the room. It would be curious to enquire, at what *distance* and of what *size*, according to the laws of vision, the stereoscopic image ought to seem in this case. For while one condition of single vision, the absolutely necessary one, viz: that the retinal images shall occupy corresponding points on the two retinæ, is satisfied; another condition, which if not absolutely necessary, is present in every act of single vision except this one—a condition which determines the apparent place and size of the object or stereoscopic image—viz: the *meeting of the two visual lines, is not satisfied.* In all cases of single vision, whether of natural objects or by stereoscopic combinations, the object or stereoscopic image is seen at the intersection of the visual lines, which is therefore called the *point of sight.* But in this case there is no point of sight at all—the visual lines do not meet at all except behind the head.

In one of my papers on binocular vision* I gave a new method of representing the position of double images; a method which, however, represents equally well the position of images

1. 2.



seen single by stereoscopic combination. The facts which I have just presented may be perfectly represented by this method, but cannot by any other. Let R and L (fig. 1) represent the position of the eyes in sleepiness, and A the object

* This Jour., Ser. III, vol. i, p. 33.

contemplated; then the lines A N, Lv Rv, will represent the position of the median line and the two visual lines and R A, L A of the ray-lines from the object A to the eyes. The visual result, if all these lines were visible, is represented by fig. 2. The object A, fig. 1, is seen double at a and a', fig. 2. If, instead of one object at A, there be two similar objects, e. g., stereoscopic pictures at v and v, fig. 1, then these will combine and be seen single at V somewhere along the combined visual lines E V, fig. 2. Of course there will be seen also, unless cut off by a septum, two other images, v and v', to the extreme right and left, as already explained in my previous paper. I cannot even conceive how these phenomena can be represented by the usual method.

VIII. *In binocular vision the law of corresponding points may be opposed to the law of direction. In such cases the law of corresponding points prevails.*

There are two well known fundamental laws of vision, viz: the *law of visible direction* and the *law of corresponding points.** The one is the fundamental law of *monocular*, as the other is of *binocular* vision. The one gives the true position of all objects and radiants, and therefore completely explains erect vision with *inverted* retinal image; the other combines the double external images of the same object at the point of sight, and therefore completely explains *single* vision with *double* retinal images. The former is usually regarded as the more fundamental—as underlying and explaining the other law, and as therefore itself capable of explaining all the phenomena of

* The law of *visible direction* may be thus expressed: Every impression on the retina reaching it by a ray line passing through the optic center, is *referred back along the same ray line* to its true place in space. Thus for every *radiant* point in the object there is a corresponding *focal* point in the retinal image, and every focal point is referred back along its ray line to its corresponding radiant, and the *external* image (object) is thus re-constructed in its proper position. Or it may be otherwise expressed thus: Space in front of us is, under all circumstances, an *outward projection of retinal states.* With the eyes *open*, the field of *view* is the outward projection of the *active* state; with the eyes *shut*, the field of *darkness* is an outward projection of the *passive* state of the retina. Thus the internal retinal concave with all its states is projected outward and becomes the external spatial concave, and the two correspond point for point. Now the lines connecting the corresponding points internal and external intersect each other at the optic center, and impressions reach the retina and are referred back into space along these lines. This would give the true position of all objects and radiants, and therefore completely explains erect vision with inverted retinal image.

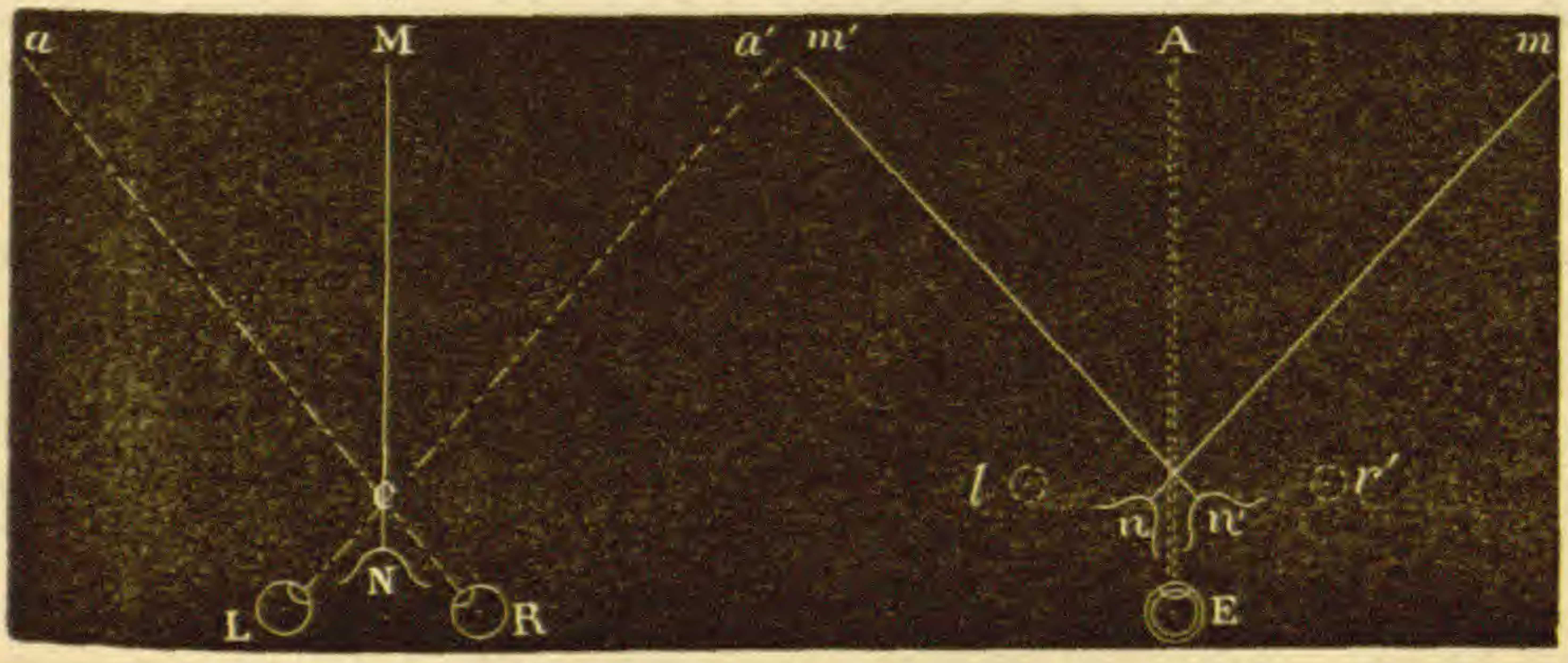
The law of corresponding points may be thus briefly expressed: Imagine the two eye-balls placed together in such wise that they geometrically coincide throughout, then the coincident points of the two retinæ are what are called corresponding points. Now the law of corresponding points declares that images or impressions of any kind falling upon corresponding points of the two retinæ are referred back to the same place in space and therefore seen single, while impressions falling on non-corresponding points are seen double. The determination of the horopter, as a geometric problem, is the determination of the surface or line, the ray lines from every point of which would impress corresponding points of the retinæ.

vision both monocular and binocular. The law of visible direction does indeed explain all the *ordinary* phenomena of single vision with two eyes; for in all ordinary cases of single vision—in all ordinary voluntary acts of binocular sight—in all cases of vision of objects lying in the horopter (whether this be a line or a surface), since ray lines from an object or radiant come to each eye from the same spot in space, by the law of direction the two images must be referred back along these ray lines to the same spot and therefore *superposed* and *seen single*. Thus single vision becomes in these cases a necessary result of the law of direction, and the law of corresponding points becomes only a particular case of the more general law of direction.

But in all cases of *double* images, the apparent position of these to the binocular observer is always different, and in some cases very different from the true position of the object which they represent. The difference may amount even to 45°. For example: The binocular field of view in my own case is about 100° in a horizontal direction. By strong convergence I can almost wholly obliterate this common field. In such case the images of objects lying near the extreme margins of the common field, and therefore at least 90° apart, are brought together and united in the middle, and seen apparently directly in *front;* while objects really in front are doubled and their images are separated 90° from each other, and each 45° from the true position of the object which they represent.

Fig. 3 represents the actual position of parts in this experiment, R and L being the right and left eye respectively, N the

3. 4.



root of the nose, a a' objects in the visual line 45° to the right and left, M N the median line and M an object in front; and figure 4 is the visual result represented by my method. It will be seen by comparing the two figures that the two eyes R and L are combined and rectified to form the single binocular eye E, the visual lines Ra and La' become the common visual line A E, the objects a and a' combine at A, while the median line and the object M are doubled and the images of the latter are seen at m and m'.*

It is true that in the case of the objects a and a' seen directly in front, it may be argued that this visual result is not in violation of the law of visible direction, but is in fact easily explained by that law. For if the combined images be referred to the point of ocular convergence (c, fig. 3) as in fact they often are, then each eye sees its own object in the true *direction* but only mistakes their *distance*. To this I answer, that *each eye* does indeed give the true direction, as is quickly shown by shutting one eye, but the *two eyes* do not. Each eye sees its own object in the true direction, but the *binocular observer* sees their combination in a wrong direction. The law of direction is true in all cases in *monocular* vision, but is not always true in *binocular* vision. In the case of the double images m and m' of the object M, it is still more difficult to explain their apparent position by the law of direction.

I suppose, however, that in all cases of ocular *convergence* it may be possible by an ingenious device to save the law of direction; but in the case of ocular *divergence* it is impossible by any device to explain the position of double images by that law. The position of images in this case is in direct violation of that law; the laws of direction and of corresponding points are in contradiction to each other and the *law of corresponding points prevails.* This we now proceed to show.

We have seen, p. 160 and figs. 1 and 2, that in drowsiness the optic axes may diverge 20°, and that in such cases the double images of an object in *front* are seen right and left 10° from the real position of the object which they represent; and on the other hand, that objects really in the direction of the visual lines, and therefore 20° apart, are combined and seen directly in front. Unfortunately, we cannot diverge the optic axes voluntarily and therefore cannot make experiments of this kind at will; but by pressing the eye-balls on their outer side the axes may be made to diverge considerably. By strong, almost painful pressure on the outer portion of both eye-balls. I have succeeded in making the double images of an object directly in front separate 50°, and those of objects 50° apart combine directly in front. There can be no doubt that if we could turn our eyes directly outward, or if our eyes, retaining

* By comparing these figures with those of my previous paper, it will be seen that I have modified slightly the mode of representation by including the parts of the face itself in the rotation, as well as in the *shifting*, of the field of view of each eye. In *convergence* this brings the two images of the nose nearer together in front and thus narrows the common field, which is exactly what actually happens. In divergence, on the contrary, the double images of the nose separate and the common field is widened.

their present organization, were transferred to the sides of our heads, with their axes directed straight right and left, and therefore making an angle of 180° with each other, *images of objects in the direction of these axes, and therefore directly right and left, would be moved round* 90° *each and combined and seen directly in front.* This seems an extraordinary result, but is a necessary consequence of the law of corresponding points. The retinal images of the two objects are on corresponding points; by the law of corresponding points, therefore, they must be seen as *one.* But where else can this take place but in front.

The foregoing results, as extraordinary as they may seem, are completely explained by the principles brought out in my previous papers, especially that "On the mode of representing the position of double images," and that "On so-called images of illusion."* Those who have read these papers will remember that I have there shown that there are two apparent movements of the field of view accomplished by the eyes in binocular vision. The first is a bodily *shifting* of the field of the right eye one-half interocular distance to the left, and of the field of the left eye the same distance to the right; so that the two eyes are brought together in the middle and combined to form a *single binocular eye*, and the two visual lines combined to form a common visual line. This movement is habitual and involuntary, but it produces little change in the apparent position of objects unless they be very near. The second is a *rotation* of the whole field of view of both eyes about the optic center, whenever the two eyes move in opposite directions, as in *convergence* or *divergence.* This rotation is always in a direction opposite to the motion of the eyes, and therefore homonymous in convergence and heteronymous in divergence. It is this movement which changes so greatly the apparent position of all objects in the field of view under the conditions mentioned, and it is this, therefore, which concerns us in the explanation of the phenomena related above. In monocular vision, as also in binocular, when the eyes move together right or left, up or down, external objects seem stationary, and the visual lines seem to move across them. But in binocular vision, when the two eyes move in opposite directions, the visual line seems to remain stationary (i. e., we seem to look in the same direction), while external *objects* or their images seem to move. In converging or diverging the optic axes, the external images belonging to each eye, like trooping shadows, seem to sweep in opposite directions, toward each other in convergence, away from each other in divergence. As the visual lines *actually* approach and sweep across objects successively, the images of these objects *seem* to advance and

* This Jour., III, vol. i, p. 33, and vol. ii, pp. 314 and 417.

take their places successively in front of the observer. And this is true whatever the degree of convergence or divergence. In all cases, whatever be the position of the eyes, objects in the visual lines, and whose retinal images therefore fall on the central spots of the retinæ, are seen in front. If therefore the two eyes could be turned directly outward, or if the eyes were placed on the sides of the head so that the optic axes were directed straight right and left, objects directly right and left would be seen in front, and therefore 90° from their true position.

IX. *Comparative Physiology of Binocular Vision.*

For many years past I have reflected much, and attempted to make some observations, on the phenomena of vision of lower animals, for the purpose of testing the existence or non-existence of binocular vision in them. I must frankly confess I have accomplished but little. The phenomena of binocular vision are so essentially subjective, that it seems almost impossible to reach any satisfactory results by observations or experiment. As the subject, however, as far as I know, has never been touched, I will bring forward my somewhat crude thoughts, in the hope that others may follow them up with more success.

In man the axes of the conical eye-sockets diverge about 25°, or each makes an angle with the median line of about 12°. In these slightly diverging conical sockets, the eye-balls are so placed, and the muscles so adjusted, that in the waking passive state their axes are parallel; and from this passive parallel condition they may easily be converged even upon very near objects. In man, then, though the eye-sockets still diverge considerably, the eyes are set in front with axes naturally parallel. This is evidently the position most suitable for binocular vision.

In monkeys the position of the eyes is much the same as in man. They are placed well in front, near together, their axes apparently parallel, and therefore well adapted to binocular convergence. But as we go down the vertebrate scale, the eyes are placed wider and wider apart; the axes of the eye-sockets diverge more and more, the difficulty of convergence upon a near point becomes greater and greater, until in some mammals, such as the Cetaceæ, in most birds and in all fishes, the eyes are placed no longer in front, but on the sides of the head, with their optic axes inclined nearly or quite 180° to each other. It seems quite evident that animals with eyes so placed cannot converge the optic axes on a single point, especially a near point. In fact, it is well known that most birds, when viewing an object very attentively, turn the head on one side and *look with one eye.* It seems impossible that the law of corresponding points can exist for these animals ; for if it did, as we have already seen (p. 167), it would only lead to constant and fatal mistakes as to the position of external objects. In a word, it is impossible that these animals can enjoy a true binocular vision, with its double and its combined images, its stereoscopic effects, and the complex but accurate visual judgments founded on these effects. They see indeed with two eyes; but these do not act together as one instrument—as a single binocular eye; they are independent and see each for itself. This is the case with the other senses even in man. However much their organs may be multiplied, each organ perceives for itself. The property of corresponding points, from which arise all the phenomena of binocular vision, is something peculiar to the eye. Nothing analogous exists in the other senses. Binocular vision in its perfection, as it exists in man, is the last result of the gradual improvement of that most refined and wonderful instrument, the eye; specially adapting it to meet the wants of the higher faculties of the mind.

Below the vertebrates, of course, binocular vision does not and cannot exist.

There is another peculiarity of the human eye, probably closely connected with binocular vision, which still more quickly disappears as we go down the vertebrate scale. I refer to the existence of the so-called yellow spot or *central spot* of the retina.

It is well known that in the very center of the retina, just where the optic axis or continuation of the visual line pierces the retina, and therefore just where the images of objects in the visual line fall, there is a small depression about $\frac{1}{10}$ inch in diameter, bordered by a yellow margin. This depression is called the central spot. It is the most highly organized and most sensitive spot of the retina. It differs from other portions, 1st, in the fact that here the layer of rods and cones, the true receptive organ of the retina, is not covered by the fibrous layer, but directly exposed to the impression of light; and 2d, in the fact that here the cones are much smaller and more numerous than elsewhere.

Now it is a familiar fact that while gazing steadily at a certain point we see very clearly only a very small area about the point of sight. This small area corresponds, point for point, to the central spot of the retina. If now, while gazing steadily, we observe the relative distinctness of vision in other portions of the field of view, we shall find that it becomes less and less distinct in proportion as the point observed is more distant from the line of sight. In other words, there is a perfect graduation of distinctness from the point of sight, where it is greatest, to the margins of the visible field, where it is least. Now as the retina corresponds with the visible field point for point, it follows that there is a corresponding graduation, certainly in sensitiveness, probably in fineness of organization of the receptive layer of the retina, from the central spot even to the extreme anterior margin. Except in the central spot this increasing fineness of organization has not been demonstrated, but it doubtless exists, for the increasing distinctness of vision toward the point of sight is its effect and its representative in the field of view.

As we go down the vertebrate scale, the central spot is found only in some monkeys. After a total absence in other mammals and in all birds, it is said to reappear in some lizzards; but whether it there has the same structure, and therefore the same significance, as in the human eye is not certain. It seems fair to conclude, therefore, that the graduation of distinctness toward the point of sight and the limitation of the greatest distinctness to that point, do not exist in most of the lower animals.

The importance of the central spot in the highest animals, and especially in man, is very evident. The limitation of the greatest distinctness to the point of sight is absolutely necessary to the *concentration and limitation of the most thoughtful attention* to that point. If all portions of the retina were similarly organized, and therefore all points in the field of view equally distinct, it would be impossible to fix the attention steadily and thoughtfully on any one point to the exclusion of others. We might *see* equally well and over a wider field, but we could not *look* attentively. We could not *observe* thoughtfully. But in the lower animals, especially those which are preyed upon by others, it is far more important to see well in every direction than to fix the attention too exclusively on one point; the advantages of exquisite microscopic distinctness of the center of the field is sacrificed for the much greater advantages of moderate distinctness over a very wide field. The most important thing for them is a very wide field, and the equal distribution of attention over every part. Hence their eyes are prominent, set wide apart on the margins of the front or on the sides of the head, and destitute of central spot; so that they sweep the whole horizon and see all parts with nearly equal distinctness.

The connection of the central spot with binocular vision is also quite evident. These central spots are, more than all others, endowed with the properties of corresponding points, and the somewhat complex binocular judgments expressed by the words "stereoscopic perspective" are accurate and reliable only in the vicinity of the point of sight. This is the great difficulty in the way of experimental determination of the horopter, as already explained in one of my early papers.*

* This Jour., II, vol. xlvii, p. 153.

The following, then, are the general changes in the vertebrate eye, as we go up the scale: 1. A gradual change of the *position* of the eyes from the *sides* to the *front* of the head, and a consequent change of the angle of inclination of the optic axes from 180° to parallelism. 2. A gradually increasing graduation of the fineness of organization, and therefore the sensitiveness of the retina, from the anterior margins toward the central parts, so as finally to form in monkeys and in man a central spot. 3. A gradually increasing power of converging the optic axes upon a single near point, so that the images of that point may fall upon the central spots of both eyes. 4. The gradual evolution of the properties of corresponding points, and therefore of all the distinctive phenomena of binocular vision.

These changes seem all intimately connected with each other and with the development of the higher faculties of the mind.

Oakland, Cal., Oct. 26, 1874.

ART. XIX.—*Jeffries Wyman. Address of Professor* A. GRAY at the Memorial Meeting of the Boston Society of Natural History, Oct. 7, 1874.*

[Concluded from page 93.]

IN attempting these analyses, I am drifting into a fault which Prof. Wyman never committed, that of being too long. So I must leave many of his papers unmentioned, and barely refer to two or three others which cannot be passed over. The most noteworthy of the shorter papers, however, are upon less technical or more generally interesting topics, so that we have need only to be reminded of them. Among them are his "Observations on the Development of the Surinam Toad," and the same of "*Anableps Gronovii*," and the paper "On some unusual Modes of Gestation." The importance of these papers lies, not in being accounts of some of the most striking curiosities of the animal world, but in the sagacity and quickness with which he discerned, and the clearness with which he taught, the lessons to be learned from them. Any good zoologist, with the same excellent opportunities, would have worked out all the details of the development of the Surinam toads in the skin of the back of their mother, and would equally have noted the morphological significance of the branchiæ and tail, that are never to know any thing of the element they are adapted for; but Dr. Wyman remarks upon the development of the limbs independently of the vertebral axis, as showing

* From the "Proceedings" of the Society.

that, whatever view be taken of their homology, they are something superadded to it, and not evolved from it; he notes how the *whole* yelk-mass is moulded into a spiral intestine; and that the embryo at the end of incubation forms a larger and heavier mass than existed in the egg when it commenced, —showing that there was an absorption of material furnished by the dermal sac of the mother,—"a solitary instance among Batrachians, if not among Reptiles generally, in which the embryo is nourished at the expense of materials derived from the parent." From this he is led (in the later paper above mentioned) to infer the probability that the developed larvæ of *Hylodes lineatus*,—carried about inland upon the back of their mother, and destitute of limbs adapted to terrestrial locomotion,—may depend upon a secretion from the body for needful sustenance—an interesting and rudimentary foreshadowing of mammalian life, of which he discerned the bearings.

His "Description of a Double Fœtus" (in the Boston Medical and Surgical Journal, March, 1866) gives him the opportunity of briefly recording some of the results of his studies of the development of double monsters, and to bring out his view, that "the force, whatever it be, which regulates the symmetrical distribution of matter in a normal or abnormal embryo, has its analogy, if anywhere, in those known as polar forces;" that "studying the subject in the most general manner, there are striking resemblances between the distribution of matter capable of assuming a polar condition and free to move around a magnet, and the distribution of matter around the nervous axis of an embryo." That this is not one of those vague conceptions by which many speculators set about to explain that of which they know little by means of that of which they know less, but that he had striking parallelisms to adduce, the close of this striking paper shows.

The subject of fore and hind symmetry, thus brought directly under notice, had been broached by Dr. Wyman several years before. He returned to it the year following, in his very important morphological paper, "On Symmetry and Homology in Limbs," read to this society in June, 1867, and published in the Proceedings of that date. It is interesting to observe with what caution and restraint he handled this doctrine of "reversed repetitions," which has since been freely developed by one of his pupils, who has a special predilection for speculative morphology, Prof. Burt Wilder.

Prof. Wyman's "Notes on the Cells of the Bee," in the Proceedings of the American Academy for January, 1866, is a characteristic specimen of his way of coming directly down to the facts, and making them tell their own story. I could not recapitulate his results much more briefly than he records them in his paper. I need not recall to you how neatly he made this investigation, and represented some of the results, filling the comb with plaster-of-paris and then cutting it across midway, so that the observations might be made and the cells measured just where they are most nearly perfect; and then printing impressions of the comb upon the wood-block, he reproduces on the pages of his article the exact outlines of the cells, with all their irregularities and imperfections. But I cannot refrain from citing a portion of his remarks at the close:—

"Here, as is so often the case elsewhere in nature, the type-form is an ideal one; and with this real forms seldom or never coincide. . . . . An assertion, like that of Lord Brougham, that there is in the cell of the bee 'perfect agreement' between theory and observation, in view of the analogies of nature is more likely to be wrong than right; and his assertion in the case before us is certainly wrong. Much error would have been avoided if those who have discussed the structure of the bee's cell had adopted the plan followed by Mr. Darwin, and studied the habits of the cell-making insects comparatively, beginning with the cells of the humble-bee, following with those of wasps and hornets, then with those of the Mexican bees (*Melipona*), and finally with those of the common hive-bee. In this way, while they would have found that there is a constant approach to the perfect form, they would at the same time have been prepared for the fact, that even in the cell of the hive-bee perfection is not reached. The isolated study of anything in natural history is a fruitful source of error."

Let me add to this important aphorism its fellow, which I have from him, but know not if he ever printed it. "*No single experiment in physiology is worth anything.*"

The spirit of these aphorisms directed all his work. It is well exemplified in his experimental researches—the last which I can here refer to,—upon "The formation of Infusoria in boiled solutions of organic matter, enclosed in hermetically sealed vessels and supplied with pure air," and its supplement, "Observations and Experiments on living organisms in heated water," published in the American Journal of Science and Arts, the first in the year 1862, the other in 1867. Milne-Edwards could not have known the man, when he questioned the accuracy of the first series because they do not agree with those of Pasteur, and thought the difference in the results depended upon a defective mode of conducting the experiments. As Dr. Wyman remarks in a note to the second series, "the recent experiments of Dr. Child of Oxford, and those reported in this communication, are sufficient answer to the criticisms of M. Edwards." Then as to his thoroughness: most persons would have rested on the results of his thirty-three well-devised experiments, proving "that the boiled solutions of organic matter made use of, exposed only to air which has passed through tubes heated to redness, became the seat of infusorial life;" but all would not have concluded that, after all, they "throw but little light on the immediate source from which the organisms have been derived," nor would many have closed an impartial summary of the opposing views in this judicial way:—

"If, on the one hand, it is urged that all organisms, in so far as the early history of them is known, are derived from ova, and therefore from analogy we must ascribe a similar origin to these minute beings the early history of which we do not know, it may be urged with equal force, on the other hand, that all ova and spores, in so far as we know anything about them, are destroyed by prolonged boiling; therefore from analogy we are equally bound to infer that Vibrios, Bacterians, etc., could not have been derived from ova, since these would all have been destroyed by the conditions to which they have been subjected. The argument from analogy is as strong in the one case as in the other."

Returning to the subject again a few years later, with a critical series of twenty experiments, each of three, five, ten, fifteen, or even twenty flasks, used by way of checks and comparisons, —a rigorous experimenter would have been satisfied when he had proved that sealed solutions, subjected to a heat of at least 212° for from *one* to *four* hours, became the seat of infusorial life, at least of such as Vibrios, Bacterians and Monads, while all infusoria having the faculty of locomotion were shown by a special series of experiments to lose this at a temperature of 120°, or at most 134° Fahr. But Prof. Wyman carried the boiling up to *five* hours, and in these flasks no infusoria of any kind appeared. The question of abiogenesis stands to-day very much where Prof. Wyman left it seven years ago.

I must omit all notice of the ethnological work which has occupied his later years, merely referring to the seven Annual Reports of the Trustees of the Peabody Museum of American Archæology and Ethnology, of which he was curator. The last of these, issued just before the writer's death, contains the principal results of his investigation of the human remains he collected in the shell-heaps of East Florida, and convincing evidence of the cannibalism of those who made them. A fuller memoir, embodying all his observations of the last six winters upon the Florida shell-mounds, was sent to the printer just before he died.

The thought that fills our minds upon a survey even so incomplete as this is: How much he did, how well he did it all, and how simply and quietly! We knew that our associate, though never hurried, was never idle, and that his great repose of manner covered a sustained energy; but I suspect that none of us, without searching out and collecting his published papers, had adequately estimated their number and their value. There is nothing forth-putting about them, nothing adventitious, never even a phrase to herald a matter which he deemed important.

His work as a teacher was of the same quality. He was one of the best lecturers I ever heard, although, and partly because, he was the most unpretending. You never thought of the speaker, nor of the gifts and acquisitions which such clear exposition were calling forth,—only of what he was simply telling and showing you. Then to those who, like his pupils and friends, were in personal contact with him, there was the added charm of a most serene and sweet temper. He was truthful and conscientious to the core. His perfect freedom, in lectures as well as in writing, and no less so in daily conversation, from all exaggeration, false perspective, and fictitious adornment, was the natural expression of his innate modesty and refined taste, and also of his reverence for the exact truth.

It has been a pleasure to learn, from former college students, who hardly ever saw him except in the lecture-room, that he gave to them much the same impression of his gifts and graces, and sterling worth, that he gave us who knew him intimately —so transparent was he, and natural.

With all his quick sense of justice, and no lack of occasion for controversy, it seemed to cost him no effort to avoid it altogether. He made no enemies, and was surrounded by troops of life-long friends. When he first went abroad, in 1841, he was told by some near friends, who recognized his promise, that a chair of Natural History in his alma mater would soon have to be filled, and that he should be presented as a candidate. In the winter following the present incumbent, responding to an invitation to visit Boston, which he had never seen, and to consider if he would be a candidate, then first heard of Wyman's name and of his friends' expectations or hopes; whereupon he dismissed the subject from his mind. Probably he felt more surprise than did Dr. Wyman, when notified, a few months afterward, of the choice of the Corporation. The exigencies of the Botanic Garden probably overbore other considerations. I doubt if Dr. Wyman ever had an envious feeling. Certain it is that no one welcomed the new professor with truer cordiality, or proved himself a more constant friend.

In these days it is sure to be asked how an anatomist, physiologist, and morphologist like Prof. Wyman regarded the most remarkable scientific movement of his time, the revival and apparant prevalence of doctrines of evolution. As might be expected, he was neither an advocate nor an opponent. He was not one of those persons who quickly make up their minds, and announce their opinions, with a confidence inversely proportionate to their knowledge. He could consider long, and hold his judgment in suspense. How well he could do this appears from an early, and so far as I know, his only published presentation of the topic, in a short review of Owen's "Monograph of the Aye-Aye" (in Am. Journ. Science, Sept., 1863)—the paper in which Prof. Owen's acceptance of evolution, but not of natural selection, was promulgated. Dr. Wyman compares Owen's view with that of Darwin (to whom he had already communicated interesting and novel illustrations of the play of natural selection); and he adds some acute remarks upon a rather earlier speculation of Mr. Agassiz, in which the latter suggests that the species of animals might have been created as eggs rather than as adults. He states the case between the two general views with perfect impartiality, and the bent of his own mind is barely discernible. In due time he satisfied himself as to which of them was the more probable, or, in any case, the more fertile hypothesis. As to this, I may venture to take the liberty to repeat the substance of a conversation which I had with him some time after the death of the lamented Agassiz, and not long before his own. I report the substance only, not the words.

Agassiz repeated to me, he said, a remark made to him by Humboldt, to the effect that Cuvier made a great mistake, and missed a great opportunity, when he took the side he did in the famous controversy with Geoffroy St. Hilaire; he should have accepted the doctrines of morphology, and brought his vast knowledge of comparative anatomy and zoology, and his unequalled powers, to their illustration. Had he done so, instead of gaining by his superior knowledge some temporary and doubtful victories in a lost cause, his preëminence for all our time would have been assured and complete. I thought, continued Wyman, that there was a parallel case before me,—that if Agassiz had brought his vast stores of knowledge in zoology, embryology, and palæontology, his genius for morphology, and all his quickness of apprehension and fertility in illustration, to the elucidation and support of the doctrine of the progressive development of species, science in our day would have gained much, some grave misunderstandings been earlier rectified, and the permanent fame of Agassiz been placed on a broader and higher basis even than it is now.

Upon one point Wyman was clear from the beginning. He did not wait until evolutionary doctrines were about to prevail, before he judged them to be essentially philosophical and healthful, "in accordance with the order of Nature, as commonly manifested in her works," and that they need not disturb the foundations of natural theology.

Perhaps none of us can be trusted to judge of such a question impartially, upon the bare merits of the case; but Wyman's judgment was as free from bias as that of any one I ever knew. Not at all, however, in this case from indifference or unconcern. He was not only, philosophically, a convinced theist, in all hours, and under all "variations of mood and tense," but personally a devout man, an habitual and reverent attendant upon Christian worship and ministrations.

Those of us who attended his funeral must have felt the appropriateness for the occasion of the words which were there read from the Psalmist:—

"The Heavens declare the glory of God, and the firmament showeth his handy-work. . . . . O Lord, how manifold are thy works! In wisdom hast thou made them all: the earth is full of thy riches; so is this great and wide sea, wherein are things creeping innumerable, both great and small beasts. Thou sendest forth thy spirit, they are created, and thou renewest the face of the earth."

These are the works which our associate loved to investigate, and this the spirit in which he contemplated them. Not less apposite were the Beatitudes that followed:—

Blessed are the meek; blessed are the peace-makers; blessed are the merciful; blessed are the pure in heart.

Those who knew him best, best knew how well he exemplified them.

ART. XX.—*Brief Contributions to Zoology from the Museum of Yale College.* No. XXXI.—*The Gigantic Cephalopods of the North Atlantic;* by A. E. VERRILL.

(Continued from page 130.)

ACCOUNTS of an attack made upon two men by another gigantic cephalopod, in Conception Bay, Oct. 27, 1873, have been published in this Journal,* and in many other magazines, as well as in the newspapers. In the encounter the monster lost two of his arms by amputation with a hatchet. A portion of one of these arms, measuring nineteen feet in length, was preserved by Rev. M. Harvey and Mr. Alexander Murray for the museum at St. John's, Newfoundland. It has been photographed, and cuts copied from the photograph have been pub-

* See vol. vii, p. 158, 1874; and American Naturalist, vol. viii, No. 2, p. 120, February, 1874, in a letter from Mr. Alexander Murray.

lished in some of the English magazines.* Before it was secured for preservation it had been considerably injured, many of the larger suckers having been torn off or mutilated. Owing to this fact they were originally described by Mr. Harvey as destitute of marginal denticulations, but he has recently re-examined the specimen, at my request, and now informs me that he is satisfied that they were all originally denticulated. Of this specimen I have seen only the photograph and some of the smaller suckers.

It is stated that six feet of this arm had been destroyed before it was preserved, and the captors estimated that they left from six to ten feet attached to the creature, which would make the total length between 31 and 35 feet. According to Mr. Murray, the portion preserved measured but 17 feet in length, when he examined it, Oct. 31, 1873, after it had been a few days in strong brine; the circumference of the slender portion was 3·5 to 4 inches; of the enlarged sucker-bearing part, 6 inches; length of the part bearing suckers, 30 inches; diameter of largest sucker, 1·25 inches. Calculating from the photograph, the portion bearing the larger suckers was about 18 inches in length, and about 2·4 inches broad, across the face; distance between attachments of large suckers, 1·68; outside diameter of larger suckers, 1·16 to 1·28; inside diameter, ·74 to 1 inch; diameter of small suckers of the outside rows, ·40 to ·48 of an inch. Mr. Harvey has recently sent to me a full series of measurements of this arm, as now preserved. It has contracted excessively in the alcohol, and is now only 13 feet and one inch in length (instead of 19 feet, its original length), the enlarged sucker-bearing portion being 27 inches; the large suckers occupy 12 inches; the terminal part bearing small suckers, 9 inches; circumference of slender portion 3·5 to 4·25 inches; of largest part 6 inches; breadth of face, among large suckers, 2·5 inches; from face to back, 1·62 inches; diameter of largest suckers outside, ·75 of an inch; inside, ·63 of an inch. It will be evident from these measurements, when compared with those made while fresh and from the photograph, that the shrinkage has been chiefly in length, the thickness remaining about the same, but the suckers are considerably smaller than the dimensions previously given. Comparing all these dimensions with those of the Logie Bay specimen, and calculating the proportions as nearly as possible, it follows that this specimen was very nearly one-third larger than the latter, but the large suckers appear to have been relatively smaller, for they were hardly one-twelfth larger than in

* See Annals and Magazine of Natural History, IV, xiii, p. 68; and "The Field," Dec. 13, 1873. The central line of this photograph is reduced four and a quarter times, while the front part is reduced about four times.

the Logie Bay specimen. As the relative size of the large suckers is a good sexual character among squids, it is probable that this individual was a *female.* In form, proportions and structure, it agrees very closely with the specimen first described, and therefore I do not hesitate to refer it to the same species. The fishermen estimated the body of this individual to have been about 60 feet in length and 5 feet in diameter; but if the above proportions be correct, as I believe, then the body could not have been more than about 10 feet long, and 2·5 in diameter, and the long arms should have been about 32 feet in length. Allowing two feet for the head, the total length would, therefore, be about 44 feet.

Another specimen (No. 3), probably of the same species, and similar in size to the last, was captured at Coombs' Cove, Newfoundland. The following account has been taken from a newspaper article of which I do not know the precise date, forwarded to me by Professor Baird, together with a letter, dated June 15, 1873, from T. R. Bennett, Esq., of English Harbor, N. F., who states that he wrote the article, and that the measurements were made by him, and are perfectly reliable.

"Three days ago, there was quite a large squid run almost ashore at Coombs' Cove, and some of the inhabitants secured it. The body measured 10 feet in length and was nearly as large round as a hogshead. One arm was about the size of a man's wrist, and measured 42 feet in length; the other arms were only 6 feet in length, but about 9 inches in diameter, very stout and strong. The skin and flesh were 2·25 inches thick, and reddish inside as well as out. The suction cups were all clustered together, near the extremity of the long arm, and each cup was surrounded by a serrated edge, almost like the teeth of a hand-saw. I presume it made use of this arm for a cable, and the cups for anchors, when it wanted to come to, as well as to secure its prey, for this individual, finding a heavy sea was driving it ashore, tail first, seized hold of a rock and moored itself quite safely until the men pulled it on shore."

It would appear from this description that one of the long arms had been lost before the capture. The large diameter of the short arms, compared with their length, and with the size of the long arms, is the only point in which this specimen apparently differed essentially from those described above. Possibly the *circumference* was intended,* which would make the proportions agree well with those of the other specimens.

In a letter from Mr. Harvey, dated Dec. 10, 1873, he says that the Speaker of the House of Assembly stated to him that

* A similar mistake actually occurred in the description of the long arms, in the letter from Mr. Murray, published in the American Naturalist for February, 1873, p. 122, referred to above, but in that instance the error was very obvious.

he had measured a specimen cast ashore in Fortune Bay, which was between 42 and 43 feet in length, the body and head together being between 12 and 13 feet, and the two long arms each 30 feet. This we may designate as No. 6.

Dr. Honeyman, geologist of Nova Scotia, has published, in a Halifax paper, a statement made to him by a gentleman who claims to have been present at the capture of another specimen (No. 7) in the Straits of Belle Isle, at West St. Modent, on the Labrador side. "It was lying peacefully in the water when it was provoked by the push of an oar. It looked fierce and ejected much water from its funnel: it did not seem to consider it necessary to discharge its sepia, as mollusca of this kind generally do, in order to cover their escape." * * * * "The length of its longest arm was 37 feet; the length of the body 15 feet; whole length 52 feet. The bill was very large. The suckers of its arms or feet, by which it lays hold, about 2 inches in diameter. The monster was cut up, salted, and barrelled for dog's meat." In this account the length given for the "body" evidently includes the head also. This creature was probably disabled, and perhaps nearly dead, when discovered at the surface, and this seems to have been the case with most of the specimens hitherto seen living. Animals of this sort probably never float or lie quietly at the surface when in good health.

Mr. Harvey also refers to a statement made to him by a clergyman, Rev. M. Gabriel, that two specimens (Nos. 8 and 9), measuring respectively 40 and 45 feet in total length, were cast ashore at Lamaline, on the southern coast of Newfoundland, in the winter of 1870–71. These may also have been of the same species as those described above, all of which I now refer to *Architeuthis monachus* of Steenstrup.

Mr. Harvey also mentions, in a recent letter, that a specimen was cast ashore at Bonavista Bay, December, 1872, and his informant says that the long arms measured 32 feet in length, and the short arms about ten feet in length, and were "thicker than a man's thigh." The body was not measured, but he thinks it was about fourteen feet long, and very stout, and that the largest suckers were 2·5 inches in diameter. The size of the suckers is probably exaggerated, and most likely the length of the body also. It is even possible that this was the same specimen from which the beak and suckers described in my last article, as No. 4, from Bonavista Bay, were derived, for the date of capture of that specimen is unknown to me. The latter, however, was much smaller than the above measurements, and it will, therefore, be desirable to give a special number (11) to the former.

Another specimen, which we may designate as No. 12, was cast ashore this winter, near Harbor Grace, but was destroyed before its value became known, and no measurements are given.

Architeuthis princeps Verrill. Plate v, figures 14, 15, 16.—This species is based on the lower jaw mentioned as No. 1 in my former papers, and on the upper and lower jaws designated as No. 10, in the first part of this article; besides these jaws we only have the rough measurements of the body of No. 1, and an estimate of the diameter of the sessile arms. The jaws of No. 10 were obtained from the stomach of a sperm whale taken in the N. Atlantic, and were presented to the Essex Institute by Capt. N. E. Atwood, of Provincetown, Mass., but the date and precise locality of the capture are unknown. The form of these jaws is well shown in figures 14 and 15. The total length of the upper jaw (fig. 14) is 5 inches; greatest breadth, 1·45; front to back, 3·5 inches; width of palatine lamina, 2·32. The frontal portion is considerably broken, but the dorsal portion appears to extend nearly to the posterior end, the length from the point of the beak to the posterior edge being 3·4 inches. The texture is firmer and the lamina are relatively thicker than in *A. monachus.* The rostrum and most of the frontal regions are black and polished, gradually becoming orange-brown and translucent toward the posterior border, and marked with faint striæ radiating from the tip of the beak, and by faint ridges or lines of growth parallel with the posterior margin; a slight but sharp ridge extends backward from the notch at the base of the cutting edge, and other less marked ones from the anterior border of the alæ. The tip of the beak is quite strongly curved forward, and acute, with a slight shallow groove, commencing just below the tip, on each side, and extending backward only a short distance and gradually fading out. The cutting edge is nearly smooth and well curved, the curvature being greatest toward the tip; at its base there is a broad angular notch, deepest externally. The inner face of the rostrum is convex in the middle and concave or excavated toward the margins, which are, therefore, rather sharp. The anterior borders of the alæ are convex, or rise into a broad, but low, lobe or tooth beyond the notch, but beyond this they are nearly straight, but with slight, irregular lobes, which do not correspond on the two sides. The anterior edges of the alæ make nearly a right angle with the cutting edges of the rostrum. The palatine lamina is broad, thin, and dark brown, becoming reddish brown and translucent posteriorly, with a thin, whitish border. The surface is marked with unequal divergent striæ and ridges, some of which, especially near the dorsal part, are quite prominent and irregular; the posterior border has a broad emargination in the middle, but the two sides do not exactly correspond. The lower jaw (plate v, fig. 15) was badly broken, and many of the pieces, especially of the alæ, are lost, but all that remain have been fitted together. The extreme length is 3·63 inches; the total breadth, and the distance from front to back, cannot be ascertained, owing to the absence of the more prominent parts of the alæ; from tip of beak to posterior dorsal border of mentum, 1·68; from tip of beak to posterior lateral border of alæ, 2·20; from tip of beak to posterior dorsal border of gular lamina, 2·37; from tip of beak to bottom of notch at its base, ·80; tip of beak to inner angle of gular lamina, 1·85; height of tooth from bottom of notch, ·25; breadth between teeth of opposite sides, ·60; from front to back of gular lamina, in middle, 1·75. The rostrum is black, with faint radiating striæ, and with slight undulations parallel with the posterior border; the beak is acute, slightly incurved, with a notch near the tip, from which a very evident groove runs back for a short distance, while a well marked, angular ridge starts from just below the notch, and descends in a curve to the ala, opposite the large tooth, defining a roughened or slightly corrugated and decidedly excavated area between it and the cutting edges: the cutting edge below this ridge is nearly straight, or slightly convex; the notch at its base is rounded and deep and strongly excavated at bottom; the tooth is broad, stout, obtusely rounded at summit, sloping abruptly on the side of the notch, and gradually to the alar edge. The anterior edge of the alæ, beyond the tooth, is rounded and strongly obliquely striated; it makes, with the cutting edge, an angle of about 110°. The inner surfaces of the two sides of the internal plate of the rostrum form an angle of about 45°.

The lower jaw of No. 1 (plate v, fig. 16) is represented only by its anterior part, the alæ and gular laminæ having been cut away by the person who removed it. It agrees very well in form and color with the corresponding parts of the one just described, but is somewhat smaller. The lateral ridges of the rostrum are rather more prominent, and the area within it is narrower and more deeply excavated, especially at the base of the notch, where the excavation goes considerably lower than the inner margin. The notch is narrower and not so much rounded at its bottom. The tooth is about the same in size as that of No. 10, and appears to be even more prominent, because the edge of the alæ is more concave at its outer base; it is also more compressed and less regularly rounded at summit. This jaw measures 1·30 inches from the tip to the posterior dorsal border of mentum; ·65 from tip to the bottom of the notch; ·16 from bottom of notch to tip of the tooth.

Both these lower jaws agree in having a very prominent tooth on the alar edge, with a large and deeply excavated notch between it and the cutting edge, and in this respect differ from the two lower jaws of *A. monachus* in my possession, for in the latter the tooth or lobe is low and broad, and scarcely prominent, while the notch is narrow and shallow. This seems to be the best character for distinguishing the jaws of the two species. But they also differ in the angle between the alar edge and the cutting edge of the rostrum, especially of the lower jaw, for while in *A. monachus* this is hardly more than a right angle, in *A. princeps* it is about 110°. Moreover, the darker color and firmer texture of the jaws of the latter seem to be characteristic.

The proportions of the body seem to be quite different, if we can judge by the measurements given of the specimen (No. 1) which was found dead and floating at the surface of the water, at the Banks of Newfoundland, by Capt. Campbell, of the schooner B. D. Haskins, from Gloucester, Mass., in October, 1871.* It is stated that this specimen was measured, and that the body was 15 feet long and 4 feet and 8 inches in circumference. The arms were badly mutilated, but the portions remaining were estimated to be 9 or 10 feet long and about 22 inches in circumference, two being shorter than the others. This would indicate a much more elongated form of body than that of *A. monachus.* If these proportions be correct, the body of No. 10 must have been about 19 feet in length and 5 feet 9 inches in circumference.

This specimen is probably the largest invertebrate hitherto actually examined by any naturalist.

Notes on specimens described by other writers.—We are mainly indebted to Professor Steenstrup and to Dr. Harting for our knowledge of the specimens preserved in European museums, or cast ashore on the European coasts. Professor Steenstrup has given interesting accounts, compiled from contemporary documents, of a specimen taken in 1546, and of two specimens of huge cephalopods cast ashore at Iceland in 1639 and 1790, and has also described and figured† the jaws of another specimen of *A. monachus*, obtained at Jutland in 1853. In the same memoir, of which I have seen only the first part, there are references to a description and figures of *A. Titan*, obtained in 1855, by Capt. Hygom, in N. lat. 31°, W. long. 76°. The latter specimen appears to be the same that Harting ‡ mentioned, under the name of "*Architeuthis dux* Steenstrup," as collected at the same time and place, and of which he pub-

* See the American Naturalist, vol. vii, p. 91, Feb., 1873.

† In a paper of which I have only seen some proof-sheets, given by him to Dr. Packard, entitled "Spolia Atlantica." Whether this memoir has been published I do not know. The plate (I) that I have seen is marked "Vid. Selsk. Skrifter, V. Række, naturv. og mathem. Afd. iv Bind;" and there are references to three other plates illustrating *A. Titan*, etc.

‡ Description de quelques fragments de deux Céphalopodes gigantesques. Publiées par l'Académie Royale des Sciences à Amsterdam. 1860. 4to, with three plates.

lished an outline figure of the lower jaw, copied from a drawing furnished to him by Steenstrup. Harting states that the pen or "gladius" of this specimen is six feet long. Many important parts of this specimen were secured, and I regret that I have been unable to see the figures and description of it, referred to by Harting as forming part of Prof. Steenstrup's memoir, then unpublished. But to judge by the outline figure given by Harting, it is a species quite distinct from those described above. The lower jaw resembles that of *A. monachus* more than *A. princeps*, and is a little larger than that of our No. 5. The beak is more rounded dorsally, less acute, and scarcely incurved, the notch is narrow, and the alar tooth is not prominent.

Harting, in the important memoir referred to, describes specimens of two species, both of which are evidently quite distinct from all those enumerated above.

The first of these (his plate I) is represented by the jaws and buccal mass, with the lingual dentition, and some detached suckers, preserved in the museum of the University of Utrecht, but from an unknown locality. These parts are well figured and described, and were referred to *Architeuthis dux* by Harting. But the character of the dentition (plate IV, fig. 8) is so totally different from what I have found in *A. monachus* that it will be necessary to refer this species to a different genus, if not to a distinct family. The form of the lower jaw is quite unlike that of *A. dux*, for the beak is very acute, the cutting edge is concave, the notch shallow and broad, and the alar tooth is somewhat prominent. The size is about the same as our No. 5. The suckers figured are from the sessile arms, and agree pretty nearly with those of *A. monachus.* The edge is strengthened by an oblique, strongly denticulated ring. The internal diameter of the largest of these suckers is ·75 of an inch; the external, 1·05 inches. They were furnished with slender pedicels, attached obliquely on one side. The lingual teeth (see fig. 8, copied from Harting) are in seven regular rows, and resemble closely those of *Loligo* (fig. 7). In fact, I cannot find, in the figures and description, any character by which this species can be separated from *Loligo*, and at the same time it is evident that it is a species distinct from all others known. I would, therefore, propose to designate it by the name of *Loligo Hartingii.*

The other species described by Harting was from the Indian Ocean, and belongs to the genus *Enoploteuthis.*

Mr. Kent, in the article already referred to,* mentions a sessile arm of a giant cephalopod, which has been long preserved in the British Museum, but of which the origin is

* Proceedings Zoological Society of London for 1874, p. 178.

unknown. He states that it is 9 feet long; 11 inches in circumference at the base, tapering off to a fine point. There are from 145 to 150 suckers, in two alternating rows, those at the base being half an inch in diameter. The relatively small size of the suckers and great length of the arms show that this arm cannot belong to the same species as our *Architeuthis monachus*, which Mr. Kent thought probable. But as the arms of *A. princeps* and *Loligo Hartingii* are still unknown, it might belong to one of those species; or it may belong to the species observed, but not captured, by the officers of the "Alecton," in 1861, near Teneriffe, and named *Loligo Bouyeri* by Crosse and Fischer, but known only from the imperfect descriptions of it given by the officers, and a sketch of it prepared while the crew were making unsuccessful attempts to get it on board.

The body of this one was estimated at 15 to 18 feet in length, with the arms somewhat shorter.

EXPLANATION OF PLATE.

Plate v.—Figure 14. Upper jaw of *Architeuthis princeps* V. (No. 10); natural size.
Figure 15. Lower jaw of the same. The dotted line shows the parts that are present on the opposite side.
Figure 16. Part of lower jaw of *Architeuthis princeps* (No. 1); natural size.

ART. XXI.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXXII.—*The Trap Rocks of the Connecticut Valley;* by GEORGE W. HAWES.

IT has been already stated in this Journal* that Mr. E. S. Dana and myself have been engaged in the study of the eruptive rocks of the Connecticut Valley. Some of the results obtained by me through chemical analysis are here presented.

The dikes which intersect the Mesozoic sandstone and the adjacent strata are very numerous and oftentimes very different both as to the physical appearance and composition of the rocks. The analyses of some of these traps show them to be nearly anhydrous and of the same composition as the rock which is called dolerite. They have, moreover, a bright and apparently unaltered appearance, and under the microscope a clear crystalline character. Others are hydrous and also contain carbonic acid; their luster is dull and they are more or less green, and possess the composition and the chloritic character of the rock called diabase. Every grade of variation between the extreme cases can be found; but the attempt will be made to show, by the following analyses, the

*** See Abstract of a paper on the Trap Rocks of the Connecticut Valley, by E. S. Dana, this Journal, III, viii, 390. (Read before the American Association at the Hartford meeting, Aug., 1874.)**

uniform character of the ejected material, and what were the changes which took place to alter it into its present varieties, and what were the causes of the same.

The specimens of which analyses are here given have in general been taken from railroad cuts or working quarries, in order to avoid material which had been altered by surface action.

1. Dolerite.

Lying to the west of New Haven there is a long ridge of trap, ending in a high bluff which is called West Rock. The trap is very firm, and analyses show it to be dolerite, the typical rock of this region.

West Rock. Sp. gr. = 3·03.

	I.	II.	Mean.
Silica	51·80	51·76	51·78
Alumina	14·21	14·19	14·20
Ferrous oxide	8·26	8·23	8·25
Ferric oxide	3·55	3·62	3·59
Manganous oxide	·42	·45	·44
Lime	10·68	10·73	10·70
Magnesia	7·63	7·64	7·63
Soda	2·15	2·13	2·14
Potash	·39	·38	·39
Phosphoric acid	·14	·14	·14
Ignition	·63	·64	·63
	99·86	99·91	99·89

West Rock is one of the southernmost dikes of the old Connecticut Valley. The red sandstone region extends northward through Connecticut to the northern boundary of Massachusetts, and in the latter State are Mount Tom and Mount Holyoke. A fresh specimen from the latter mountain had the following composition:

Mount Holyoke. Sp. gr. = 2·97.

	I.	II.	Mean.
Silica	52·70	52·65	52·68
Alumina	14·11	14·17	14·14
Ferrous oxide	9·78	9·80	9·79
Ferric oxide	1·87	2·03	1·95
Manganous oxide	·45	·44	·44
Lime	9·36	9·39	9·38
Magnesia	6·42	6·35	6·38
Soda	2·54	2·57	2·56
Potash	·89	·87	·87
Ignition	1·61	1·58	1·60
	99·73	99·85	99·79

These analyses show it to be dolerite, differing from the trap of West Rock in the proportion of its ingredients.

A specimen from the Mesozoic sandstone region of New Jersey, taken from a deep railroad cut in Jersey City, afforded the following results:

JERSEY CITY. Sp. gr. = 2·96.

	I.	II.	Mean.
Silica	53·16	53·09	53·13
Alumina	13·87	13·62	13·74
Ferrous oxide	9·09	9·10	9·10
Ferric oxide	1·01	1·14	1·08
Manganous oxide	·44	·43	·43
Lime	9·44	9·50	9·47
Magnesia	8·56	8·59	8·58
Soda	2·28	2·32	2·30
Potash	1·03	1·04	1·03
Ignition	·89	·91	·90
	99·77	99·74	99·76

Another specimen taken from a trap hill lying to the eastward of New Haven, called East Rock, was also analyzed. But enough has been given to show the uniform character of the unaltered rocks of this era; no two analyses differing from one another more than would those of samples which could be selected from the same dike.

The principal mineral ingredients are pyroxene and labradorite, with a small amount of magnetite, and often, as Mr. Dana has detected by his microscopic examinations, a little chrysolite and apatite. The *pyroxene* can be recognized by its cleavage. Spots are sometimes found in the rock where the crystals of pyroxene have considerable size, and often the prismatic angle as well as the basal cleavage can be distinctly seen. From one piece it was possible to extract a sufficient number of crystalline fragments of apparent purity for an analysis.

PYROXENE FROM WEST ROCK.

Silica	50·71
Alumina	3·55
Ferrous oxide	15·30
Manganous oxide	·81
Lime	13·35
Magnesia	13·63
Ignition	1·17
Alkalies and loss (by difference)	1·48
	100·00

On comparing this analysis with those of the dolerites, it leaves little doubt but that the feldspar is labradorite, as the low percentage of silica and the presence of so much lime proves. The presence in one case of a feldspar with even a lower percentage of silica (see beyond) renders it improbable that the chief feldspar constituent has a higher percentage than labradorite. Moreover, in the analyses, making due allowance for the magnetite, the oxygen ratio of the bases and silica is even less than one to two, which would not be the case if the feldspar were oligoclase.

The *magnetite*, which is always present, is quite variable in amount. There is much more in the trap of West Rock than in any of the other specimens analyzed. This is evident from the amount of sesquioxide of iron present, which, if it be all contained in magnetite, would represent five per cent of that ingredient. In the Mt. Holyoke and New Jersey specimens there is less magnetite, as is shown by the lower percentage of sesquioxide of iron, the higher percentage of silica and the inferior specific gravities. In some cases the amount is very large. In a part of one of the dikes, that form the "Hanging Hills" of Meriden, the rock is quite black and the amount of iron has been the cause of rapid disintegration, so that now the fine earthy debris reaches to the top of the ridge. A determination of the iron in this rock gave

	I.	II.
FeO	8·52	8·55
Fe_2O_3	5·30	5·35
	13·82	13·90

A few feet distant, however, the rock becomes as firm and undecomposed as usual, showing that the gathering of the magnetite was of no great extent. Often octahedral crystals of magnetite can be seen in the rock with the unaided eye.

The analysis of the pyroxene shows it to be ordinary augite containing equal amounts of lime and magnesia; and as magnesia does not enter into the composition of the feldspar, the evident excess of magnesia above that which would form such a mixture of labradorite and pyroxene belongs to the chrysolite. The minute crystals of apatite detected by Mr. Dana account for the presence of phosphoric acid.

The feldspar *anorthite* is sometimes a constituent of these dolerites. Passing up the West Rock ridge, at about a mile from its southern face, a smaller dike is seen with an eastern and western strike, while West Rock runs nearly north and south. This dike upon one side of West Rock forms the dam of Wintergreen Lake, then cuts directly through the main dike, and projecting out several yards upon the other side of West Rock ridge, forms what is called the buttress. Its position, intersecting the main dike, shows it to be of later origin. The direction of the columns of this buttress are horizontal, while the columns of the main ridge are nearly vertical, which shows that the main ridge must have cooled sufficiently to determine the position of the columns of the buttress, since the columns are always at right angles to the cooling surfaces. This dike is characterized by large grains (¼ to ⅓ inch across) of a clear whitish cleavable mineral, which render it sparsely porphyritic. Even at the extremity, where the dike becomes very small, and where in consequence the rock is very fine in texture owing to the more rapid cooling, this porphyritic character is retained. A sufficient quantity of the pure material was extracted for an analysis; its composition was

ANORTHITE.

		O.
Silica	45·95	24·50
Alumina	34·70	16·31
Ferrous oxide	·64	
Lime	15·82	5·06
Magnesia	*trace*	
Potash	·45	
Soda	1·80	
Ignition	·96	
	100·32	

It is therefore a lime feldspar; and the oxygen ratio for RO, R_2O_3 and SiO_2 is 1 : 3·2 : 4·8, which shows the feldspar to be anorthite. Mr. Dana informs me that under the microscope it has a different appearance from the other feldspar, and although triclinic it shows less tendency toward twinning. An analysis of a sample of the trap of the dike in which the anorthite occurs shows it to be a dolerite of the same composition as the others; which is proof of the uniformity of the ejections at different times in this period.

DOLERITE FROM WINTERGREEN LAKE. Sp. gr. = 3·00.

	I.	II.	Mean.
Silica	52·38	52·45	52·42
Alumina	14·59	14·50	14·54
Ferrous oxide	9·89	9·79	9·84
Ferric oxide	1·27	1·22	1·25
Manganous oxide	·50	·53	·51
Lime	10·63	10·54	10·59
Magnesia	7·36	7·31	7·33
Soda	2·20	2·27	2·23
Potash	·51	·48	·49
Ignition	·55	·55	·55
	99·88	99·64	99·75

The rock is therefore a mixture of pyroxene and labradorite, from which the anorthite crystallized out on account of its different composition; for a very slight change in the composition of the whole mass would account for the formation of the small amount of anorthite which the rock contains, and the difference in its fusibility, that of labradorite being 3, and that of anorthite 5, would favor the separation of the anorthite.

2. Diabase, or Chloritic Dolerite.

In the examination of the various dikes we find the rocks in all stages of alteration, from the almost anhydrous rocks, like the preceding, to those in which the original ingredients seem to have undergone an almost complete change. This difference we conclude to be connected with geographical location and not with geological age; and the following analysis, as well as the study of the positions of the different varieties, prove this.

The rocks which were selected for analysis were taken from the eastern side of the sandstone region and are typical specimens of very large and long dikes. The Lake Saltonstall ridge, which is hydrous through its whole extent, is cut through near its southern extremity by the Shore Line Railroad, and it was from this spot, at some distance from the surface and from any amygdaloidal cavities, that the sample was selected.

Lake Saltonstall. Sp. gr. = 2·86.

	I.	II.	Mean.
Silica	49·27	49·29	49·28
Alumina	15·87	15·97	15·92
Ferrous oxide	10·17	10·23	10·20
Ferric oxide	1·93	1·88	1·91
Manganous oxide	·35	·40	·37
Lime	7·46	7·42	7·44
Magnesia	5·90	6·07	5·99
Soda	3·45	3·36	3·40
Potash	·74	·69	·72
Water	3·92	3·88	3·90
Carbonic acid	1·12	1·17	1·14
	100·18	100·36	100·27

A specimen from the southern dike of a high ridge called the Durham Mountains exhibits still greater alteration, for the amount of water shows that the larger part of the pyroxene has been changed to chlorite.

It will be seen that the alteration of these rocks has not been attended by further oxidation of the iron, and therefore it could not have been accomplished by any surface action, since the oxidation of protoxide of iron is one of the chief causes of surface alteration; while in this case one mineral containing protoxide has been changed into another protoxide mineral. It would, therefore, seem certain that the alteration took place at

SOUTH DURHAM MOUNTAIN. Sp. gr. = 2·83.

	I.	II.	Mean.
Silica	46·56	46·51	46·54
Alumina	14·75	15·05	14·90
Ferrous oxide	9·89	9·78	9·83
Ferric oxide	3·58	3·50	3·54
Manganous oxide	·33	·35	·34
Lime	7·99	7·90	7·94
Magnesia	4·83	4·89	4·86
Soda	2·47	2·38	2·43
Potash	·59	·60	·60
Water	4·50	4·54	4·52
Carbonic acid	4·38	4·32	4·35
	99·87	99·82	99·85

the time of ejection, as has been urged by Prof. Dana.* If the trap-rocks of this eastern region, when coming up melted through the red sandstone strata, encountered subterranean waters, and if it would be impossible for the vapors produced by the heat to be pressed back, owing to the hydrostatic pressure above, then these vapors, together with other vaporizable material, as carbonic acid, set free from its combinations in the strata by the heat, would pass into the mass of molten matter. In this way we have a sufficient explanation of the change that made this diabase out of the material that formed the dolerite.

The pyroxene was the mineral that was most attacked, the result of the alteration being chlorite. As chlorite is a magnesian mineral, lime was set free by this change. Part or all of this lime united with carbonic acid; for on touching any of these hydrated rocks with a drop of dilute acid, effervescence takes place. In many of the amygdaloidal traps this carbonate of lime fills the cavities. The pyroxene, however, does not furnish sufficient alumina for chlorite; this was furnished by the feldspar, which also participated in the change, and which, under the microscope, appears more or less dimmed by decomposition. As a result, silica was liberated, which also fills many of the amygdaloid cavities; and often both silica and carbonate of lime are found in the same cavity. In other cases it has united with the lime and alkalies to form zeolites, which are common in the cavities. The exact chemical reactions that took place will be considered at another time, when more of the products of decomposition have been analyzed. That there was such a passage of vapors through the molten mass is evident; for the rock of some dikes contains long pipe-stem-like cavities, which were made by the ascending vapors, and which are generally filled with calcite.

* See this Jour., III, vi, 104. "J. D. Dana on Igneous Ejections and Volcanoes."

On excluding the water and carbonic acid from the two preceding analyses, (columns 3 and 4 below,) it will be seen how nearly the original unaltered material resembles that of the dolerites (columns 1 and 2) in composition. As usual, there is a small difference in the amount of magnetite and in the proportion between the pyroxene and feldspar.

	1. West Rock.	2. Mt. Holyoke.	3. L. Saltonstall.	4. Durham Mt.
Silica	52·11	53·54	51·90	51·06
Alumina	14·29	14·37	16·77	16·35
Ferrous oxide	8·30	9·95	10·74	10·79
Ferric oxide	3·61	1·98	2·00	3·88
Manganous oxide	·44	·45	·39	·39
Lime	10·77	9·53	7·83	8·72
Magnesia	7·67	6·49	6·31	5·33
Soda	2·15	2·60	3·59	2·66
Potash	·39	·88	·75	·66
	99·73	99·79	100·28	99·84

There is a remarkable uniformity at all points in the ejected material, which seems to prove that, whether now anhydrous or chloritic, it must have had a common source, and this a deep-seated one; for so great uniformity would be well nigh impossible if the source were nearer the surface among the metamorphic rocks of the crust, as has sometimes been supposed.

ART. XXII.—*On the Comparison of Certain Theories of Solar Structure with Observation;* by S. P. LANGLEY. With a plate.

IN memoirs already published,* allusion has been made to the interest which would attend studies of the almost unknown interior of the umbra of sun-spots, and of forms there which, owing to the relative darkness, are hitherto nearly undescribed, and reference has also been made to certain so-called "crystalline" shapes seen at times, and which are especially associated with large spots and periods of great disturbance.

Doubtless owing to the difficulty of seeing appearances so delicate, these "crystalline" types have never been minutely delineated, and it has been naturally assumed that their existence lent some confirmation to the views of those who regard the photosphere as the luminous covering of an incandescent fluid, and consider spots as deposits of cooling matter, more or less analogous to the scoria deposits of terrestrial volcanoes. M. E. Gautier has, in a very interesting communication to M. Faye,†

* American Journal of Science, February, 1874. Royal Astronomical Society's Notices, March, 1874.

† Comptes Rendus, May 18, 1874.

referred to these forms, and to my description of them. They are indeed so remarkable, and at first sight so apparently confirmatory of the views alluded to, that only after long study I have been led to think them not so much assimilable to the products of cooling upon a liquid surface as to certain cloud forms of our own atmosphere.

To furnish material for a public examination of these details, whose study is so eminently instructive, it is necessary, as has been already remarked, (since photography cannot yet seize them,) to make drawings in which the single aim of the designer is to set down with a minute fidelity specific forms; aiming, in short, much more to produce a piece of accurate topography than a picture; but while it is on studies made of this minute exactness that discussion will be most profitable, their reproduction for the press is a work of so much labor that this kind of illustration will probably remain unusual.

The steel engraving, plate VI, from studies made at the Allegheny Observatory chiefly with the full aperture (13 English inches) of its equatorial, has been prepared by the kind furtherance of Prof. George F. Barker, of Philadelphia, its execution being secured at the hands of an engraver who has done his work with peculiar fidelity and skill. I trust it will be accepted as a means of putting the reader in a certain sense in the place of the observer, and enabling him himself to directly compare theory with the facts of observation. This plate is made from sketches taken on the 23d, 24th and 25th of December, 1873, of the eastern extremity of the great spot then nearing the center of the sun, and about 12° south of the solar equator. It is called a "typical spot" because (since the details could not be completed at a sitting) it is less an accurate outline of what could be seen at any one moment, than an assemblage of the different types presented, in their proper connection. The whole, then, is taken from observation; but while the details of the adjacent photosphere have been supplemented from other studies, everything in the main body of the spot is the most literal transcript I could make of specific penumbral and umbral forms.

The sun had been hidden here for some days before the 23d of December, when the sky cleared, disclosing a spot of more than usual size. Although a daily record of the solar surface is maintained at the Allegheny Observatory, the weather for some weeks before had interrupted it so capriciously that I am unable to say with certainty what the age of the spot was when it suddenly presented itself, but unquestionably it had at this time already passed through the initiatory stage of its formation, and had entered upon that in which the forms seen earlier have commenced to become segmented or distorted, while still retaining characteristics which show the type from which they have sprung.

Attention was first directed to that dark interior, in which Dawes discerned still darker shades, which he called *nuclei*, as the unusual size of the spot and the irregularity of shade in the umbra seemed to favor their investigation. Aided by special optical devices, there became visible to close attention, forms which appeared to be affiliated to the better known ones of the penumbra, which were studied also, and a description of a part of whose characteristics, interesting perhaps in their bearing upon solar theories, follows.

It was observed: (1.) That the now well-known filaments of the penumbra, and those (still to be described) of the umbra, were all disposed in curves. These curves might be described in general as portions of rude spirals, since while there was such a variety as to make classification difficult, the spiral type was, as a whole, beyond any question the dominant one. This and the characteristic forms of the outer penumbral edge, elsewhere partly described, bear witness to the existence of a force, or perhaps I should say the component of a force, directed in a general sense to the center of the spot, while at the same time the absence of a common direction of rotation, and the existence even of distinctly marked opposite flexures in the same filaments, show the complexity of the action which had been at work.

(2.) An appearance which deserves remark is this. It has long since been observed that the interior border of the penumbra is commonly brighter than its exterior; but the hitherto unrecognised cause is here shown, in a general tendency of these singular objects, the filaments, to grow progressively brighter toward their extremities. It should be noticed that it is not only here meant that these grow brighter at the inner edge of the penumbra, but that the many filaments, not long enough to reach wholly across the penumbra, and whose ends in this case lie partly down its slope, in every case show the same tendency, so that it is difficult to resist the impression that these extremities have a general disposition to turn upward and to appear as though lifting their points above some obscuring medium.

(3.) In this connection we may best study the umbral forms previously referred to, about which so little has hitherto been known, owing to the darkness in which they are involved. That this darkness is only relative has been long surmised, and I have found by direct experiment that when all extraneous light is excluded, except that from the "blackest" part of the umbra, this proved to be not only intrinsically bright, but insupportably intense to the naked eye. By the optical device referred to, then, I have been able to look within the sun to some limited extent, or farther at least below the surface than is commonly seen. Thus armed, we find that the reddish-brown masses within the umbra are resolved into filaments, analogous to the penumbral ones; like them disposed in curves, and like them apparently in planes, whose direction is usually approximately horizontal. Here also we see that these umbral filaments grow brighter toward their extremities, which *appear* as if curling upward, their ends thus occasionally furnishing that appearance of isolated bright points in the umbra which has been already observed.

Leaving these for the moment, let us consider what was, on the whole, the most remarkable feature of the spot: a plume-like appearance in its lower portion,* which, in connection with adjacent peculiar curves, presented forms of what has been called the "crystalline" type. The impression that agencies like those which mould the delicate crystallizations of water have been here engaged, is a natural one, and has been expressed before, the term "photospheric crystal" having apparently been used by M. Chacornac as long ago as 1853. This part of the spot, if any, would seem to justify the remark of M. Gautier, that the modifications of certain spot forms recall rather the effects of mineral or saline deposits than that of the action of whirlwinds. They may certainly be said to remind us of such deposits, but is it by a true analogy or by a superficial resemblance? If we look closer; if we increase our telescopic power, we find that filaments which elsewhere possess a scarcely sensible magnitude become here of immeasurable fineness, and lie, not so much at the sharp angles of a crystalline deposit, (as they with lower powers seem to do,) as like finely carded wool. We may be in doubt whether to treat these "plumes" as part of the penumbral or umbral structures, their brightness seeming to affiliate them to the former, while, on minute examination, their fibers may yet be discerned prolonged through the umbral shade and rising again (apparently) above it, in the luminous points just referred to. The resemblance seen here, then, is rather to the filamentary types found in the chromosphere, and which no one questions are purely gaseous. There is frequently remarkable symmetry displayed in these forms, but very rarely as much as in the present example, which was the most regular I have ever seen. The balance of its parts around a central axis was almost as exact as in a sculptured ornament, and here again the regularity of certain crystalline forms is suggested. The "plume," however, whatever it may be, is evidently an integral structure, not due to the casual union of heterogeneous elements, and it was found on measurement to be approximately 20″ in length and 10″ to 12″ in

* **Seen in the lower portion of the drawing.**

width. Are we prepared to admit the existence of a body properly analogous to a "crystal," covering over ten times the area of Europe? Even on the sun, where everything is enormous, this taxes belief. But once more, the extremely attenuated filaments of the "plume" do not appear to be in any single plane. The great length of nearly 10,000 English miles, through which they apparently extend, is a curtate distance, or that in which we see them as projected on the apparent plane of the solar disc. If I do not misinterpret the indications given by the brightening ends, they can hardly be spread upon the surface of a liquid, or upon any single surface whatever,—they bend *down* and *up*. All through the umbra are to be noted similar appearances; we seem to look down through increasing depths, but as far as vision extends, without coming to any liquid or solid floor,—always down through volumes of whirling vapor, (whirling, if we judge from their forms, which are disposed as if by vortical action,) and growing fainter till lost to sight at an unknown depth below the surface. Speaking, then, without reference to any hypothesis, it seems to me that the resemblance to crystalline structure (though I agree that it is striking) does not appear to be more than superficial. We have at certain rare intervals remarkable cirrous clouds in our own atmosphere, whose resemblance to these forms is equally close, and in which, I think, we may see not only a resemblance but an analogy. Some of these rarer cirrous types of our own sky, which I have studied in connection with solar forms, might, so far as external appearance went, certainly be fancied to display crystalline action as clearly as any frost-figure on a window, yet we have no difficulty in seeing that in this case the eddies of our own atmosphere have been in some way a principal cause. While recognizing the danger of pushing too far, conclusions drawn from terrestrial analogy, I should then (pending a more complete study of these appearances), regard them as most nearly typified by certain cloud-forms of our own atmosphere.

This spot presented other interesting types not here referred to. But I may mention, in support of previous observations, that in the upper portion of the penumbra, just below where a considerable part of the photosphere was islanded, the sudden and abrupt change of direction of the filaments marked the apparently unmistakable passage of one cloud stratum over another. This disposition was also marked elsewhere on the spot, whole banks of clouds moving one over the other, so as to form a *terraced* appearance. In very many other spots, this movement of one stratum over and frequently at right angles to another has been recognized, so that after long study, I have felt justified in elsewhere formally announcing it as an ascertained fact, observed not in an isolated instance, but as a general characteristic of the solar surface, whose features are thus again assimilated to atmospheric ones in some degree like our own.

From the preceding facts of observation, it appears that the following conclusions may be drawn:

(1.) Without prejudice to the important considerations on which its distinguished author has framed the theory of the existence of a liquid or viscous solar shell, it seems to me, speaking simply as an observer, that, from what has been stated of the appearance of umbral forms, such a shell or crust must, if it exist, be at a distance, below the surface of the photosphere, considerable even with reference to the dimensions we here deal with.

(2.) It seems difficult to reconcile the bright, sharply-defined inner penumbral edge, and the regular structure discerned in the umbra, with another view, in which this umbra is a sort of stagnant pool, formed by cold vapors, or clouds, which have settled there after depressing the general surface by their weight till the penumbral slope is determined. So much of the early hypothesis of Herschel as regards the umbra as an opening (however made) *through* which we look into a non-luminous interior of the sun, extending everywhere beneath the photosphere, seems common to views which, differing widely elsewhere, agree on this point more nearly with these observations than with the views peculiar to Father Secchi.*

(3.) Finally, it seems to be little more than a summary of the facts of observation already rehearsed, to say that traces of a vortical action are found throughout the spot, and especially in the umbra. The theory which regards cyclonic or vortical action as a prominent agent in determining the forms we have studied, appears then to be in closer accordance with observation than the former.

As the substance of the present article was written before Father Secchi's remarks appeared in the August *Memorie*, it was originally prepared without reference to the questions raised there, and without any special reference to the cyclonic theory; and it is in no sense meant as a complete expression of opinion on those several points, in connection with which Father Secchi has done me the honor to cite my name. As one of the few who have used an instrument of adequate power in the particular field of research in which a large part of his labors have lain, I am more able than most, perhaps, to appreciate his eminent qualities as an observer. When, however, he states that longer study of the sun than I have yet given, will

* . . . "Il solo errore dell 'illustre osservatore (i. e., Herschel) fu di estendere la massa oscura su tutto il globo sotto la fotosfera, *mentre in realtà essa non forma che pezze o chiazze assai limitate.—P. Secchi, Memorie, Agosto,* 1874.

change my views upon the theory of M. Faye, I may remark that those views were not emitted so hastily, or on such light grounds, as to be readily altered; for they were the result of several years of observation, with an instrument of greater power than that Father Secchi employs. Doubtless, before adopting conclusions in any way differing from those reached by one whose ability as an observer deserves such respect, I was bound in every way to verify the grounds on which these conclusions rested. If what seem to me the facts of observation conducted, and still continue to conduct me, to views in many ways differing from those which he maintains, in opposition to distinguished Italian and French astronomers, I have less hesitation in trusting to observations which agree more nearly with theirs, from the belief that no personally cherished hypothesis has subjected me to that unconscious bias in the collection and interpretation of facts, against which common experience shows that even eminent ability is not a certain protection.

Allegheny Observatory, Allegheny, Pennsylvania, December 29, 1874.

ART. XXIII.—*Notes on Costa Rica Geology;* by W. M. GABB.

SINCE the beginning of 1873, I have been engaged in an exploration of the southeastern corner of the republic of Costa Rica, a region of about 3,000 square miles, known politically as the District of Talamanca. Previous to my going there, the country was probably the least known of any part of Central or Isthmian America. It comprises the Atlantic slope of nearly one half of the length of the republic, and is inhabited by tribes of Indians who, with good reason, have such a hatred to everything called Spanish, that the people of the country have never dared to penetrate it. Strange to say, the hatred is not against the white race; only against "Spaniards," i. e., persons of that race, or speaking that language. A few English-speaking traders have had dealings with these people for half a century, and have invariably treated them well; so that an Englishman or American can go among them with impunity; while one speaking only Spanish is looked upon with distrust, and either treated with insolence, or at best left severely alone.

I was at first engaged by a company of the leading persons in Costa Rica, natives and foreigners, but afterward the Government took charge and assumed the responsibility of the work. The prime object of the exploration was the re-discovery of some mines, reported by tradition to exist in the region, and of which the most fabulous stories were told. Suffice it here to say that such mines do not, and for sufficient geological reasons cannot, exist there. This, however, is not surprising to one who has been in California or in the West Indies, where such traditions exist everywhere. Having now completed the field-work of this little isolated region, I consider it advisable to put on permanent record a bare *resumé* of the leading facts and observations, leaving all theories and deductions for a future occasion. It is difficult, and perhaps unadvisable, to attempt to generalize where one's observations have been so entirely circumscribed as mine have been in this district. I have not been able to carry my observations to the Pacific; and the conglomerate rocks, of which I shall speak, point to older sedimentary formations which I have not seen, and which may have played an important part in the history of Isthmian America.

The central Cordillera of the lower part of Costa Rica is not much less than 6,000 feet high at its lowest point. Along this crest rise several prominent peaks, that of U-jum, at the head of the Coen River, and Mt. Lyon, at the head of the Lari, being probably over 8,000 feet each, while Pico Blanco, or Kamuk, the culminating point, is 9,652 feet, by careful barometrical measurement. Farther down the isthmus the reputed volcanoes of Chiriqui and Robalo are said to be of corresponding heights; but to the northwest a decided depression of the range occurs, before we reach the high region of Central Costa Rica. The direct distance from the summits of the range to the coast is hardly more than thirty miles; but the country is so cut up by sharp ridges and deep cañons, so covered with dense forests and impassable swamps, and so poorly supplied even with Indian trails, that the distance travelled is fully three times as great. In an open country, with good routes of travel, I could easily have accomplished in three or four months all the geological explorations that necessitated seventeen months of the hardest labor I ever did in my life. This is not the place to speak of toil and suffering, of exposure for weeks to continued rains, of fording swollen rivers at the risk of our lives, of fevers; in short, of all the pleasant episodes inevitably connected with work in primeval tropical forests. We have been through them all, and without the loss of a single life in my corps; albeit, several Indians paid that penalty, and, although I escaped with health uninjured, some of my assistants have been less fortunate in this respect.

The chain slopes rapidly to the northeast, and in a dozen miles from the summit is barely more than a thousand feet high. The next dozen miles is a still more gentle slope; and the coast is bordered by a flat region of swamp, broken by only a few low spurs.

Two large rivers drain the region. These are the Tiliri (sometimes called the Sicsola) and the Tilorio (likewise known at its mouth as the Changinola). These names in parenthesis were given by the Mosquito negroes to the mouths of the rivers, and, although they occur on the maps, are not the real names of the streams. The Tiliri is the more important of the two, draining by far the larger area, by means of five great branches, viz., the Tiliri proper, the Coen, the Lari, the Uren, and the Zhorquin. All of these branches, except the last, unite, in the space of a mile, in a broad valley of over 100 square miles of area. The Zhorquin is the smallest branch, does not descend from the main range, as the others do, and enters the Tiliri a few miles below the junction of the other branches.

The Tilorio drains the region east of Pico Blanco, by one great arm and its branches, and the country back of Pico Robalo, by another arm. This latter is entirely unknown, and is likely to remain so, until some traveller more adventurous than any yet found dares to penetrate the region. The Indians reported the country to be almost impassable, and say it is inhabited by a small band of Indians who refuse unconditionally to hold any communication with civilized people, or to permit them to enter their district. Several such refugee bands of savages are known to exist in this vicinity, and I have little doubt but that there is good foundation for the story.

The high mountains of Talamanca are in great part made up of a mass of granitic rocks, bearing in some respects a marked resemblance to those of the island of Santo Domingo. There is one important point of difference, however, between the manner of occurrence of this rock here and in Santo Domingo. In the latter country, granitic dikes often cut through or extend into the sedimentary rocks for great distances. They are of all sizes, from a thread to hundreds of yards in thickness, and often contain fragments of the jaspery slates entangled in them, and perfectly soldered by fusion. In Costa Rica I have never seen a granitic dike. The material seems to have been forced up from below in a plastic state, sufficiently heated to have changed the character of the overlying rock wherever it came in contact with it, but never sufficiently fluid to penetrate any possible fissures that may have existed. True granite rarely occurs, while syenites are much more common. The rock is almost always rather fine-grained, and while hornblende abounds, mica is rather the exception than the rule. The rock is lighter in color, and of a slightly coarser grain at the more eastern exposures than farther west. I saw nowhere the slightest approach to a gneissoid structure, or any other sign that would indicate a metamorphic origin for the mass, but several facts point to its having been quite recently in a heated condition. On the upper part of the Coen River, on one of its largest western branches, I found a single small boulder of mica slate, but I could not trace it to its source.

Lying on the flanks of the granite, in the region of the Tiliri, and extending to the coast, there is a deposit, only a few hundred feet thick, of Tertiary rocks, where, in contact with the granite, they are highly tilted, dipping seaward; a large fold or two follows this uplift in the higher mountains, and more gentle undulations extend to the coast. There is not a regular system of plications, however, since I have observed local variations of strike, even as great as at right angles, within a mile, accompanied by high dips. This is markedly the case on the Zhorquin, near its mouth, where, perhaps, the underlying granite is not far below the surface. Close to the granites the sedimentary rocks are highly metamorphosed, and in most cases their bedding is entirely destroyed; but I was fortunately able to collect fossils at a number of localities scattered not only over the greater part of Talamanca, but also farther north and northwest, in the adjoining parts of Costa Rica. These prove, beyond a reasonable doubt, that the rocks are an extension of the great Miocene deposit found not only on the isthmus proper, but over so many of the West Indian islands. I recognized at sight many familiar species, and have no doubt that others only await comparison to identify them with known species.

These Miocene rocks are made up principally of conglomerates and fine shales, with occasional beds of sandstone, and a very little limestone. The limestone occurs most abundantly in the central regions of Costa Rica, in the Candelaria Mountains, and on the Reventazon River near Sapote, and are almost entirely wanting in Talamanca. The conglomerates and shales are also found as far as the latter locality; while the last mentioned rock is the most important constituent of the Candelaria range. Wherever the shales are found unaltered, they carry small beds of very inferior coal. It is to this member that the coal mines of Chiriqui belong: and, half a dozen miles south of San José, the capital of Costa Rica, there is a small mine of coal now being worked experimentally, with results far from encouraging.

The conglomerates are made up entirely of pebbles of a metamorphosed claystone. I have studied them with great care at almost every locality where I found exposures, and have never met with a single boulder or pebble of crystalline material. Even where close to the granitic rocks, I failed completely to find the slightest trace of granite. Nor have I been able to trace to their source these claystone pebbles. The formation must have been extensive to have furnished such a bulk of coarse material, to say nothing of the shales probably derived from the same source. The absence of granite pebbles proves conclusively that this rock was not exposed at the time of the deposition of the Miocene. Another peculiarity of the conglomerate is that, while from the region of the Tiliri west and north, as far as the line of the railroad now being constructed, the pebbles are hard and well rounded by attrition, and cemented by a matrix of different character, on the Tilorio the rock is rather a mottled claystone than a true conglomerate. The pebbles seem to have been but little altered, to have been imbedded in a matrix formed from their own material, disintegrated, and the whole, after deposition, to have undergone metamorphism together for the first time.

The trend of the granitic intrusion is not coincident nor coextensive with the mountain range. It bears more to the east, Pico Blanco being its culminating point; beyond this to the east it extends almost to the Tilorio River, ending in a narrow tongue. I was unable to ascend the Tilorio, back to the granite belt; but although there are large streams penetrating westward from the Tilorio toward Pico Blanco, there are no granite boulders in that river on its head waters.

Both the granite and the Miocene rocks are cut by numerous porphyritic dikes of a pretty uniform character, but entirely different from the more modern volcanic rocks of Central Costa Rica. These seem to have penetrated the two groups equally, and vary from a few yards to a mile in length. One of these dikes forms the apex of Pico Blanco, and has been exposed by the decomposition and denudation of the surrounding softer granite. This is nearly 300 feet high, and forms the extreme tip of what is otherwise an ordinary granite mountain. Space does not permit me to enter into a detailed discussion of this question here. I was three hours on the summit of the mountain. It is a simple, straight ridge, of which the western end rises in a sharp cone, perhaps fifty feet higher than the rest. There is no sign whatever of a crater, and 300 feet below the summit there is no volcanic rock. It must, therefore, be struck from the list of volcanoes.

The two neighboring peaks, Mt. Lyon, between the Lari and its branch, the Dipari, and U-jum, at the head of the Coen, are said by the Indians to be volcanoes. But after my experience with Blanco, I feel great hesitation in accepting the statement, although it is fortified by many very plausible stories of fires and smoke seen on their summits. The latter, especially, with its sharp, regular cone, certainly looks volcanic, and I had hoped to reach it; but after my excursion to Pico Blanco, all hands of my party, white as well as Indians, decided that for the time, at least, it was impracticable. It would have cost a month of hard work, and I had not so much time at my disposal.

Before closing my account of the mountain region, there is one other item deserving mention. My instructions required me to look for mines, and I examined carefully for traces of the precious metals wherever I went. I found in a few places quartz veins; one of considerable size, the others practically valueless. I also found deposits of placer gold in a few localities. But the existence of gold here is rather of scientific than of economic interest. The gold occurs in the metamorphosed Miocene rocks, and always at a greater or less distance from the granites. The point at which I found gold nearest to the granite was at least a mile distant, although the rock was highly metamorphosed. The spot where I found the largest quantity of gold was miles away from the granitic intrusion.

There is little more to be said about the geology of Talamanca. The coast is low and swampy, and is bordered by a few patches of Post-pliocene rocks of the character which I have designated as Antillite in the West Indies. Near Moen, back of the border reef, there was a little bay, where a dark gray claystone was deposited, and this bed, nearly 100 feet thick in one place, abounds in beautiful fossils, all of recent species of shells and Radiates. Many of the Mollusca retain their colors quite bright. On the beach, at some points, are large deposits of iron sand of great purity, which might be utilized.

To my great regret, I have not been able to carry my section completely across Terraba to the Pacific. On the summit of Pico Blanco, after robbing Irazu of its boast that it was the only point whence both oceans can be seen at the same time, we could only look over Terraba and wish. The granite was pushed up after the deposition of the Miocene. This I have demonstrated by the absence of granitic pebbles in the conglomerate. It therefore seems probable to me, *à priori* (I admit a not perfectly safe argument), that the same formation extended across; and standing on the peak, and looking at the hills and plains on both sides, I could not but feel convinced that on the south base of the mountain I must find the same rock as on the north. Add to this, that but a few miles farther east the rock does actually run around the end of the granite, there seems good reason for expecting to find the plains of Terraba to be Tertiary. Further, as far north and northwest as I have traced sedimentary rocks, they are of the same age, as proven by fossils. The whole Atlantic slope of Costa Rica may be safely predicted to be Miocene.

Above Moen are broad, flat plains, which sweep around to the bases of the volcanic peaks of Turrialba and Irazu, and the farther north I followed the Miocene the less disturbed I found it. East of the volcano of Turrialba I found Miocene, with abundance of characteristic fossils, but little tilted, and in one place actually horizontal. Sweeping round to the westward, the Candelaria range is made up of the same rock, here somewhat disturbed, but with a general strike corresponding to the trend of the range. Beyond this everything is covered with great beds of volcanic ash and cut up by innumerable dikes of volcanic rock. North of the valley the magnificent line of volcanoes, Turrialba, Irazu, Barba, and Poos covers all the other rocks; but on the west face of the Aguacate Mountains, where the coating of ash is in places absent, we find highly altered claystones. These are rich in mineral veins, and have been thoroughly explored for mines of gold and silver. Whether the rock is the ancient clay slate from which the conglomerates were formed, or whether it is highly metamorphosed Tertiary, we have, as yet, no means of knowing, and the problem will require careful study for its solution.

Costa Rica, Nov. 29, 1874.

ART. XXIV.—*Note on the Discovery of a new locality of Primordial Fossils in Rensselaer County, N. Y.;* by S. W. FORD.

SEVERAL weeks ago, in company with my friend Mr. James C. Bell, Jr., of this city, I visited the hills a short distance to the east of the village of Lansingburgh, for the purpose of examining more minutely than I had previously done the interesting series of rocks there exposed. The strata first met with in going eastward from the village consist, in ascending order, as follows: (1) a series of thin-bedded gray sandstones with slight shaly partings; (2) a series of fine black slates and shales alternating with thin sandstone layers of a pinkish color, the surfaces of which are frequently profusely covered with ripple-marks and worm-burrows; and (3) a deposit of heavy-bedded gray sandstone with fractures running in every direction, and with now and then thin shaly seams which serve to indicate the bedding: the surfaces of the fractures, with few exceptions, thickly studded with small crystals of quartz. The thickness of the above enumerated beds cannot here be given with exactness; but that of the thin sandstones is not far from thirty feet, and that of the superposed slates and shales about twenty. The heavy-bedded sandstones are of much greater extent. At one point they form a sharp, bold elevation, locally known as "Diamond Rock." All of these beds are arranged in a series of close synclinal and anticlinal folds, leaning to the northwest; and, as a result of this arrangement, the rocks of this region have a nearly uniform southeasterly dip. I was unable to obtain any fossils in these rocks, but at a locality about half a mile eastward of the first exposures examined I was more successful. At this point an apparently higher series of slates is met with, and these are, in turn, succeeded by a considerable deposit of conglomerate limestone. This latter rock is a most singular formation, appearing as if composed of innumerable blocks and wedges of limestone confusedly thrown down and afterward firmly cemented together. It appears almost incredible, at first sight, that fossils should occur in such a looking mass. But in a detached block of limestone lying only a short distance from the deposit in question, and to which I am satisfied it belongs, I found upward of half a dozen imperfect heads, and three perfect specimens of what I consider to be the pygidium of *Conocephalites* (*Atops*) *trilineatus* Emm. In addition to these I obtained from the main mass an unequivocal specimen of *Hyolithes Americanus* Billings; and on examining, on my return home, a piece also broken from the rock *in situ* by Mr. Bell, I found a specimen of the species described by me under the name of *Obolella nitida.* All of these species likewise occur in the Lower Potsdam limestones at Troy. No perfect specimens of the pygidium of *C. trilineatus* have, to my knowledge, hitherto been found; and while reserving the complete description of it till another time, I will refer to its leading characters here. It is nearly semicircular in form, the axis strong, composed of seven segments, with a row of obtuse spines along the middle; lateral lobes composed of five segments each, with distinct intervening grooves; marginal-rim nearly flat, widest toward the front, and distinctly and regularly notched or denticulated all around.* The surface of the border is finely granular. On page 405 of his "Palæozoic Fossils," vol. i, Mr. Billings has figured the pygidium of a trilobite from the Quebec group, which has the marginal-rim notched in precisely the same manner as that of *C. trilineatus.* Mr. Billings does not refer it positively to any genus. On comparing the characters furnished by the figure with those of the pygidium of *C. trilineatus*, I strongly suspect that the form in question belongs to the genus *Conocephalites.* At present, it appears to me quite probable that it is the tail piece of *Conocephalites Zenkeri*, described on page 398 of Mr. Billings' work cited.

* In the configuration of the border above noticed, this species differs widely from any species of the genus hitherto described. Barrande, in his beautiful work on the Trilobites, places the genus *Conocephalites* in his group of genera in which the border of the pygidium is unbroken or entire (Système Silurian de la Bohême, vol. i, p. 220). The species known as *Conocephalites Iowensis*, from the Wisconsin Primordial, furnishes another exception to the rule. In that species the border of the pygidium is prolonged backward into two long diverging spines. (16th Reg. Rep.)

I regard the Lansingburgh limerock as the stratigraphical equivalent of my limestone band No. 1, at Troy. (See this Journal for August, 1873.) They are lithologically similar; and, moreover, have furnished two species in common, namely, *C. trilineatus* and *Hyolithes Americanus.* At Troy this deposit is similarly underlaid by a heavy slate formation, while apparently below this, and in the same line of outcrop, there are exposed at one point a few layers of thick-bedded sandstone similar to that constituting "Diamond Rock." The inferior slates and thin-bedded sandstones of the Lansingburgh section are, so far as direct observation goes, here wanting; but, if I am right in my interpretations, they are most probably present, but are not brought up to view. The equivalency of the Troy and Lansingburgh beds cannot be proved by actual inspection of the rocks between these two places, since, for the greater portion of the distance, there are almost no exposures. In my first regular paper relating to the rocks of this district (this Journal, July, 1871), I briefly referred to the Lansingburgh slates and sandstones described at the opening of the present article, and spoke of them as most probably an inferior division of the Lower Potsdam. This provisional reference was based alone upon the stratigraphical evidence I then possessed, as the accompanying limerock had at that time yielded no positive testimony bearing upon the subject. The evidence now in hand seems to sustain the correctness of that reference, but it is quite possible that these lower sandstones may yet be found to contain a still more ancient fauna. I hope in the coming spring, if my opportunities permit, to give this field a more careful and extended study.

Troy, N. Y., Dec. 26th, 1874.

ART. XXV.—*Abstract of a Memoir on the Origin, and Mechanism of Production, of the Prismatic or Columnar Structure of Basalt;* by ROBERT MALLET, F.R.S. (Read before the Royal Society, January 21st, 1875.)*

THE author, having briefly traced the history of geological opinion on this subject from before the period when the controversy in which the igneous or aqueous origin of basalt may be viewed as settled, and having stated the views of some of the more prominent British authors of recent date on this subject, points out that, up to the present, no clear and definite theoretic views have been enunciated to account for the prismatic structure in basalt, and that it is impossible to gather, with

* We are indebted to the author for this abstract.—EDS.

any distinctness, from systematic writers, whether prismatic structure be due to contraction by cooling alone, or whether the structure is due to preëxisting concretionary or crystalline arrangement of the integral particles of the mass, or to this coacting with enormous external pressures, the origin of which is left perfectly vague, or to some play of successive and joint actions of all these various forces.

Professor James Thomson, in a paper read some years ago, and since repeated at the Belfast Meeting of the British Association, has proposed views in some respects new, tracing prismatic structure to contraction by cooling only, and has expressed entire doubt as to the part supposed to be played by concretionary spheroids pressed together. Professor Thomson's views, however, are still far from complete, and the mode assigned by him to the production of cup-shaped cross joints in the prisms fails to account for the phenomena.

The aim of the author is to point out in this paper that all the salient phenomena of the prismatic and jointed structure of basalt, as observable in nature, can be accounted for upon the admitted laws of cooling, and contraction thereby, of melted rock possessing the known properties of basalt, the essential conditions being a very general homogeneity in the mass cooling, and that the cooling shall take place slowly, principally from one or more of its surfaces.

Thus, taking the simple case of a tabular mass of molten basalt, whose top surface is level, the depth being great, and the two other dimensions indefinitely greater than that, and assuming the material at one temperature initially, and homogeneous and isotropic, and that cooling takes place from the top surface only, he, on these data, proceeds to consider the phenomena that will successively result by contraction in cooling.

While the mass remains at its upper part still plastic by heat, contraction will be met by internal movements and subsidence of the top surface, and no cracking or splitting can take place until the material there has become rigid enough to break under tensile strain. He points out that this degree of rigidity, or "splitting temperature," is not reached until the top surface has fallen to between 900° and 600° Fahr.

At this temperature the cooling surface begins to separate by fracture, penetrating perpendicularly to it into smaller surfaces. These must be similar and equal in area, and such that their edges in contact can make up a continuous superficies. To relieve the orthogonal strains in the cooling surface, and to meet the above conditions, only three geometric figures for the separating surfaces are possible, namely, the equilateral triangle, the square, and the regular hexagon.

The author then inquires why the last of these is normally the force found in nature. He traces this to the law of least action which governs the play of all natural forces whose final result is produced by the least possible expenditure of force. He shows that, in a contracting surface splitting up into equal areas, the expenditure of work will, for the equilateral triangle, the square, and the regular hexagon, be approximately as the numbers 1·000, 0·680, and 0·519. This economy of force decides the hexagon as the form found in nature. The diameter of the hexagon, which is the upper surface of the inceptive hexagonal prism, is shown to be fixed by the relation that subsists between the coefficient of contraction and that of its extension at rupture by a tensile force at the splitting temperature. This decides the diameters of the separate prisms. The splitting by contraction proceeds into the mass always in a direction perpendicular to the cooling surface, and at any instant the splitting is limited in its progress by the isothermal *couche*, which is at the splitting temperature within the mass; for within that *couche* the mass is still plastic. In the case assumed the prisms formed are straight and vertical. When the splitting has proceeded to some distance within the mass, the further cooling of each prism takes place not only from the top, but from the sides, and the more important conditions influencing the latter in nature are pointed out.

Any one prism is coldest at its extremity, and its temperature increases along its length to the other end, where the splitting is still proceeding. The prism is hotter, also, for any transverse section, as we approach its axis, than about the exterior; differential strains in the longitudinal direction thus take place, by cooling and contraction, between the successive imaginary *couches*, taken from the exterior to the axis of the prism, which tend to cause the outer portions of the prisms to tear asunder at intervals in length dependent, like the diameter of the prisms themselves, upon the relation subsisting between the coefficient of contraction and of extensibility at rupture of the material.

The prism contracts not only in its length, but in its diameter; transverse fracture at its surface, when it occurs, is therefore due to the resultant of two orthogonal forces, the one parallel to the axis of the prism, as already referred to, and the other in a plane transverse to the axis. These two forces are proportionate, the first to the length of the prism from a preceding joint, or from its extremity, the second approximately to the semi-diameter of the hexagon; and the resultant of these two, at any point taken round the prism, is oblique to the axis, and tending toward it in direction. As fracture in a homogeneous solid always takes place transverse to the line of strain, so the fracture producing a transverse joint takes place oblique to the sides of the prism; the obliquity becoming less as the fracture advances toward the axis of the prism, so that when complete it is cup-shaped, the convex surface of the fracture always pointing in the same direction as that in which the splitting of the prism itself is proceeding.

This solution, which is believed to be the first ever presented which, resting upon admitted laws, completely accounts for the production of the very remarkable cupped-shaped joints, is verified and illustrated by several diagrams, showing the mode of production of these joints, and the modifications of their curvature produced by varied conditions in the cooling.

It is further shown that the partial or complete detachment of certain fragments, frequently observed to be partially or wholly detached from the cusps of the concave side of these joints at and near the solid angles of the hexagon, is a consequence necessarily resulting from the mode of production of the joints themselves. The author then points out that in the case of very slender prisms other (and mechanical) conditions besides those of differential cooling enter into the production of the cross joints, which are at more considerable and irregular distances apart, and in planes of fracture often nearly transverse to the axis of the prism.

He also discusses the modifications produced in the prisms themselves, and in their cross joints, by heterogeneity in the mass of basalt itself—as, for example, by a more or less previously developed cleavage in the basalt in planes transverse to the axis of the prism, or by the presence of heterogeneous substances imbedded in the mass. To these latter, and to differences in conductivity, or in the cooling energy at different points of the cooling surface, are chiefly to be ascribed the divergencies from the normal hexagonal form of the prisms, as occasionally observed, the author remarking that where such divergencies occur they disappear, and the normal hexagonal form is returned to in such a manner as to require only the minimum expenditure of work.

The conditions producing greater or less interspaces between the prisms, which may vary from point to point of the same mass, are pointed out, as also those which cause the spaces between successive joints in adjacent prisms to coincide in successive planes, transverse to their axes, or the contrary.

The author then proceeds to discuss the various positions in space, and relatively to each other, which the axes of the prisms must assume, dependent on the general law, as already stated, that the axes of the prisms, however produced, are always normal to successive isothermal couches or planes at the splitting temperature, taken in succession within the mass.

If the mass be tabular, as already assumed, and cooling take place only from the top surface, the prisms will be straight and vertical, extending from top to bottom nearly of the tabular mass, and being separated from the bottom on which it rests by a more or less thick layer of irregular angular fragments, or of badly conducting material, tufa, scoriæ, &c., the convex surface of the joints all pointing downward. If the mass cool, both from the bottom and the top, the prisms, vertical and straight, will split upward and downward, and meet in an irregular intermediate stratum of angular fragments, the convex surfaces of the joints of the lower prisms pointing upward, and the respective lengths of the upper and lower ranges depending on their relative rates of cooling. If the tabular mass cool also from one or more of its sides, as by an abutting wall of rock, prisms will be produced with their axes perpendicular to that wall, and will be separated from the vertical ranges of prisms by an inclined stratum of angular fragments. Also if the basalt fill a crevasse producing a dyke, the prisms formed by cooling will be generally transverse to the plane of its walls, and meet somewhere toward the center in a stratum of more or less irregular fragments, due in all cases to the irregular contractions at the extremities of the prisms breaking up their mass there into wholly irregular forms. If the upper and cooling surface have a curved convex contour, the prisms shall be taper and convergent from the surface of the mass; and on the contrary, if the cooling surface have a concave contour, or rest upon a concave bottom, the prisms shall be divergent from the interior of the mass, the natural law of economy of work limiting the length or amount of taper in either case, limiting the length of the prisms, and a new range of larger diameter partially or wholly then commencing. The convergence or divergence are simple consequences of the general law, that the splitting takes place always normal to the isothermal *couches*, which are at the splitting temperature.

The author then proceeds to develop and illustrate by diagrams some of the varied and curious combinations which are observable in nature, and due to the more or less combined play of these conditions. He then proceeds to develop, as a consequence of the general law, the production of curved prisms, or those with apparently bent axes, which are observed in almost all basaltic countries. If the cooling mass of basalt be in one of its vertical sections of such a form that successive isothermal *couches*, taken in descending order, are not parallel to the original cooling surface, as they are in all cases of straight and parallel prisms, but divergent gradually from the cooling surface and from each other, then the lines of splitting of the prisms, always normal to these *couches*, must be curved in one direction. This will be true whether the isothermal *couches* be plane surfaces divergent from a thinner to a thicker part of the mass, or whether they be curved surfaces arising from the mass reposing on a curved bottom, and diverging in like manner. This explanation of the production of curved prisms, without the necessary intervention of external mechanical forces, having bent into curves prisms originally formed straight, is, the author believes, here for the first time presented. He shows that great difficulties exist to the supposition that curved prisms are ever the result of the bending of prisms originally straight by extraneous mechanical effort. The author having thus shown that all the salient phenomena presented in nature by the forms, jointings, positions of the prisms, &c., of columnar basalt are accounted for as consequences of contraction in cooling, submits that this solution given by him must be the true one. He, however, proceeds to examine at some length the different views of those who have imagined that prismatic and jointed basalt has resulted from the squeezing together by some wholly imaginary external force of spheroidal masses, more or less resembling those known as "onion stones," or concretionary spheroids, such as those imagined by Mr. Gregory Watt. The author submits all points of the subject to a searching examination, and points out that, upon the only probable suppositions that can be made as to the pre-arrangement of such spheroids, no extraneous force of compression could produce prisms at all, but must squeeze the spheroids instead into rhombic dodecahedrons.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Atmospheric Hydrogen Peroxide.*—Between the first of July and the first of December, 1874, Schöne examined one hundred and thirty specimens of rain, and twenty-nine specimens of snow, for hydrogen peroxide. These experiments were made in the vicinity of Moscow. Of the whole number of specimens of rain, only four failed to respond to the test, though out of the twenty-nine specimens of snow, twelve gave no reaction. Having established the fact, the author continued his investigations with reference to the following points: (1) Form of occurrence of hydrogen peroxide in the atmosphere; whether gaseous or dissolved in the fluid, or solid rain or hail; (2) Relation to other meteoric phenomena, to time of day and to season of the year; (3) Relation to the ozone of the atmosphere; (4) How produced in the air; (5) Part played by it geologically and botanically; (6) Action upon the animal economy when breathed; and (7) Hygienic

importance. For this purpose, all the rain, hail, snow, dew, and frost were collected and tested for hydrogen peroxide, the analysis being quantitative when possible. Further, at various times, especially in clear weather, artificial dew and frost were prepared and examined. Careful meteorological records were kept during the entire interval at the adjoining observatory. The ozone was determined by a Schonbein's ozonometer. The results show: that the quantity of hydrogen peroxide in rain varies from 0·04 to 1·00 milligram per liter; that the larger the drops, the greater the amount; that the first rain after dry weather is poorer in peroxide than that which falls later; that the peroxide is greatest when the wind is south and southwest, that in the rain brought by the equatorial current being greater than that which falls in the rain produced by the conflict of this with the polar current, or brought by the latter current itself; that the relative quantity of peroxide in rain increases from the summer solstice to the autumnal equinox, and then diminishes; that the quantity is not greater in rain which falls during a thunder-shower; and that during the four months, the absolute quantity of hydrogen peroxide contained in the 221 liters of rain which fell upon each square meter was only 62·9 milligrams. In snow there was only 0·05 mgr. peroxide to the liter, the amount diminishing toward the winter solstice. Natural dew and frost contain no peroxide, or at least, less than one twenty-five millionth of this substance. In artificial dew and frost, the amount of peroxide varied from 0·04 to 0·05 mgr. per liter, reaching on a bright moonlight night in summer 0·09 mgr. The amount increased with the altitude of the sun. The daily maximum was reached between 12 and 4 o'clock P. M., and the annual in the month of August. The amount is greater the lighter the temperature, the clearer the sky, the higher the absolute and the lower the relative humidity of the air. The author concludes that the peroxide is contained in the air both free and in solution, to the extent, as a maximum, of 0·000000268 c.c. in a liter. He also believes that sunlight plays an important part in its production. The experiments are still in progress.—*Ber. Berl. Chem. Ges.*, vii, 1693, Dec., 1874.

G. F. B.

2. *On the Absorption Spectra of Potassium and Sodium.*—ROSCOE and SCHUSTER have examined the absorption produced in the spectrum by the vapors of potassium and sodium. Fragments of the former metal, placed in tubes filled with hydrogen, were heated until the green vapors appeared. A continuous spectrum from a calcium light placed behind the tube, suffered absorption within it, and was examined by means of a Steinheil spectroscope of two prisms. A complicated absorption spectrum appeared, consisting of three groups of bands; the first, group α, appeared first and was in the red; the second, β, was on the one side, and the third, γ, on the other of the D lines. These bands shaded off toward the red and resembled in general the bands of iodine. The position of the bands was approximately measured. Group

α consisted of nineteen bands, varying in wave-length from 6844 to 6275 ten-millionths of a meter; group β of eight lines, from 6059 to 5901; group γ of thirteen lines, from 5860 to 5667. The ordinary spectrum lines of the metal were not seen reversed owing to the too feeble intensity of the calcium light. Similar experiments with sodium led to similar results. The blue vapor gave an absorption spectrum showing in the blue a group of bands (γ) eleven in number, followed soon after by a group in the red and yellow (α) consisting of twelve bands, and then by group (β) in the orange made up of seven bands. Sodium vapor in an iron tube heated to redness shows an absorption spectrum in which the red, the green and a part of the blue are removed. The D absorption lines widen considerably and a strong absorption band appears in the green. Hence only a part of the orange, the green and the ultra-blue are transmitted.—*Proc. Roy. Soc.*, xxii, 362; *J. Phys.*, iii, 344, Nov., 1874. G. F. B.

3. *Preparation of Glacial Formic Acid.*—In the ordinary preparation of strong formic acid, by passing hydrogen sulphide gas over lead formate, gently heated over a free fire, the product is always contaminated with sulphur products which communicate an unpleasant odor to the acid, and which cannot be removed. M. BERTHELOT finds that this may easily be avoided by conducting the decomposition at a low temperature. The well-dried lead formate is placed in a U tube which is immersed in an oil bath, the temperature of which must not surpass 130° C. Hydrogen sulphide is then slowly passed over it and the product is collected and purified by fractioning. Placed in a freezing mixture and solidified, it may be concentrated. The pure acid solidifies at a temperature of 8·6, a temperature considerably higher than that usually stated in the text-books.—*Bull. Soc. Ch.*, II, xxii, 440, Nov., 1874. G. F. B.

4. *On Phosphenylous Acid.*—Precisely as phosphorous chloride reacts with water to produce phosphorous acid, so phosphenylous chloride reacts to yield phosphenylous acid, according to the equation: $C_6H_5PCl_2+(H_2O)_2=C_6H_5PH_2O_2+(HCl)_2$. MICHAELIS and ANANOFF have made use of this acid, discovered by them, for the purpose of getting some light upon the constitution of phosphorous acid itself. The phosphenylous acid is obtained in white crystalline plates, easily soluble in water and alcohol, and fusing at 70°. It is monobasic. The author describes the potassium, ammonium, calcium, barium, lead and iron salts. Between the two views held on the constitution of phosphorous acid, one that it is a trihydroxyl derivative of phosphorus, $P(OH)_3$, the other that it is derived from phosphoric acid by replacing hydroxyl by hydrogen and is $PO(OH)_2H$, the authors sought to decide from the reactions of phosphenylous acid. This may be considered either as $P(OH)_2C_6H_5$, or as $C_6H_5PO(OH)H$. Which of these formulas is correct, may be determined by the action of phosphoric chloride. In the first case the reaction is:

$$P(OH)_2C_6H_5+(PCl_5)_2=PCl_2C_6H_5+(POCl_3)_2+(HCl)_2,$$

the products being phosphenylous chloride and phosphoryl chloride. In the second case:

$$C_6H_5PO(OH)H+(PCl_5)_2=C_6H_5POCl_2+POCl_3+PCl_3+(HCl)$$

the products now being phosphenylous oxychloride, phosphoryl chloride, and phosphorous chloride. Experiment entirely confirmed the latter view. In the case now of phosphorous acid itself, the products given when it is acted on by phosphenyl tetrachloride must be according to one of two equations. In the first case: $P(OH)_3+(C_6H_5PCl_4)_3=PCl_3+(C_6H_5POCl_2)_3+(HCl)_3$. In the second case, the reaction is:

$$OPH(OH)_2+(C_6H_5PCl_4)_3=POCl_3+(POCl_2C_6H_5)_2+C_6H_5PCl_2+(HCl)_3.$$

The phosphorous acid was prepared by acting on the chloride with water, and was treated with the tetrachloride in a flask. Phosphoryl chloride, but no phosphorous chloride, was formed. The fraction of the distillate boiling above 220° gave, when treated with water, phosphenylous and phosphenylic acids, thus proving the presence of the corresponding chlorides, $POCl_2C_6H_5$ and $PCl_2C_6H_5$. The authors believe, therefore, that the formula $OPH(OH)_2$ represents the true constitution of phosphorous acid.—*Ber. Berl. Chem. Ges.*, vii, 1688, Dec., 1874. G. F. B.

5. *On the Production of Sarcolactic Acid by Fermentation.*—MALY some time ago showed that, under the influence of the mucous coat of the stomach, many of the carbohydrates, as cane-sugar, grape-sugar, milk-sugar, dextrin, etc., were converted into lactic acid. The ferment in this case is a product of the dead tissue, since the living mucous membrane has no power to effect this conversion. Since that time, the author has observed that often, but not always, there is simultaneously formed some sarcolactic acid, proved to be such by the composition of the zinc salt and its much greater solubility. The precise conditions under which this formation takes place have not been determined; though in one case sarcolactic acid was the sole product. This acid has been alike produced from grape and from milk-sugar; the separation of the two zinc salts being effected by fractional crystallization. Maly also mentions the discovery of sarcolactic acid in the fluid of an ovarian cyst, far from muscular tissue.—*Ber. Berl. Chem. Ges.*, vii, 1567, Dec., 1874. G. F. B.

6. *On the Antiseptic Action of Salicylic Acid.*—KNOP, at Kolbe's suggestion, has made some experiments to ascertain the action of salicylic acid upon vegetation. The results prove that this acid has a marked action upon the vegetative activity of cells, whether these be the chlorophyll cells of the higher or the non-chlorophyll cells of the lower orders of plants, provided only the acid remain free in the liquid. Two vigorous maize plants, 4 or 5 decimeters high, grown in his well-known solution and well rooted, were immersed in 500 c.c. of this solution, to which had been added 100 c.c. of a solution of salicylic acid containing 0.4 per cent of the acid. A third, fourth and fifth plant was simi-

larly treated, using tartaric, citric, and lactic acids respectively in place of salicylic. In the salicylic solution, the roots were killed. The new roots put out during the duration of the experiment became dark upon their ends, and under the microscope their cells were seen to be markedly affected, the protoplasm separating from the cell-walls. A second crop of roots fared similarly; but the third was more successful, and the plant continued to live in the solution for a long time. No mould, however, formed on the surface of the liquid even after three weeks. The other acid solutions killed the maize plants in three weeks, but the surfaces were covered with a thick layer of mould. Neither maize nor buckwheat grains germinate after soaking in water to which an equal volume of a saturated solution of salicylic acid has been added, not even by planting in earth. Fifteen grains of corn were soaked in water containing $\frac{1}{1000}$ of salicylic acid, and then placed in a germinating fluid consisting of 50 c.c. gypsum solution, 50 c.c. solution salicylic acid of 0·1 per cent, in a liter of water; 14 failed to germinate. The same fact appeared with buckwheat, wheat, rye, and oats. A similar depression of vegetative activity was observed in the case of mould; the difficulty of germinating seeds in solutions in June and July, owing to the rapid production of mould, being entirely obviated by the use of a highly dilute solution of salicylic acid.—*J. pr. Ch.*, II, x, 351, Nov., 1874.

G. F. B.

7. *Outlines of Proximate Organic Analysis;* by ALBERT B. PRESCOTT, Professor of Organic and Applied Chemistry in the University of Michigan. 192 pp. 12mo. New York, 1875 (Van Nostrand).—This work is a useful and much needed laboratory manual, for the identification, separation, and qualitative determination of the more commonly occurring organic compounds. It is well arranged for the use of the student in the laboratory, and will be found valuable also to the teacher. It is to be followed by a manual of the "Chemical Examination of Alcoholic Liquors," by the same author.

8. *Passage of Gases through Liquid Films.*—Dr. F. EXNER has determined quantitatively the penetration of various gases through the film of a soap bubble, an effect shown qualitatively by Draper and Marianini. Calling C the co-efficient of absorption of the gas for the liquid of which the film consists, and δ the density of the gas, he has deduced the law that the velocities of diffusion of gases are proportional to C divided by $\sqrt{\delta}$. For the diffusion velocities of the gases examined, putting that of air $=1$, the following numbers were found by observation: $N=0·86$, $O=1·95$. Illuminating gas $=2·27$, $H=3·77$, $CO^2=47·1$, $H_2S=651$, $NH_3=46{,}000$. Within these extraordinarily wide limits, between 0·86 and 46,000, the observations are in perfect accord with the formula $\frac{C}{\sqrt{\delta}}$. Experiments were also made for the purpose of ascertaining the absolute velocity of diffusion. These gave for the diffusion of H in air through a soap film, that in one minute 1·88

cubic centimeters H and ·50 cub. centim. of air simultaneously pass through one square centim. of the film.—*Roy. Acad. Sciences, Vienna*, Nov. 5th, 1874; *Phil. Mag.*, xlviii, 547. E. C. P.

9. *Late improvements in Magneto-Electric Machines.*—M. L. T. GRAMME describes the improvements effected in the machine which bears his name, by which its power is greatly increased. In 1872 one machine was made for producing the light, two for plating, and several small machines. The latter could redden 10 cms. of platinum wire ·3 mms. in diameter. Those now made redden 60 cms. of the same wire, though there is no increase in the cost or weight. This large increase is principally due to the employment of the new magnets in sheets of Jamin. In 1872 and 1873 twelve large machines for plating were constructed weighing 750 kgs. and containing 175 kgs. of copper apiece. Their height was 130 cms., their length 80 cms., they deposited 600 grams of silver per hour and required for this work a force of 75 kilogrammeters. The new plating machine has but one central ring instead of two, weighs 177 kgs. and contains 47 kgs. of copper. Its dimensions are 55 cms. on a side and 60 cms. high. Like the other, it deposits 600 grs. per hour, but requires only 50 kgmtrs. to run it. It therefore occupies but one-half the space of the old form, the weight is reduced three-quarters and the motive force one-third. These improvements are effected by suppressing the exciting bobbin, putting the electro-magnet directly into the circuit, by a better arrangement of the copper, and by slightly increasing the speed. The coils, instead of being formed of wire, are now constructed of a band of thin copper, of width equal to one-half the length of the bars of the magnet, so that four large ribbons are used for each machine.

The plan of putting the electro-magnet into the main circuit gives rise sometimes to a curious change in polarity. When the machines are in motion, and the circuit closed through metallic baths, the direction of the current remains the same indefinitely. But if suddenly stopped, the current induced by the electro-magnet reverses the polarity of the latter, so that if the machine is again started the current passes in the opposite direction and removes the silver it has just deposited. To avoid this trouble, he inserts in the circuit an electro-magnet, which ordinarily hold up an armature, and keeps the circuit closed, but as soon as the speed slackens below a certain point, the armature drops and breaks the circuit, thus preventing the induced current. By applying these improvements to the old form of machine, its capacity was at once raised from 600 to 2,100 grams per hour.

The first machine for generating the light weighed 1,000 kgs., the copper of the magnets weighing 250 kgs., that of the ring 75 kgs. The space occupied was 80 cms. on a side and 125 cms. high. This was used a long time in the tower of Westminster, and for two years has not given much trouble, though it heated a little and gave sparks around the commutator. The new form weighs 183 kgs. and contains only 47 kgs. of copper. Its length and breadth are 55 cms., and its height 60 cms. The capacity is however much less, being only 200 Carcel burners, instead of 1,000. A greater light may nevertheless be obtained by an increased speed, as is shown by the following results of ten series of experiments: 650 turns gave a light of 77 burners; 850 gave 125; 880, 150; and 900, 200 without heating or sparks. 935 gave 250 with slight heating, and 1,025 gave 290, but produced heating and sparks. Comparing with the machine of the company of the Alliance, in use at the lighthouse of La Hève, we find that this also gave a light of 200 burners, but weighs 2,000 kgs. and occupies a space of 170×135×150 cms. Its weight is therefore twelve times as great, the surface covered seventeen times as great, and the volume eighteen times as great.

These machines having neither cranks, connecting shafts or dead-points, are well adapted to the transformation of electricity into work. One of the small machines gave the results shown in the accompanying table, when run with Bunsen cells of 0·20. The first column gives the number of cells, the second the number

Cell.	Turns.	Power.	Cell.	Turns.	Power.
2	760	·32	7	1100	4·14
3	810	1·02	8	1100	5·00
4	1000	1·02	8	900	4·81
4	900	1·80	9	1500	5·11
5	1100	2·50	10	1700	5·52
6	1000	3·36	10	1300	6·16

of turns, and the third the work done in kilogrammeters. This suggests a convenient method of transmitting power, placing one machine near the source, and transmitting the current to any distance by a wire or cable. A conclusive experiment was made as follows: a machine was driven by a steam engine, by a power of 75 kgmtrs., determined by a friction brake. The current moved a second machine with a second brake, which gave 39 kgmtrs., or more than half. But as the power was first changed into electricity and then the electricity into power, the coefficient of efficiency of each machine must have been over 70 per cent.

A curious form of machine is made by winding with two wires, one coarse, the other fine. The current from two Bunsen cells is then passed through the first, running the machine, and producing a current of high tension in the fine coil. A telegraph may thus be run by two Bunsen cells.—*Compt. Rend.*, lxxix, 1178. Articles fully illustrated on the same subject may also be found in *Engineering*, Nov. 27th, 1874, and in the *Annales Industrielles.* E. C. P.

10. *Expansion of Phosphorus.*—MMS. PISATI and DEFRANCHIS have measured the expansion of both solid and liquid phosphorus at temperatures from 0° to 270° C. They employed a cylindrical dilatometer with a graduated neck. This was immersed in a bath of oil kept stirred continuously, and the greatest errors were estimated at a tenth of a degree. The readings were all reduced to degrees of the air-thermometer by a direct comparison. From a

large number of experiments they deduced the following results. The specific volume of solid phosphorus is given by the equation:

$$w_t = w_0 + 2000 \times 10^{-7} t + 1150 \times 10^{-10} t^2$$

and of liquid phosphorus by:

$$w_t = w_{50} + 2969 \times 10^{-7} (t - 50) + 2115 \times 10^{-10} (-50)^2$$

The mean co-efficient of dilatation per degree for solid phosphorus from 0° to v° is given by the formula:

$$R = 3674 \times 10^{-7} + 211 \times 10^{-9} t,$$

and for liquid phosphorus:

$$R = 5167 \times 10^{-7} + 370 \times 10^{-9} (t - 50).$$

—*Gazz. Chim. Ital.*, iv, 1874. E. C. P.

11. *Velocity of Light.*—M. CORNU gives the results of some measurements he has made on the velocity of light under the direction of the Council of the Observatory, at the suggestion of LeVerrier and Fizeau. The method employed was that of the toothed-wheel, first employed by Fizeau in 1849. The result then obtained was 298,500 meters from measurements between the Polytechnic School and Mt. Valérian. The stations now selected were the Observatory and the tower of Montlhery, distant about 23 kilometers, a distance accurately determined, and famous for its use in the determination of the meter, and more recently for the velocity of sound. The telescope at the Observatory had a focal length of 885 cms. and an aperture of 37 cms., the other a focal length of 200 cms. and an aperture of 15 cms. A simple reflector was placed at its focus, and the whole was enclosed in a large iron tube and built into the wall. The toothed wheel could be turned with any velocity up to 1600 turns per second, and by a chronograph and electric register the time measured to thousandths of a second. The method of measurement is well known, and the precise time of disappearance was marked and the velocity measured electrically. This was necessary, since it was impossible to preserve a perfectly uniform motion. 504 observations were thus taken, and the results are given in the following table. The column headed n gives the number of teeth that passed during the passage of the light; the column headed m gives the number of times the observation was made, and the column V gives the corresponding velocity. The mean of the whole, giving

n	m	V	n	m	V
4	15	300,130	13	4	300,340
5	33	300,530	14	9	300,350
6	20	300,750	15	65	300,290
7	10	300,820	16	4	300,620
8	7	299,940	17	22	300,000
9	94	300,550	18	35	300,150
10	69	300,640	19	6	299,550
11	72	300,350	20	—	——
12	3	300,500	21	36	300,060

proper weights to each, is 300,330 in air, or 300,400 meters in vacuo, with a probable error of only one-tenth of one per cent.

The methods of measuring the parallax of the sun may be divided into three classes. 1st. The physical methods dependent on optical phenomena. They include the eclipses of the satellites of Jupiter and aberration of the fixed stars, together with the value of the velocity of light. Employing the results here obtained give 8″·88, 8″·88 and 8″·80, or a mean 8″·85 as the solar parallax. 2d. The analytical methods of astronomical observations with theoretical laws based on the theory of gravitation. They give the value 8″·86. 3d. The purely geometrical methods by the parallax of the planets near the earth. The opposition of Mars in 1862 gave 8″·84. But the greatest accuracy is attained by the observations of the transit of Venus.—*Comptes Rendus*, lxxix, 1361. E. C. P.

12. *On a new way of illustrating the Vibrations of the Air in Organ Pipes;* by Prof. JOSEPH LOVERING, of Cambridge, Mass. (From the Proceedings of the American Association for the Advancement of Science, vol. xxiii.)—I shall begin with a brief description of the methods adopted by W. B. Rogers and Kœnig for making visible the vibrations of the invisible air in organ pipes. By the first method two gas burners were fed from a common reservoir; a glass tube was placed over one burner and the length of the flame altered until it was brought into unison with the fundamental note of the tube, and an energetic vibration of the flame and the column of air began. The flame on the other burner also vibrated from sympathy. The individual vibrations of this naked flame were unraveled by making the burner revolve in a small circle of about one inch in diameter. A cylindrical sheet of light resulted from the motion, which was channelled by dark spaces as soon as the sound was heard. The method has the advantage of giving an object which can be seen in all directions, with the disadvantage, however, on account of the small circle in which the flame travels, of crowding upon each other the alternate dark and bright spaces of the fluted surface.

The description just given has reference to the apparatus constructed by Kœnig under the name of the *Appareil à flammes chantantes de M. le Comte Schaffgotsch.* But I have not been able to find in Schaffgotsch's account of his apparatus and experiments any allusion to this method of exhibiting to the eye the individual vibrations by the revolution of the flame itself. Probably, it was an appendage to Schaffgotsch's apparatus suggested to Kœnig by the experiment of Prof. W. B. Rogers.*

In this experiment only a single flame was employed; a tube being placed over it large enough to allow the interior flame to revolve in a small orbit.

The second method for accomplishing the same object is a device by Kœnig, and is known under the name of the *Manometric Flames.*† An opening is made in the side of an organ pipe at the place where the greatest changes of density occur when the pipe is sounding: to this hole he applied a small box, the end which is placed upon the hole being covered with a delicate membrane.

* Amer. Journ. Science, xxvi, 1858. † Ann. Chem. und Phys., cxxii.

Gas is introduced into this box by one tube and then conducted from the box to the burner by another tube. The vibrating air in the pipe plays upon the membrane, and communicates vibration to the flame. The individual vibrations of the flame are revealed to the eye, by reflecting it in a revolving mirror after the manner of Wheatstone. Four mirrors placed upon the four vertical sides of a revolving cube produce the same effect with a smaller velocity. This method has the disadvantage of substituting for the flame itself a faint and virtual image, not easily seen in daylight or in all directions. It has the advantage of admitting of a large orbit of revolution and thus separating widely the individual vibrations of even high notes.

I have endeavored to combine the advantages of both methods without incurring their disadvantages. Imagine eight arms of gas pipe, each one foot in length, arranged as the spokes of a horizontal wheel upon a hollow hub, which is lengthened out below to the extent of six inches. This hub is closed at the upper end by steel and is balanced upon a steel point at the top of a hollow upright through which the gas is delivered. Two holes are made in the sides near the top, through which the gas flows out into the hollow hub and the attached arms. The upright comes up through the bottom of a vessel, into which water is poured in sufficient quantity to immerse the bottom of the hub and prevent leakage of the gas below. In this way great freedom of motion is secured on the steel point, with a perfectly tight joint. The arms are rotated in a large circle by clock-work, and their weight suffices to make them serve as a fly-wheel and acquire a uniform motion. The arms are closed at the ends, and the gas issues in eight vertical streams from as many holes in the tops of the arms. When these streams are lighted, the rotation produces a large cylindrical sheet of light. The greater the number of arms the smaller is the velocity required to produce persistency of impression in the eye, with the additional benefit of having a well-balanced instrument. Vibration of the flames is produced by attachments to the organ pipes similar to those used by Kœnig. When the full pressure of the gas is on, the cylindrical sheet of light is three or four inches in height, and, when the organ pipe speaks, it is broken up as neatly as when the virtual image is used in Kœnig's apparatus. The effect can be seen readily in full daylight and from every part of a large room. The best effect is with organ pipes at least three feet in length and open at both ends. Of course, the serration is finer when shorter pipes are used. The experiment is very beautiful, even with short pipes, if the flame is brought down to the size of a pea. In this case the illuminated circle, as soon as the sound begins, is broken up into bright beads loosely strung upon a dark cord. On one side of each flame a screen is placed, which moves on a hinge and can be set at any angle with the plane of rotation. These screens serve the double purpose of checking the velocity, if the energy of the clock movement is too great, and of preventing the flame from flaring if the motion is too rapid. For purposes of research, Kœnig's apparatus may be all that is desired. But for illustration in class rooms, and especially to large numbers, the new arrangement just described will be found to possess great advantages.

II. Geology and Natural History.

1. *New Order of Eocene Mammals.*—At the last meeting of the Connecticut Academy, Feb. 17th, Professor O. C. Marsh made a communication on a new order of Eocene Mammals, for which he proposed the name *Tillodontia.* These animals are among the most remarkable yet discovered in American strata, and seem to combine characters of several distinct groups, viz: Carnivores, Ungulates, and Rodents. In *Tillotherium* Marsh, the type of the order, the skull has the same general form as in the Bears, but in its structure resembles that of Ungulates. The molar teeth are of the ungulate type, the canines are small, and in each jaw there is a pair of large scalpriform incisors faced with enamel, and growing from persistent pulps, as in Rodents. The adult dentition is as follows:—Incisors $\frac{2}{2}$; canines $\frac{1}{1}$; premolars $\frac{3}{2}$; molars $\frac{3}{3}$. The articulation of the lower jaw with the skull corresponds to that in Ungulates. The posterior nares open behind the last upper molars. The brain was small, and somewhat convoluted. The skeleton most resembles that of Carnivores, especially the *Ursidæ*, but the scaphoid and lunar bones are not united, and there is a third trochanter on the femur. The radius and ulna, and the tibia and fibula are distinct. The feet are plantigrade, and each had five digits, all terminated with long, compressed and pointed, ungual phalanges, somewhat similar to those in the Bears. The other genera of this order are less known, but all apparently had the same general characters. There are two distinct families, *Tillotheridæ*,* in which the large incisors grew from persistent pulps, while the molars have roots; and the *Stylinodontidæ*, in which all the teeth are rootless. Some of the animals of this group were as large as a Tapir. With *Hyrax* or the *Toxodontia* the present order appears to have no near affinities.

2. *On the alleged parallelism of Coal beds;* by J. J. Stevenson. (Proc. Amer. Phil. Soc., xiv, 283.)—Mr. Stevenson in this paper gives examples, from this country and England, of the subdivision of coal beds, and of variations in the thickness of the intervening rock strata. The interval between the Upper Freeport and Kittaning coal beds along Yellow Creek in Ohio varies from 80 to 160 feet in five miles. The same interval on Wells Creek varies in one mile from 8 feet to 28, and from this it enlarges beyond [distance not stated] to 110 feet. In six sections given by Prof. Rogers in his Pennsylvania Report the intervals are 184, 143, 142, 117, 109, 103. The total interval between the Pittsburgh coal bed and the Upper Freeport varies in Ohio from

* This family may possibly prove to be identical with *Anchippodontidæ.*

420 feet at the west to 505 at Steubenville; in Pennsylvania it is 200 feet at Ligonier, 220 at Elk Lick, and 450 to nearly 600 feet on the Monongahela River; in West Virginia, along the Monongahela and Tygart's Valley River, it varies not much from 420 feet.

Mr. Stevenson, after stating many other facts, observes, in conclusion, that the variation in thickness arises mainly from the fact that the beds were deposited in a great trough having the Cincinnati uplift on one side and the Alleghany region on the other; that the diminution in thickness is quite regular east and west from the middle of the trough; that the subsidence as a whole was regular, approaching uniformity, but that there were "bulgings or other irregularities such as could not fail to accompany any operations so extensive." He further concludes that "all the coals of the Upper Coal group are offshoots from one continuous marsh, which existed from the beginning of the era to its close, and which in its full extent is now known as the Pittsburg coal seam."

3. *Diatoms of the Carboniferous.*—Count F. CASTRACANE of Rome has found, in an examination of the ashes of mineral coal from Liverpool, a large number of species of Diatoms. The most of them are freshwater; but with these occur a number of marine kinds.—*Am. Mag. Nat. Hist. for February, from the Actes de l' Acad. Pontif.*, Feb., 1874.

4. *A new Mastodon.*—Professor COPE has announced his obtaining *Elephas primigenius* var. *Columbi* from Quarternary beds at the base of the Zandia Mountains, and the *Mastodon Ohioticus* from corresponding beds near Taos, and from the valley of the South Platte in Northwestern Colorado. The Pliocene of Santa Fé affords the remains of a Mastodon, referred by Leidy to his *M. obscurus*, of which Cope makes a new species, *M. productus.*

5. *The Geology of New Hampshire. A Report comprising the results of Explorations ordered by the Legislature.* C. H. HITCHCOCK, State Geologist; J. H. HUNTINGTON, Principal Assistant. *Part I, Physical Geography.* 668 pp. roy. 8vo, with many illustrations. Concord, 1874.—This First Part of the Report on the Geology of New Hampshire commences with a history of the Geological Surveys in New Hampshire by Prof. Hitchcock. The chapters on this subject are followed by a history of explorations among the White Mountains by W. Upham; a chapter on the climatology of New Hampshire by J. H. Huntington; another excellent one on the use of the magnetic needle in surveying by E. T. Quimby, illustrated by maps; others on the topography of the State by C. H. Hitchcock, including a long catalogue of altitudes from railroad and other surveys; another on the river-systems by W. Upham; on the distribution of Insects in N. Hampshire, with a map, by S. H. Scudder (noticed on page 232); on the distribution of Plants by W. F. Flint; on the Natural History of the Diatomaceæ by A. Mead Edwards, with a plate; and chapters on the Scenery of the State by C. H. Hitchcock and J. H. Huntington. The illustrations are numerous and a number of them are photographic.

The survey has brought much to light that is new respecting the geology of New Hampshire. The occurrence in metamorphic New England of Upper Silurian fossils within a few miles of the White Mountains, which it has made known, is a fact of the highest geological importance; and that of the labradorite and chrysolite rocks in the White Mountain region is another. These discoveries are enough of themselves to prove the survey a success as far as geological science is concerned; for they are destined to give great aid toward unravelling the knotty points in New England geology.

Professor Hitchcock has reserved the details respecting these and the other geological results for another volume, and has given in the one issued—on the Physical Geography of the State—only his general conclusion with regard to the *ages* of the crystalline rocks, the facts being brought out in a chapter on "the physical history of New Hampshire." This subject, moreover, is illustrated by a series of six colored maps representing the supposed geography—or areas of dry land and water—of the region of New Hampshire and Eastern Vermont during these several ages, four of which are made *pre-Silurian*, one *Cambrian* or *Primordial*, and one *Helderberg*. We only remark that the author does not seem to have sufficiently appreciated the fact that in a region which is metamorphic throughout, the immense amount of denudation that has taken place in past time throws great doubt over all attempts to mark out over it outlines of the *dry land* of successive pre-Silurian ages by the present superficial distribution and positions of the different kinds of rocks.

Some other opinions in Professor Hitchcock's part of the volume appear to us to need revision.

After speaking of the "extremely abundant Laurentian vegetation" (p. 508), he observes, with regard to the origin of beds of iron pyrites and copper pyrites in his "Huronian rocks," that "For the formation of sulphurets we require originally a sulphate ocean, just as in the case of gold," and then speaks of the deoxidizing agency of vegetation, reducing the sulphates to sulphurets; but he does not explain how "an extremely abundant vegetation" could have existed in "a sulphate ocean."

Mr. Hitchcock recognizes the existence of a long Azoic era, as well as Eozoic era, in pre-Silurian time, and then objects to the term *Archæan* for the pre-Silurian, on the ground that the terms Azoic and Eozoic are sufficient alone. In this we should agree with him *if* the rocks of the Eozoic part of the pre-Silurian time could in all cases be distinguished from those of the Azoic.

The existence of great beds of iron ore in pre-Silurian terranes is regarded as evidence (in this following Prof. T. Sterry Hunt) of the existence during the era of abundant vegetation—on the ground that, in making marsh-beds of iron ore, the oxide of iron, when carried in by the waters, is in the state of iron-salts of organic acids. But the era was a very long one: Helmholtz made the time which elapsed during the cooling from 2,000° C. to 200° C.

350,000,000 of years; and many more millions should be added for the continuation of the cooling down to 100° C.; all of which necessarily antedated the first appearance of the simplest forms of life; and more still to reduce the temperature to 38° C. (100° F.), which limit was probably reached before the close of the Archæan. And in that long era, even to its close, the atmosphere certainly contained a greatly larger proportion of carbonic acid than now, if not also other acids; and also, for this reason, it had much greater density. Hence carbonic acid, which does now some of the work of iron-transportation, may have done far more then. It is surely very unsafe to conclude from the existence of those iron ore beds that the vegetation was extremely abundant, or that any then existed.

Neither does the phosphate of lime (apatite), which is so generally disseminated through the iron ores, afford good evidence of life. The amount of this mineral in Archæan rocks exceeds that in all the later rocks of the globe, and would certainly indicate the existence of an extraordinary amount of life over the Archæan marshes and lands if of any at all. Some of the earliest shells of the Silurian (*Lingulæ* and a few related kinds) consist largely of phosphate of lime, as shown by Hunt, and this appears to prove, as this author has observed, that the waters of the ocean then held in solution more phosphates than they now do. And the grains or crystals of phosphate of lime in the iron ore may be proof only of the same fact with regard to the ocean's waters. The chemistry of the globe during any part, even the last, of the hundreds of millions of years before the opening Silurian is too doubtful for positive speculation as to what chemistry did not do and life did.

On the question of the animal nature of the *Eozoon* Prof. Hitchcock writes judiciously, excepting in a single remark. He observes that "those who disbelieve the organic theory are mostly better skilled in mineralogy than biology." But Messrs. King and Rowney, the chief contestants, are not mineralogists, but zoologists, and Mr. Carter of England, another strong opponent of the "organic theory," is also a zoologist, and one particularly versed in the lower orders of animal life. There are probably mineralogists that doubt, as there certainly are zoologists, but we can recall no articles by any such on the subject, excepting one or two which aim to show that the limestones containing *Eozoon* are sometimes of igneous origin, an observation which, whether sustained or not, cannot be attributed to mineralogical prejudices.

Notwithstanding some exceptions to the volume, we regard it as a repository of much valuable information on the physical geography and productions of the State.

6. *First Annual Report of the Geological and Agricultural Survey of Texas;* by S. B. Buckley, State Geologist. 142 pp. 8vo. Houston, Texas, 1874.—This Report is occupied mainly with observations of economical interest relating to soil, rocks, ores, trees. There are brief notices of the Tertiary, Cretaceous and older

rocks. But these show much ignorance of the subject. In a paragraph headed in capitals DEVONIAN, we find the author saying that "in 1860, when engaged with Dr. Shumard in the survey of San Saba County, some of the limestones and shales in the eastern part of that county were referred by him to the Devonian. The Trenton limestone was the formation recognized: its chief fossils found were of the following genera: *Belerophon*, *Maclurea*, *Orthis*, *Murchisonia*, *Pleurotomaria*, and some other genera of that period." A "State geologist" who refers the Trenton limestone to the Devonian is evidently not a geologist, whatever his State appointment. Such a mistake Dr. Shumard could not have made.

Another specimen of the Report may do its author better justice. In the chapter, a little over a page long, on the Jurassic of the State, three lines are used in stating that half a mile west and northwest of Phantom Hill, Callahan Co., there are "what may be fossils of the Jurassic period;" and three more in saying, "Intending to make a more careful study of them, I placed them in a box and shipped them to Austin, since which I have not seen them." The rest of the page on the Jurassic is occupied with an account of the scenery, buffaloes, etc., of Callahan County, in the course of which he says: "Old buffaloes, especially the old bulls, delight to roll and wallow in the soft dirt. I have seen them roll and kick up their heels, over and over, and then get up and shake themselves apparently with great satisfaction. It will not be many years before Northwest Texas will be resorted to by crowds of Northern invalids for the purpose of breathing its pure air, to behold its charming landscapes, and hunt and fish; hunt the buffalo, the antelope, the deer, wild turkeys, etc., and catch thousands of fish. Such pastimes will kindle the spark of life anew, and give new life to the body." This much for the Jurassic.

The Report contains charges against the late Dr. Shumard and his assistant, Mr. A. R. Roessler, which should have been stricken out by the Governor of Texas, to whom the Report is addressed, before the manuscript was sent to the printers. Dr. Shumard was an excellent geologist, and we believe an honorable man.

7. *Second Geological Survey of Pennsylvania. Report of Progress for* 1874; by PETER LESLEY, Director of the Survey.—The appointments for this new survey were not made until the month of June had far advanced, and consequently the parties were not in the field until July and August. The assistants appointed are: Mr. A. S. McCreath, chemical assistant; Prof. F. Prime, Jr., assistant in charge of the Lehigh district: Prof. P. Frazer, Jr., in charge of the York and Adams district; J. H. Dewees, in charge of the Juniata district; F. Platt, in charge of the Clearfield and Jefferson coal district; J. F. Carll, in charge of the Venango oil district; Dr. F. A. Genth, chemist and mineralogist; H. E. Wrigley, on the petroleum region of Western Pennsylvania; E. B. Harden, draughtsman. Two more assistants are to be appointed, one for Greene and Washington Counties, and

the other for the northern tier of counties, Tioga, Branford, Susquehanna and Wayne. Besides these there are a number of volunteers.

Although the parties were late in the field, valuable results have been obtained, which will soon be published in the Report for the year. Dr. Genth's Mineralogical Report is nearly printed; it will extend to about 150 pages. The geological reports of Professor Frazer, Professor Prime, Mr. Platt and Mr. Dewees, illustrated by several maps and sections, are finished and are either in the printer's hand or will soon be. Besides these, the volume for 1874 will include a special report on petroleum by Mr. H. E. Wrigley, which will contain a large map of the oil regions of West Pennsylvania and West Virginia, a small map of the oil regions of the Middle States and Canada, sections and other illustrations. Mr. Lesley's extensive knowledge of geology, theoretical and practical, and of the range of subjects that will come under investigation in the survey, together with his thoroughness and energy, ensures for the State of Pennsylvania, and for the science of the land, results of the highest value.

8. *Geographical Explorations and Surveys west of the 100th Meridian;* First Lieut. G. M. Wheeler, Corps of Engineers, U. S. A., in charge.

(1.) *Preliminary Report upon Invertebrate Fossils collected in* 1871–1873, with descriptions of new species; by C. A. White, M.D.—The species included are from the Primordial of the Cañon of the Colorado, Mohave Co., Arizona, the vicinity of Antelope Spring, House Range, Utah, and Pioche in Nevada; from the Quebec group of Utah and Nevada; the Trenton beds in Nevada, New Mexico and Arizona; the Subcarboniferous of Arizona, Nevada and Utah; the Carboniferous of Arizona, New Mexico and Nevada; the Jurassic period of Utah and Arizona; the Cretaceous of New Mexico, Arizona and Utah.

(2.) *Report upon Ornithological Specimens collected in* 1871–1873. 148 pp. 8vo. 1874.—Contains a Report on the birds collected in 1872, by Dr. H. C. Yarrow and H. W. Henshaw; on those of 1873, by H. W. Henshaw; annotated list of the birds of Utah, by H. W. Henshaw. The papers are full of valuable notes.

9. *Notes on the Natural History of portions of Montana and Dakota*, being the substance of a Report to the Secretary of War, on the collections made by the North Pacific Railroad Expedition of 1873, Gen. D. S. Stanley, Commander; by J. A. Allen, Naturalist of the Expedition. 62 pp. 8vo. 1874. (From the Proc. Bost. Soc. Nat. Hist., vol. xvii, June, 1874.)—Consists of notes on the Mammals, Birds, Reptiles, Amphibians, Plants and Butterflies collected by the Stanley Expedition.

10. *Geological and Geographical Survey of the Territories;* Dr. F. V. Hayden, Geologist in charge. Department of the Interior.

(1.) *Seventh Annual Report*, for 1873. 718 pp. 8vo. Washington, 1874.—This report is noticed from an incomplete copy, extending to page 533, in the December number of this Journal. A complete bound copy reached us on the 11th of February. The closing part includes Reports on Insects by W. L. Carpenter, C. R. Osten Sacken, H. A. Hagen; on Crustacea by S. I. Smith and A. S. Packard; on the methods of Topographical Survey by James T. Gardner; Topographical Report on the Middle Park Division by S. B. Ladd, and on the Gold Hill Mining Region, by A. R. Marvine. A further notice is reserved to another number.

(2.) *Bulletin, Second Series*, No. 1. 48 pp. 8vo. 1875.—Contains memoirs on the Fishes of the Tertiary shale of the South Park, by E. D. Cope; On the Cranial and Dental Characters of Mephitinæ, with description of *M. frontata*, a new species from the bone-caves of Pennsylvania; Ancient ruins in Southwestern Colorado, by W. H. Jackson, with four plates; on fossils from near the eastern base of the Rocky Mountains, west of Greeley and Evans, Colorado, and others from about 200 miles farther east, with descriptions of a few new species, by F. B. Meek.

(3.) *Contributions to the Fossil Flora of the Western Territories. Part* 1, *The Cretaceous Flora;* by LEO LESQUEREUX. 136 pp. 8vo, with 30 lithographic plates. Vol. vi. of the Reports.—Mr. Lesquereux has here brought out the results of his long and careful study of the Cretaceous flora of the Rocky Mountain region. The plants described are from the Dakota group, the lowest of the Cretaceous beds in that region. The facts show that the leaves lie near where they were dropped. The localities are between the parallels of 39° and 47°; and the leaves indicate a general uniformity of climate over these parallels, with perhaps a slightly warmer temperature in Kansas, where alone occur the genera *Credneria*, *Pterospermites* and *Dombeyopsis;* where the species of *Liriodendron*, and of some other genera have large leaves, while those of the Nebraska species are small. The climate indicated, according to Lesquereux, is like that now existing between the parallels of 30° and 45°, as is inferred from the occurrence of the genera *Salix*, *Fagus*, *Platanus*, *Sassafras*, *Aralia*, *Magnolia*, *Liriodendron*, *Menispermum*, *Rhus* and others.

He observes also that Heer finds evidence of the same climate in Greenland during the Upper Cretaceous, 28 species of the genera *Populus*, *Myrica*, *Ficus*, *Sassafras*, *Proteoides*, *Credneria*, *Andromeda*, *Diospyros*, *Panax*, *Magnolia*, *Rhus*, and others having been identified by him from beds in latitude 70°; while from the Lower Cretaceous he has made out a very different range of species, including 9 *Cycads*, 3 *Equisetaceæ*, 17 *Conifers*, 1 *Lycopod*, 5 *Monocotyledons* and 1 *Dicotyledon*, with 38 *Fucoids*.

Besides the genera above enumerated, Lesquereux has the following, exclusive of Cryptogams, in his catalogue of the groups represented. It includes, besides his own, Newberry's results.

Pterophyllum, of the order of Zamiæ?; *Sequoia*, *Araucaria*, *Abietites*, *Glyptostrobus*, *Phyllocladus*, *Geinitzia* of Conifers; *Arundo; Dioscorea; Flabellaria* among Palms; *Liquidambar*, *Populus*, *Populites*, *Myrica*, *Betula*, *Betulites*, *Alnus*, *Quercus*, *Celtis*, *Ficus*, *Nyssa*, *Laurus*, *Laurophyllum*, *Persea*, *Cinnamomum*, *Oreodaphne*, *Proteoides*, *Embothrium*, *Aristolochites*, *An-*

dromeda, *Diospyros*, *Sapotacites*, *Bumelia*, *Hedera*, *Cissites*, *Protophyllum*, *Acerites*, *Negundoides*, *Greviopsis*, *Anisophyllum*, *Celastrophyllum*, *Rhamnus*, *Juglans*, *Pyrus*, *Prunus*. The whole number of species enumerated is 130: of these, eight are of the genus *Quercus*, five, of *Populus*, six of *Plutanus*, six of *Sassafras*, five of *Magnolia*, three of *Liriodendron*, and eight of *Protophyllum*. Some of the leaves are referred with doubt to existing genera, as they embrace characters of two or more. The leaves are mostly entire, coarsely veined and coriaceous. No beds in the Rocky Mountain region older than Cretaceous contain any related species, or a single Angiosperm. The author remarks that the facts "seem to prove a collateral development of different primitive types, and therefore, the appearance at certain epochs of those original forms which, at each geological period, have changed the character of the vegetable world, and which have not any connection with antecedent types."

(4.) *Lists of Elevations principally in that portion of the United States west of the Mississippi River.* Collected and arranged by H. GANNETT, M.E. 72 pp. 8vo. Washington, 1875.—This pamphlet is the third edition of the List of Elevations issued by the Department of the Interior in connection with the publications of the U. S. Survey of the Territories. The Catalogue has been much enlarged by additions from railway levellings and other sources, and also by including the elevations of many points east of the Mississippi River. It is therefore a very important contribution to the department of North American topography.

(5.) *Meteorological Observations* made in 1873 and 1874 in Colorado and Montana, prepared by G. B. Chittenden. 58 pp. 8vo. 1875.

11. *Carte hydrologique du Department de Seine-et-Marne;* by M. DELESSE, Ingenieur-en-Chef des Mines.—This chart represents in colors and by lines of equal height above the level of the sea, the distribution of the superficial and subterranean sheets or streams of water over the Department of Seine-et-Marne, in France, and the altitude of the surface. The facts have been obtained partly by collecting all that is known of the wells of the region. The geological stratum upon which the water rests or flows over the different parts of the department, and the depths or curves of its surface, are indicated. Many interesting conclusions are arrived at, some of them of geological interest, and all of them of great value to the Department. The survey and the charts make an excellent model for the world. The charts are in the very best style of the chromo-lithographic art.

12. *Note on the genus Calamodon;* by E. D. COPE. (Communicated.)—I observe in your last number that you state, on the authority of Professor Marsh, that this genus is identical with the *Stylinodon* of Marsh, already described in your May number of the current year. If Professor Marsh's diagnosis be accurate, the genera are distinct, as the description cited ascribes six molars to *Stylinodon*, while five only exist in *Calamodon*. This I stated in

my description on p. 6 of my report on the Vertebrata of the Eocene of New Mexico.

13. *Shepherd's Pipe of the Reindeer era.*—An instrument made of the bones of birds placed together as in the shepherd's pipe, which it is supposed was used as a musical instrument, is announced by M. Piette as having been found in a deposit of the Reindeer era (Stone Age).—*Les Mondes*, Jan. 28.

14. *Lead vein in Newburyport, Mass.*—The vein of lead ore recently discovered intersecting the gneiss of Newburyport has, according to Professor R. H. Richards, a lead-bearing band against its north wall, which averages a foot in width but widens in one shaft 22 feet deep to six feet. With the galena there is a little chalcopyrite and tetrahedrite. The rest of the vein is a rusty crystalline rock free from mica, whose precise nature is not yet determined. The lead-bearing band is from one-third to one-half galena. A ton (2240 lbs.) of the crude ingot lead obtained from the ore yielded 74 ounces of silver and 341 grains of gold.—*Proc. Boston Soc. Nat. Hist.*, xvii, 200.

15. *Record of Geological Literature.*—An Annual of this title is to be commenced the coming summer by W. Whitaker of the Geological Survey Office (Jermyn st., London, S.W.). The volume will contain short abstracts or notices of Papers, Books, Maps, etc., published during the year 1874, in the departments of Geology, Paleontology and Mineralogy. It will include 200 to 300 pages and be sold for 10s. 6d. Such an Annual Record is greatly needed. Subscriptions are solicited.

16. *Composition of the native alloy of Gold and Silver in the Comstock Lode, Nevada.*—Mr. Melville Attwood, of San Francisco, in a communication to the Microscopical Society in April, 1874, describes the pale yellow alloy from the Comstock lode as occurring in similar form and composition throughout the whole length of the lode and from the croppings down to the bottom of the deepest workings. It is found occasionally in coarse pieces, but in general is finely disseminated and intimately mixed with the silver ore. It exhibits imperfect octahedral crystals and is found also in aborescent filiform masses. Hardness 3; specific gravity 12·5; after melting, 13·5 to 13·7. Color white, with a slightly yellowish tinge when freshly broken, but becomes more yellow on exposure for some time. Analysis yielded Mr. Attwood 55·37 per cent of gold, 42·87 of silver and 1·74 per cent of substances undetermined. W. P. B.

17. *Mineralogical Note;* by Albert R. Leeds, Prof. of Chemistry, Stevens Institute. *A magnesia-iron Tremolite, not asbestiform, from the soapstone quarry above Manayunk, Pa.* (Contributed by the author.)—This mineral is the *anthophyllite*, so called, given in the list of American localities on page 780 of Dana's Mineralogy, 5th edition. It occurs in a dark-colored serpentine rock, in bladed masses sometimes exceeding 1 mm. in thickness and 1 cm. in breadth in their largest part, and then thinning into fine fibers which lose themselves in the rock. These blades, with

their various alterations in size and direction, are frequently many centimeters long. They are fibrous, of vitreous luster, translucent and of slight yellow, greenish or reddish tints, derived from the serpentine and oxide of iron accompanying them. H.=2·5. Fusibility=5·5.

	I.	II.	Mean.	O. ratio.		
SiO_2	59·27	59·228	59·25	31·40	31·40	2·1
Al_2O_3	2·45	2·452	2·45	1·15		
FeO	6·50	6·494	6·49	1·43		
MnO	1·09	1·006	1·05	0·23	14·93	1
CaO	1·72	1·403	1·57	0·46		
MgO	28·30	28·105	28·16	11·26		
H_2O	undet.	undet.	----			
	99·33	98·69	98·97			

This variety of tremolite [bronzite?], it will be seen from the analysis, is distinguished by its large percentage of ferrous oxide and magnesia; and the cause of this interesting peculiarity is to be sought for in the chemical history of the magnetite-bearing serpentine in which the tremolite is imbedded.

18. *Action of light on the development of the young of Frogs.*—M. Thury took the eggs of *Rana temporaria* and placed them all under precisely the same favorable circumstances, except that while part received light through colorless glass, another part received it through green glass. The former developed rapidly, and by the end of May had a length of four centimeters, and well developed hind legs in most of them; while the latter were slowly developed, blackish in color, hardly had a length of two centimeters by the end of May, and were without a trace of the hind legs. By the 10th of June, the former had their fore legs and some were changed to frogs; the latter, still black, had no trace of legs, and breathed almost exclusively by means of their gills. By the 15th of July all the former had become frogs; but those of the latter still had no legs, and by the 2d of August they were all dead without a trace of legs having appeared. Some of the young of the latter lot transferred to the vessel of the former on the 15th of July finished their metamorphosis. At the same time some of the former transferred to the vessel containing the latter continued to develop, showing the influence of the first impulse in their development.—*L'Institut*, Dec. 23, 1874.

19. *Dimorphic Development and Alternation of Generation in the Cladocera.*—Dr. G. O. Sars has discovered a remarkable dimorphism and alternation of generation in *Leptodora hyalina*. (Om en dimorph Udvikling samt Generationsvexel hos *Leptodora*, Forhandlinger Vidensk.-Selsk., Christiania, for 1873, p. 15, and plate.) The development from the ordinary summer-eggs, as already described by E. P. Müller, is without metamorphosis and like that of ordinary Cladocera, the young when excluded from the egg agreeing essentially with the adult; while, according to Sars' observations, the young are excluded from the winter-eggs in a very imperfect condition, quite unlike the known young of

any other Cladocera, and pass through a marked post-embryonal metamorphosis. In the earliest observed stage of the young of this form, the body is obovate, wholly without segmentation, the compound eye wanting, while there is a simple eye between the bases of the antennulæ, the swimming arms (antennæ) well developed, and the six pairs of legs represented only by minute processes projecting scarcely beyond the sides of the body; but the most remarkable feature is the presence of a pair of appendages tipped with cilia and nearly as long as the body, which are evidently homologous with the mandibular palpi of other Crustaceans, although these appendages have always been supposed to be wanting in the species of Cladocera. Two subsequent stages, gradually approaching the adult form, are described. The adults from the winter-eggs have no vestige of the mandibular palpi left, yet the simple eye—which is wholly absent in ordinary individuals developed from summer-eggs—is persistent, and thus marks a distinct generation. Three stages of the young from winter-eggs are beautifully figured upon the plate accompanying the memoir.

This remarkable species has, still more recently, been made the subject of a very elaborate memoir by Prof. Weismann of Freiburg (Uber Bau und Lebenserscheinungen von *Leptodora hyalina*, Zeitschrift für wissensch. Zool., xxiv, Sept., 1874, pp. 349–418, plates 33–38), who, however, had not observed the peculiar development of the winter-eggs. The occurrence of this genus in Lake Superior is noticed in this Journal, vol. vii, p. 161, 1874.

S. I. S.

20. *Development of the European Lobster.*—Dr. SARS has also recently published, in the Proceedings of the same Society for 1874, a paper of 27 pages, illustrated by two autographic plates, on the post-embryonal development of the European lobster (*Homarus vulgaris* Edwards). He describes and figures in detail the three larval stages corresponding precisely with the first three stages which I have described in the American lobster.* Dr. Sars did not receive my papers until after a part of his memoir was printed, so that his investigations were wholly independent. In a short appendix Dr. Sars calls attention to the remarkable agreement in the results at which we had each arrived, and to the excellent opportunity afforded for a careful comparison of the early stages of these two closely allied species. Although the corresponding stages agree so closely in form and structure, they are from the first readily distinguishable by well marked specific differences in the form and armature of the appendages. In fact, the differences appear greater in the larval stages than in the adults. Dr. Sars was not able to trace the development beyond the third stage, which he had at first supposed could not be the last stage of the larva, but after comparison with the later stage of the American lobster he regards it as quite probably the last true larval stage.

S. I. S.

* This Journal, vol. iii, pp. 401–406, plate IX, June, 1872, and Transactions Connecticut Academy, vol. ii, pp. 351–381, plates XIV–XVIII, August, 1873.

21. *Cumacea from the West Indies and the South Atlantic;* by G. O. Sars. 30 pp. 4to, with 6 plates. (From the Svenska Vetenskaps-Akademiens Handlingar, Bandet xi; Stockholm, 1873.)—This memoir, in the same form as the one on the Cumacea of the Josephine Expedition previously noticed, contains minute descriptions and elaborate figures of seven species from the West Indies and from off the mouth of the La Plata. Among them there is a remarkable new genus, *Stephanomma*, in which there is a large central eye upon the front surrounded by a circle of smaller eyes.
S. I. S.

22. *Distribution of Insects in New Hampshire;* by Samuel H. Scudder. 50 pp. large 8vo, with 2 maps and a plate. (From vol. i of the Final Report upon the Geology of New Hampshire; Concord, 1874.)—Mr. Scudder first discusses the boundary between the Alleghanian and Canadian faunæ in the State and then the special relations of the alpine and sub-alpine districts of the White Mountains. He makes the Canadian fauna extend to just south of the White Mountains, while the Alleghanian fauna proper occupies only the extreme southern border, the broad intermediate space —about half the area of the State—being regarded as the "common meeting ground" of the two faunæ. These divisions and the alpine and sub-alpine districts upon the mountains are indicated by colored areas on the two maps. This introductory portion is followed by lists of the Butterflies and Orthoptera of the State, with many valuable notes on the distribution of the species, and a full account of two White Mountain butterflies, *Œneis semidea* and *Brenthis Montinus*. S. I. S.

23. *On the Cotton Worm of the Southern States, Aletia argillacea* Hübner, *a moth of the family Noctuidæ;* by A. R. Grote. (Proc. Am. Assoc., 1874.)—After a discussion of the synonymy of the cotton worm family, Mr. Grote discusses as follows the question of the origin of the moth:

"The conclusion to which I have come with regard to the cotton worm is, *that it dies out every year* (*with its food plant*), *that it occurs in the cotton belt of the Southern States, and that its next appearance is the result of immigration.* Testimony is at hand to show that for many years after the cultivation of the cotton plant was introduced into the Southern States, the cotton worm never appeared. The date at which it first appeared in central Alabama has been differently stated to me, but it evidently but little preceded the late war. That the moth is capable of sustaining long and extended flight is readily proven. Professor Packard observed the moth off the coast of the Eastern States, as also Mr. Burgess. I have observed the moth in October in Buffalo, N. Y., as also Dr. Harvey. According to Mr. Riley, the moth has been observed in Chicago, I presume in the fall. It seems that the moth follows the coast-line northward, as also the water courses that empty into the Gulf of Mexico. It is noteworthy here that the watershed of the Ohio and Mississippi extends to within fifty miles of Buffalo. As an example of the prolonged flight of moths, I will state that I have observed in the Gulf

Stream, off the Carolinas and out of sight of land, in the month of August, large numbers of a moth, the *Agrotis annexa* of Treitschke.

Again, I have been struck by the absence of parasitic checks to the cotton worm in the south. I could never discover any, although such may exist. Spreading, as I believe it to do, as a moth, the absence of peculiar parasites to the worm may be reasonably accounted for. I have already and elsewhere pointed out, that in order to make the first brood of the cotton worm the progeny of the so-called "hibernating" individuals (as Professor Riley would suppose), a period of several months has to be accounted for, since these "hibernating" moths could not wait till midsummer to deposit their eggs; and while the cotton is young, and even before it is up, insect life is active, and the weather is warm and other vegetation fully out in the region of the South where I have lived. There is also no reason to believe that the cotton worm ever breeds in the North, and this notwithstanding Professor Riley's suggestions to the contrary, in the Sixth Report before mentioned. The worm never has been noticed on any other plant than the cotton, and in the South perishes by thousands rather than eat any other. The habit of wandering in masses when food fails is a proof of this, as while the worm is supplied with cotton leaf it never quits the plant, transforming to the chrysalis on the stalk which has furnished it nutriment. The wandering habit is not normal but accidental, and the worm is not "gregarious" like the "tent caterpillar." Its "hibernation" with us must also be regarded as accidental, or at least as barren of results. For when spring comes the *Aletia argillacea* has vanished, and is not to be found with the hibernating species of Lepidoptera, renewedly active. And if it *were* found in February and March, it would find no cotton plants upon which to deposit its eggs. If oviposition ever takes place in these months in the cotton belt, the young cotton, free from worms, disproves its efficacy.

It is possible that in the southern portions of Texas, or the Floridian peninsula, the Aletia may sustain itself during the entire year; I have no means of information on this point. My observations are made on its occurrence over the central and principal portions of the cotton belt, and into which I believe it to be imported *de novo* every season that it occurs and from more southern regions.

I conclude, therefore, that while the cotton plant is not indigenous to the Southern States (where it becomes an annual), the cotton-worm moth may be considered not a denizen, but a visitant, brought by various causes to breed in a strange region, and that it naturally dies out with us in the cotton belt, unable to suit itself *as yet* to the altered economy of its food plant and to contend with the changes of the seasons.

When this fact is comprehended, it will simplify the process of artificial extermination by limiting the period during which we can successfully attack the cotton worm, and by doing away with a certain class of proposed remedies.

From the foregoing it will be evident that, 1, The artificial agent employed to destroy the cotton worm must be employed against the first brood as it appears in any given locality during the progression of the moth northward; and, 2, that, in order to be effectual, a concerted action in the application of the remedial agent in any given locality will be found necessary.

I also recommend the introduction of the English sparrow into the Southern States, and additional legal protection to insectivorous birds. Since the war there has been too much ignorant use of the gun on the part of the negroes. *All* the birds should be protected as much as possible, for many species not usually considered insectivorous are yet found, during certain seasons of the year, to live on insects."

III. Astronomy.

1. *The Transit of Venus, Dec.* 8, 1874.—The following additional information respecting the late transit has been received since the publication of the last No. of the Journal. The stations are arranged in the order of latitude:

In the Northern hemisphere.

1. *Vladivostok.* Lat. 43° 7′, long. 8h. 47m. E. Prof. Asaph Hall, of the U. S. Naval Observatory, had charge of the American station at Vladivostok. The first contact was pretty well observed, but the haze was so thick as to render it impossible to take photographs at that moment. The time of second contact was noted with accuracy, and some photographs were taken that were tolerably satisfactory. The duration of the transit was 4h. 45m., during which period the haze dispersed three times, allowing the photographers to get some excellent pictures. The time of third contact was pretty accurately noted, but at the moment of fourth contact Venus was entirely invisible. Thirteen photographs were taken and the exact time of each was noted. Some of these are well defined, but others are faint and of uncertain value.
2. *Pekin.* Lat. 39° 54′, long. 7h. 46m. E. At the French station the four contacts were observed as follows: first 21h. 32m. 42s.; second 22h.; third 1h. 50m. 15s.; fourth 2h. 17m. 13s. Also sixty good photographs were taken.
3. *Yokohama.* Lat. 35° 36′, long. 9h. 19m. E. Russian station. Two contacts were observed, and sixty pictures taken. The Mexican party at Yokohama observed all the contacts and took a large number of pictures.
4. *Beyrout.* Lat. 33° 49′, long. 2h. 21m. E. Observations successful.
5. *Nagasaki.* Lat. 32° 45′, long. 8h. 39m. E. The American observations at this station were under the direction of George Davidson of the U. S. Coast Survey. The first contact could not be satisfactorily observed on account of clouds. The second contact was well observed. The separation of the limbs was then observed, until Venus had advanced one diameter, and then measures of the diameter of the planet were made. The third contact could not be satisfactorily observed on account of clouds, and at the time of fourth contact the sun was entirely obscured by clouds. The meridian transit of the sun's first limb was observed over nine threads, the first limb of Venus over eight threads, the second limb of Venus over eight threads, and the second limb of the sun over six threads. The difference of declination of the upper limb of the sun and both limbs of Venus was measured by eighteen micrometer readings. The first and second contacts occurred about 1m. 45s. later than the American Almanac computations, and about 3m. 30s. later than the English computations. The third contact occurred near the time of the American computations.

6. *Calcutta.* Lat. 22° 35′, long. 5h. 54m. E. Observations excellent.
7. *Maddapore.* Lat. 12° 48′ (?), long. 5h. 6m. E. Italian station. The four contacts were all observed.
8. *Colombo.* Lat. 7° 0′, long. 5h. 20m. E. All the contacts observed except the first.

In the Southern hemisphere.

1. *Rodrigues.* Lat. 19° 4′, long. 4h. 14m. E. Ingress and egress were well observed, and 58 photographs taken.
2. *Mauritius.* Lat. 20° 20′, long. 3h. 51m. E. Station of Lord Lindsay. All the contacts were observed, except the first, and 110 good photographs were taken.
3. *Reunion.* Lat. 20° 51′, long. 3h. 42m. E. Dutch station. Third contact observed and a few photographs taken.
4. *New Caledonia.* Lat. 21°, long. 11h. E. French station. Second contact observed and 100 good photographs taken.
5. *Cape Town.* Lat. 33° 55′, long 1h. 13m. E. Fourteen photographs taken.
6. *Queenstown, Otago.* Lat. 45° 50′, long. 11h. 20m. E. American station. The observations at this station were under the direction of Prof. C. H. F. Peters of Hamilton College. The sky was overcast until two minutes before the first contact, when the sun shone out and continued bright for nearly two hours. The distance of Venus from the sun's limb was repeatedly measured, as also the apparent diameter of Venus. During the latter part of the transit, floating clouds interfered, but 239 photographs were taken.

E. L.

2. *Observations on the Transit of Venus at Nagasaki;* by Professor DAVIDSON. (Extract from a letter by Mrs. Davidson,* dated Nagasaki, Dec. 10th, 1874.)— . . . The preceding night was clear and beautiful until daybreak, when clouds began rapidly to form, breaking away again about $8\frac{1}{2}^h$ and again clouding over by $9\frac{1}{2}^h$. * * I was to record for my husband, who seemed calm and in good spirits notwithstanding the doubtful weather. We were all at our posts of duty by ten o'clock, and as the time drew near you can imagine our suspense. In my husband's observatory (that of the large equatorial), just before the computing time, the sun seemed to be breaking through the clouds, and all was in readiness. George, our eldest boy, holding the chronometers up to his father's eye and ear, and I (seated where I could see my husband's face), with book and pencil in hand, with closed doors and perfect stillness, save the regular beats of the clock and chronometer. It was almost a solemn moment. The sun broke forth with one gleam. I was almost startled to my feet with the shout of "*commence*" given by my husband, as a warning to the photographers that the instant was about to arrive. In a few seconds he gave an exclamation of delight, and the first contact was accomplished and duly recorded. Observations were kept up until the next critical moment, of the second contact—the sun growing less bright but still bright enough for observations. The second contact was seen and, further observations made as the body was passing over the sun. Clouds grew thicker, leaving scarcely a hope for the third contact and also for the fourth, which were not visible, and then the whole thing was over. * * * The exact spot on the sun's limb where the contact should appear was only known by

* We are indebted for this letter to Mr. Daniel B. Smith of Germantown, Pa.

computation from previous data; and under so large a magnifying power, which took in about 5½ diameters of Venus, an error of one minute of an arc would have been fatal. Mr. Davidson had gone over his calculations several times, and that same morning had revised them again to satisfy himself, then pointed his instruments, and sure enough there came Venus right in the center of his pointing, 3½ minutes later than the English computed time, and 1½ earlier than the American time.

IV. Miscellaneous Scientific Intelligence.

1. *Canadian Scientific Research in* 1874.—Mr. James Richardson (of the Geological Survey) spent the months of May, June and July in a topographical and geological examination of the inlets on the coast of British Columbia, between the 52d and 55th degrees of north latitude. * * *

Mr. George M. Dawson, geologist and botanist to the Boundary Commission, has been engaged in continuing the examination of the region in the vicinity of the 49th parallel. The work of this season extended from Woody Mountain, which is about 400 miles west of the Red River, to the watershed of the continent in the Rocky Mountains. The part of the journey from Red River to Woody Mountain lay over ground already explored in 1873, and but little of geological interest was met with. Woody Mountain, so-called, is situated on the northern edge of the plateau of the Lignite Tertiary, and from the existence of groves of poplars in the valleys, has been chosen by the half-breeds as a base for their hunting and trading expeditions. South of Woody Mountain, on the boundary line, excellent sections illustrating the junction of the Cretaceous and Lignite Tertiary were found, in which the base of the latter formation was well defined. Denudation acting on the little consolidated clays of the Tertiary, has converted a portion of the region where it occurs into *Bad Lands*, which, though perhaps not so rugged as those of Southern Dakota, are characterized by barren clay hills and gorges with scarcely a trace of verdure, and are sufficiently forbidding. Westward from Woody Mountain the Cretaceous rocks cover the greatest area, but those of the base of the Tertiary frequently appear resting on them, and almost always produce a more or less well marked plateau, the general aspect of the country being comparable to that of a cameo, the depressed parts of which are based on the dark Cretaceous clays. The Cretaceous rocks in some places yielded numerous well-preserved fossils enclosed in ferruginous or calcareous nodules, the play of color due to the original pearly matter of the shell being in many cases still apparent. The horizon indicated by most of these is that of the Fort Pierre Group or Cretaceous No. 4 of Meek and Hayden. . . .

The field work of the Boundary Commission is now over, the line having been run and properly marked from the Lake of the

Woods to the Watershed of the Mountains, where it joins that previously surveyed from the Pacific coast. The maps and detailed reports in the various departments are in course of preparation.

Professor Bell has been again engaged during the past summer in the Northwest Territories. The region more particularly explored was the high grounds extending along the western sides of Lakes Manitoba and Winnipegosis and comprising the Riding, Duck and Porcupine Mountains. The valleys of the Swan River and of the Upper Assinniboine were carefully examined, as were also those of some of their tributaries. Mr. Bell and his assistants likewise visited portions of the shore of all the lakes of the Winnipeg basin.—J. F. W. *Montreal Gazette*, Jan. 15.

2. *British Arctic Expedition.*—The scientific part of the forthcoming Polar Expedition will not fail through want of advice and instruction, for while the Geographical Society are preparing their promised Manual of Geography and Physical Geography, the Royal Society are getting ready a Manual of Physical and Natural Sciences. Thus the explorers may prepare themselves for observations on magnetism, on meteorology, on the tides, which in the Arctic zone are peculiar, on geology and botany, on natural history, particularly that part of it which includes the minor forms of marine life; and last, though not least, ethnology is to be attended to, as opportunity may offer. This is a good scheme; almost too good, for opportunities can hardly be other than rare, especially in the ethnic system, in the frozen and desolate regions around the Pole. The Admiralty have relaxed their original intention to appoint none but naval men as scientific observers, and the Council of the Royal Society have recommended for appointment as naturalists to the Expedition, Capt. Feilden, R.A. (at present in Malta) and Mr. Chichester Hart, of Dublin. Hence we may conclude that in the persons of these two gentlemen botany and zoology are provided for. Meanwhile the naval preparations are actively carried on; the two vessels selected for the Expedition, the Alert and the Bloodhound, are being strengthened with all possible dispatch, and the victualling department is busy in cooking and concentrating provisions of the best kind into the smallest possible space.—*Athenæum, Jan.* 30.

3. *Introduction to the Resources of Tennessee;* by J. B. KILLEBREW, A.M., assisted by J. M. SAFFORD, Ph.D., M.D., and others, being the First and Second Reports of the State Bureau of Agriculture; with five maps, one geologically colored. 1193 pp. 12mo. Nashville, 1874.—The State of Tennessee has an unusually wide range of climates, elevations, geological formations and vegetable productions. The Report now before us is therefore of more than usual interest, and gives the distinctive characters of a much larger area than its title would imply. On the east its border mountains have the same characters as adjoining portions of North Carolina, Virginia and Georgia; its great valley graduates upward into Virginia and downward into Georgia; the coal and iron-ore resources of the slopes of the Cumberland

Mountains and the mild equable climate of the summit plateau are continuous with those of West Virginia, Kentucky and Alabama; its central basin has the same rich "blue-grass" soil as that of Kentucky; and its western border includes a large area of the Mississippi bottoms. The work opens with a brief description of the Topographical Features and Natural Divisions, Climate and Geological Formations, followed by chapters upon Farm-Geology, Soils, Timber, Farm Products, Grasses, Live Stock, Dairy Products, Grapes, Honey, Coal, Iron, Copper, Transportation, Schools, etc., and these by others giving the details of each county separately. The volume makes a grand exhibit of the resources of the State, and will probably many times repay the cost of its publication, through the population and capital which it will be the means of attracting thither.

To make this Report quite complete it should be supplemented by full details as to the geological structure of each county, such as would be obtained in a careful geological survey. It is much to be desired that the survey, begun and so well carried forward by Professor Safford for several years before the war, should be revived on a larger scale and finished.

4. *The Microscope and its Revelations*; by WM. B. CARPENTER. Fifth edition, with 25 plates and 449 wood-cuts. Philadelphia, 1875. (Lindsay & Blakiston.)—This is an enlarged and revised edition of Dr. Carpenter's well known work on the microscope. Considerable additions have been made to the chapters relating to microscopes and the accessory apparatus. But more numerous and perhaps more important additions have been made to the portions relating to the structure of the lower forms of animals and plants, especially the Foraminifera, Bathybius, Coccoliths, Bacteria, Diatoms, etc., including many of the recent discoveries made in connection with the deep-sea dredgings. V.

5. *Mt. Katahdin.*—Through a very careful barometrical determination in August, 1874, Prof. N. C. Fernald has ascertained the height of Mount Katahdin above mean tide at Bangor, Maine, to be 5,215·5 feet, with the probable error not exceeding 4·2 feet.

OBITUARY.

D'OMALIUS D'HALLOY.—This eminent Belgian geologist, an active member of the Geological Society of France, died at Brussels, on the 15th of January, aged nearly ninety-two years.

SIR CHARLES LYELL.—Sir Charles Lyell died on the 22nd of February, aged seventy-eight years.

Annual Report upon the Survey of the Northern and Northeastern States, in charge of C. B. Comstock, Major of Engineers, Bvt. Brig. General, U. S. A., being Appendix CC to the Annual Report of the Chief of Engineers for 1874. 78 pp. 8vo. Washington, 1874.

Report of Progress of the Geological Survey of Canada, for 1873–74, Alfred C. Selwyn, F.R.S. 270 pp. 8vo. Montreal, 1874.

APPENDIX.

ART. XXVI.—*Notice of New Tertiary Mammals*, IV; by O. C. MARSH.

THE remains described in the present communication include some new forms of Quadrumana from the Eocene and Miocene; a species of the new order *Tillodontia*, recently established by the writer; the first horned Rhinoceroses found in this country; a new genus of the *Brontotheridæ;* and a number of other extinct mammals from the Tertiary of the Rocky Mountain region and the Pacific coast. The specimens described are all preserved in the Museum of Yale College.

Lemuravus distans, gen. et sp. nov.

The first announcement of the order *Primates* from the Tertiary of this country was published by the writer, Oct. 8th, 1872, and subsequently appeared in this Journal, (vol. v, p. 405, Nov., 1872). In this paper, three genera of the *Limnotheridæ*, viz: *Limnotherium*, *Thinolestes* and *Telmatolestes*, previously described by the writer, were shown to belong to the lower Quadrumana, the principal parts of the skeleton being very similar to those of Lemurs, while the jaws were somewhat like those of Marmosets. The number of teeth was stated to be greater than in any known forms of the order. Subsequent researches have fully confirmed this determination, and many new facts may now be added in regard to the characters and affinities of this well marked group. From numerous specimens, the writer has ascertained that the *Limnotheridæ* should be placed in the *Prosimiæ*. The brain was nearly smooth, and the cerebellum large, and placed mainly behind the cerebrum. The orbits are open behind, and the lachrymal foramen is outside the orbit.

In addition to the genera mentioned above, an examination of the type specimens of *Notharctos*, *Hipposyus*, *Microsyops*, and *Palæacodon* of Leidy shows that they are true Primates, and probably all belong to the *Limnotheridæ*. To these may be added *Mesacodon*, *Bathrodon*, and *Antiacodon*, described by the writer.*

The genus *Lemuravus*, here described, is nearly related to *Hyopsodus* Leidy. The latter proves on investigation to belong to the *Primates*, and not to the Ungulates. This is shown by

* *Antiacodon nanus* Marsh was redescribed by Cope, several months later, under the name *Anaptomorphus æmulus*. *Limnotherium affine* Marsh was likewise redescribed by the same author as *Tomitherium rostratum* Cope.

the close correspondence of the skeleton with that of the Lemurs, and by the general structure of the skull. *Hyopsodus* and the present genus represent a distinct family, which may be called *Lemuravidæ.* The type genus, *Lemuravus*, has 44 teeth, indicating the most generalized form of the order. *Hyopsodus* has apparently but 42. In the former, the teeth form a continuous series above and below. The canines are small, and the upper incisors are not separated on the median line, as in Lemurs. The molar teeth appear to be essentially the same as those of *Hyopsodus*, but as the latter are only known with certainty from the lower jaw first described there may be important differences. The symphysis of the lower jaw is completely coössified. The brain was nearly smooth, and of moderate size. The skeleton most resembles that of the Lemurs. The humerus has at its distal end a supracondylar foramen, and a supratrochlear perforation. The radius and ulna are distinct. The femur has a small pit in the head for the round ligament. Its distal end is more flattened antero-posteriorly than in the Lemurs. The tibia and fibula are separate. The astragalus is very similar to that of *Lemur.*

Measurements.

Space occupied by entire upper dental series, ...	30·mm·
Extent of upper molar series, ...	21·5
Extent of three upper true molars,....................	11·
Extent of three upper incisors, ...	5·5
Extent of lower molar series,.........................	23·
Extent of three lower true molars,....................	12·5
Diameter of head of femur,............................	5·
Transverse diameter of distal end of femur,...........	10·
Transverse diameter of proximal end of tibia,.........	9·
Transverse diameter of distal end,....................	5·5
Length of astragalus,.................................	7·5

The present species was about the size of the largest squirrels. The type specimen was found in 1871, in the Lower Eocene of Wyoming, by Mr. T. G. Peck of the Yale party.

Laopithecus robustus, gen. et sp. nov.

Among the interesting specimens obtained by the writer during his late expedition to the "Bad Lands" in Nebraska was the lower jaw of a monkey, the first of the order found in that region. The specimen is well preserved, and indicates an animal about as large as a Coati. The crowns of the molar teeth agree essentially with those of some South American monkeys, but still more nearly with those of the Eocene *Limnotheridæ.* From that family the present genus may readily be distinguished by the first true molar, which is the largest of the series, much larger than the penultimate. The last lower molar is smaller than the others. In the first and second true molars, the external cusps are slightly in advance of the corresponding inner ones. The anterior pair are higher and nearer together than those behind. A low ridge extends obliquely from the base of the anterior inner cone to the summit of the outer posterior cusp. The inner posterior cusp is smaller than the others, and separated from them. The crowns are bounded by a distinct basal ridge, except on the inner side. The enamel of the molars is rugose.

Measurements.

Space occupied by three lower true molars,	17·mm·
Antero-posterior diameter of first lower molar,	7·
Transverse diameter,	6·
Height of crown,	5·5
Antero-posterior diameter of penultimate molar,	5·5
Transverse diameter,	5·
Height of crown,	4·2
Depth of jaw below first lower molar,	12·6

This specimen was found in the *Oreodon* horizon of the Miocene "Bad Lands," about thirty miles south of the Black Hills.

Tillotherium fodiens, sp. nov.

Since this genus was proposed by the writer (this Journal, v, p. 485, June, 1873), much light has been thrown upon its affinities by additional remains. It proves to be quite distinct from *Anchippodus* (*Trogosus*) Leidy, although nearly related. The latter genus, unfortunately, is known only from portions of the lower jaw, but this shows marked differences from *Tillotherium*, which lacks the inner pair of small lower incisors, and has an incisor and a canine between the large scalpriform tooth and the first lower premolar. *Tillotherium* has 34 teeth in its permanent dentition (p. 221), and the molar teeth most resemble those in Ungulates. The upper true molars are similar to the premolars of some Eocene Perissodactyls, but are somewhat like the tubercular molars of the *Canidæ*. The lower molar series is of the *Palæotherium* type, and the last lower molar has a well developed posterior lobe.

In the present species, the canines were small, and the superior ones placed somewhat behind the premaxillary suture. The five digits on each foot were all well developed, and of moderate length. The metapodial bones are similar to those in *Ursus Americanus*, but the ungual phalanges preserved are more oblique, and less pointed at the extremity.

Measurements.

Length of skull, from front of incisors to end of occipital condyles,	355· mm.
Extent of entire upper dental series,	186·
Extent of upper molar series,	98·
Extent of three true molars,	59·
Antero-posterior diameter of penultimate upper molar,	20·5
Transverse diameter (greatest),	35·
Antero-posterior diameter of last upper premolar,	12·
Transverse diameter,	24·
Antero-posterior diameter of base of gliriform upper incisor,	22·
Transverse diameter,	16·5
Distance between bases of upper canines,	35·
Extent of lower dental series,	162·
Extent of last three lower molars,	70·
Extent of entire lower molar series,	93·
Antero-posterior diameter of lower gliriform incisor,	21·
Transverse diameter,	15·
Transverse diameter of condyle of lower jaw,	52·
Length of radius,	170·
Transverse diameter of humerus at distal end,	76·
Transverse diameter of tibia at proximal end,	59·
Length of calcaneum,	72·
Length of first metacarpal,	40·
Length of second metatarsal,	46·
Length of ungual phalanx,	35·
Width of articular face,	12·5
Vertical diameter,	14·

The remains here described indicate an animal about two-thirds as large as a Tapir. They are from the *Dinoceras* beds of the Eocene of Wyoming. *Anchippodus minor* Marsh (*Trogosus castoridens* Leidy) is from a lower horizon of the same formation. Both belong to the order *Tillodontia.*

Diceratherium armatum, gen. et sp. nov.

The present genus is of special interest, as it includes the first extinct rhinoceroses with horns found in America. It is an interesting fact, likewise, that these had each a pair of horns placed transversely, as in modern Ruminants, although the discovery of *Dinoceras* and *Brontotherium* has rendered this feature less unexpected. The existence of these horns is clearly indicated by large osseous protuberances on the anterior portion of the nasal bones. The latter are massive and firmly coössified, evidently to support well developed horns. The remainder of the skull, and the teeth, as well as the skeleton, so far as known, resemble the corresponding parts in *Acerathe-rium.* The dental formula appears to be,

$$\text{Incisors } \frac{1}{2},\ \text{canines } \frac{0}{0},\ \text{premolars } \frac{4}{3},\ \text{molars } \frac{3}{3}.$$

In the present species the skull is of moderate length. The horn-cores are oval in outline, and placed directly opposite each other on the free portion of the nasals, a short distance back from the extremity. They are directed upward and outward, and their surface is rugose. The orbit is small, and there is a prominent postorbital process on the frontal. The premaxillaries are slender, and each supports a single incisor, with a compressed crown. The molar teeth are large, and without cement. The posterior nares terminate in front of the penultimate upper molar. There is a large rounded tubercle on the supraoccipital, just above the foramen magnum. The bones of the limbs preserved indicate that there were four digits in the manus, and three in the pes.

Measurements.

Distance from front of first premolar to end of occipital condyles,	456·mm·
Distance from front of orbit to anterior narial opening,	133·
Extent of upper molar series,	256·
Extent of upper premolar series,	121·
Antero-posterior diameter of last upper molar,	41·
Transverse diameter,	50·
Antero posterior diameter of penultimate upper molar,	49·
Transverse diameter,	55·
Antero-posterior diameter of last upper premolar,	35·
Transverse diameter,	50·
Antero-posterior diameter of first upper premolar,	25·
Transverse diameter,	25·
Width of palate between first upper premolars,	43·
Width between penultimate upper molars,	69·
Length of third metacarpal,	190·
Width of proximal end,	50·
Length of first phalanx of third digit of manus,	31·
Transverse diameter of unciform,	60·
Vertical diameter,	45·

The known remains of the present species indicate an animal about two-thirds the size of the Indian Rhinoceros. They are from the Miocene beds, near the John Day River, in Eastern Oregon.

Diceratherium nanum, sp. nov.

A second species of the above genus is indicated by the greater part of a skull and teeth, and some other remains. These specimens pertained to an animal scarcely more than one-half the bulk of that last described. The horn-cores are more compressed, and the extremity of the nasals in front of them is pointed. The anterior narial opening is large. The premaxillaries are slender and compressed. They do not extend so far forward as the nasals.

Measurements.

Distance (approximate) from front of first premolar to postorbital process,	155·mm·
Distance from end of premaxillary to first upper premolar,	91·
Antero-posterior diameter of upper incisor,	25·
Transverse diameter,	11·
Antero-posterior diameter of first lower premolar,	24·
Transverse diameter,	14·
Antero-posterior diameter of second premolar,	26·
Tranverse diameter,	18·

The geological horizon and locality are essentially the same as in the last species.

Diceratherium advenum, sp. nov.

A species clearly belonging to the Rhinoceros family, and possibly to the same genus as the preceding, is indicated by a few fragmentary remains, which are of interest from their geological horizon and locality. The most perfect of these specimens is a last upper molar, and the corresponding lower molar. The former has a wide sigmoid valley between high and nearly parallel transverse crests. There is a strong anterior and posterior basal ridge, but only a faint trace on the inner side near the bottom of the valley. The enamel of the outer and posterior faces especially is marked by delicate vertical striæ. The lower molar has a high narrow crown. The enamel is rugosely striate.

Measurements.

Greatest antero-posterior diameter of last upper molar,	40·mm·
Transverse diameter (approximate),	42·
Depth of transverse valley,	19·
Antero-posterior diameter of last lower molar,	40·
Transverse diameter,	19·
Height of unworn posterior crest,	22·

The known remains of this species pertained to an animal half the bulk of the Indian Rhinoceros. The main interest attached to them is the fact that they were found with upper Eocene fossils, in Utah, and are the first indications of this group in that region. Possibly the strata containing these fossils may in part prove to be lower Miocene.

A comparison of the Lophiodont genus *Hyrachyus* with the Miocene Rhinoceroses, especially *Hyracodon*, seems to point to the former as the Lower Eocene representative or ancestor of the latter group. The skull and teeth of *Hyrachyus* are so similar to those of *Hyracodon* that only slight changes are necessary to transform one into the other. The skeletons, too, are much alike, but *Hyracodon* has only a rudiment of the fifth metacarpal, and hence the line of descent for the four-toed forms was probably a different one.

Brontotheridæ.

During a recent expedition to the "Bad Lands" of Dakota, the writer secured a large number of specimens belonging to the *Brontotheridæ*, most of them in good preservation. From the Miocene of Colorado, explored by the writer in 1870, and subsequently, a large amount of similar material has been obtained, so that at the present time the Yale Museum contains portions of more than 100 different individuals of this family. A study of these specimens, in connection with the types originally discribed, promises to leave but few points in doubt in regard to the structure or affinities of the group. The results will be published at an early day, but a few are given here, which may clear up some of the existing confusion about the different genera.

It may now be regarded as established that all the species of the *Brontotheridæ* had horns, and there is no reasonable doubt that these were common to both sexes. The osseous horn-cores in each species varied much in size and shape with difference of age, and probably of sex. The incisors are small, and in old specimens are frequently lost.

There appear to be four well marked genera in this family now known, which may be distinguished as follows:

1. *Titanotherium* Leidy (*Menodus* Pomel.)

Dentition = Incisors $\frac{2}{2}$; canines $\frac{1}{1}$; premolars $\frac{4}{4?}$; molars $\frac{3}{3}$. Diastema behind upper canines. Basal ridge on inner side of upper premolars not continuous. Nasals short. A postorbital process. Third trochanter rudimentary or wanting. Type *T. Proutii* Leidy.

2. *Megacerops* Leidy. (*Megaceratops* Cope), (*Symborodon* Cope in part.)

Dentition = Incisors $\frac{2}{0}$; canines $\frac{1}{1}$; premolars $\frac{4}{3}$; molars $\frac{3}{3}$. Diastema behind upper canine. Inner basal ridge on upper premolars not continuous. Nasals more elongated. A postorbital process. Third trochanter rudimentary or wanting. Type *Megacerops coloradensis* Leidy.

3. *Brontotherium* Marsh. (*Symborodon* Cope, in part.) (*Miobasileus* Cope.)

Dentition = Incisors $\frac{2}{2}$; canines $\frac{1}{1}$; premolars $\frac{4}{3}$; molars $\frac{3}{3}$. No superior diastema. Strong continuous basal ridge on inner side of upper premolars. No postorbital process. Third trochanter distinct. Type *B. gigas* Marsh.

4. *Anisacodon* Marsh, gen. nov.

Dentition = Incisors $\frac{0}{1}$; canines $\frac{1}{1}$; premolars $\frac{4}{3}$; molars $\frac{3}{3}$.

No superior diastema. Strong inner basal ridge on upper premolars. Last upper molar with two inner cones. No postorbital process. Type *A. montanus* Marsh.

Anisacodon montanus, sp. nov.

This species is especially distinguished by the emargination of the extremity of the nasals; the short premaxillaries; and the rectangular form of the last upper molar. The inner posterior cone of this molar is smaller than the one in front, and quite distinct from the posterior basal ridge.

Measurements.

Extension of premaxillaries in front of canines,	15·mm.
Distance from end of premaxillaries to narial aperture,	76·
Width of nasals above end of premaxillaries,	95·
Antero-posterior diameter of last upper premolar,	43·
Transverse diameter,	63·
Antero-posterior diameter of penultimate upper molar,	77·
Transverse diameter,	85·
Antero-posterior diameter of last upper molar,	84·
Transverse diameter,	88·

The specimen here described was found by the writer in November last, in the Miocene of northern Nebraska.

Diplacodon elatus, gen. et sp. nov.

The genus here established presents characters in some respects intermediate between *Limnohyus* and *Brontotherium*. It agrees with the former in its complete dentition (44 teeth), and in the general form of the incisors, canines, and true molars. It resembles the latter still more closely in the premolar and molar teeth, and parts of the skeleton, especially in the vertebræ, and bones of the extremities. From the Eocene *Limnohydiæ*, already described, this genus is sharply distinguished by the last upper premolar, which has two distinct inner cones, thus agreeing essentially with the first true molar. This character, which has suggested the name of the genus, is one step toward the modern type of Perissodactyl dentition. The dental formula of the genus is the same as *Limnohyus*, viz:

Incisors $\frac{3}{3}$, canines $\frac{1}{1}$, premolars $\frac{4}{4}$, molars $\frac{3}{3}$.

In other respects the teeth most resemble those of the *Bron-*

totheridæ. From this family, *Diplacodon* differs widely in its dentition, and the absence of horns.

The cervical vertebræ are short, and opisthocœlous. The radius and ulna, and tibia and fibula, are distinct, and the feet show well marked Perissodactyl characters. There were four digits in front, and apparently three behind.

In the present species, the incisors are all well developed, and those in the lower jaw are directed forward. The canines are large, and have long curved crowns with pointed extremities. The first three upper premolars have the two inner cones connate. The upper true molars are surprisingly like those of *Brontotherium.*

Measurements.

Extent of upper molar series,	242·mm·
Extent of upper true molars,	152·
Antero-posterior diameter of first upper premolar,	14·
Antero-posterior diameter of second upper premolar,	21·
Transverse diameter,	23·
Antero-posterior diameter of fourth upper premolar,	28·
Transverse diameter,	34·
Antero-posterior diameter of first upper true molar,	42·
Transverse diameter,	57·
Antero-posterior diameter of second upper molar,	52·
Transverse diameter,	57·
Antero-posterior diameter of last upper molar,	60·
Transverse diameter,	59·
Width of palate between posterior molars,	92·
Distance between bases of canines of lower jaw (2d specimen)	46·
Antero-posterior diameter of canine, at base,	32·
Transverse diameter,	28·
Height of crown,	27·
Antero-posterior diameter of first lower premolar,	17·
Transverse diameter,	10·
Antero-posterior diameter of second premolar,	26·
Transverse diameter, in front,	15·
Antero-posterior diameter of third premolar,	28·
Transverse diameter, in front,	17·
Transverse diameter, posteriorly,	20·
Length of median cervical vertebra,	45·
Transverse diameter of anterior articular face,	60·
Vertical diameter,	63·

The remains here described belonged to an animal nearly as large as a rhinoceros. They are from the Upper Eocene beds of Utah.

Orohippus Uintensis, sp. nov.

The present species is the largest of the genus, and in some respects indicates a transition between the lower Eocene species and the allied forms in the Miocene. It agrees with the known species of the genus in the number and general structure of the teeth, and in the absence of the posterior intermediate lobe of the upper molars, and especially in the presence of the fifth digit in the manus. It differs in the much deeper transverse valleys of the upper molars, and in their wider crowns. The outer faces of the external cusps of the upper molars have a strong crest extending from the basal ridge to the apex.

Measurements.

Antero-posterior diameter of penultimate upper molar,	9· mm.
Greatest transverse diameter,	12·
Extent of lower molar series,	48·
Extent of lower premolar series,	28·
Antero-posterior diameter of last lower premolar,	8·5
Transverse diameter,	6·
Depth of jaw below third lower premolar,	14·

This species occurs in the upper Eocene deposits of Utah.

Mesohippus, gen. nov.

This genus presents characters intermediate between *Orohippus** Marsh, and *Anchitherium* von Meyer. The skull and teeth are very similar to those of the latter genus, and the dental formula is the same. In the feet, however, the lateral digits are larger; the fifth metacarpal is represented by an elongated splint bone; and the second and third cuneiform bones of the pes are not coossified. The type of the genus is *Mesohippus Bairdi*, =*Anchitherium Bairdi* Leidy. *Mesohippus celer*, =*Anchitherium celer* Marsh, is a smaller species. Both are from the Miocene.

Thinohyus lentus, gen. et sp. nov.

This genus is nearly related to *Dicotyles*, and apparently represents an earlier form of the same type. This is shown in the similar structure of the skull, and form of the teeth. The most noteworthy differences seen in the remains under description are, an additional premolar in the lower jaw, and the extension of the posterior nares between the last upper molars. The orbit is not enclosed behind, and there is no antorbital fossa. The brain was small—less than one-half the size of that of a *Dicotyles* of the same bulk—and much convoluted. There is a strong bony tentorial ridge. The molar teeth have the principal cusps more isolated than in *Dicotyles*, and the intermediate lobes larger.

In the present species the temporal fossæ are separated above only by a narrow ridge. The auditory bullæ are large, and oval in outline. The nasal bones are broad posteriorly. The

* In several recent publications, Prof. Cope has referred the genus *Orohippus* to *Hipposyus* Leidy. The two, however, as shown by a comparison of the type specimens, have no affinity, the latter belonging to the Quadrumana.

postorbital process on the frontal is longer than in *Dicotyles*, and more pointed. There is a strong cingulum on the upper molars, excepting on the base of the inner cones.

Measurements.

Distance from fronto-nasal suture to inion, on median line,	97·mm·
Distance between orbits, over frontals,	64·
Expanse of zygomatic arches,	95·
Extent of last three upper molars,	43·
Antero-posterior of first upper true molar,	14·
Transverse diameter,	14·
Antero-posterior diameter of second molar,	16·
Transverse diameter,	14·
Width between auditory bullæ,	9·
Antero-posterior diameter of auditory bulla,	24·
Transverse diameter,	18·
Length of symphysis of lower jaw (second specimen),	54·
Distance between lower canines,	13·
Space between lower canines and first premolar,	8·
Space between first and second lower premolars,	10·

The present species was somewhat larger than the *Dicotyles torquatus*. The remains here described are from the Miocene, of the John Day River, in Oregon.

Thinohyus socialis, sp. nov.

A second species of the same genus, about half as large as the preceding, is indicated by some fragmentary remains, and particularly by some portions of upper jaws with teeth in excellent preservation. In the present species, the last upper molar is proportionately narrower, and the intermediate lobes of all the upper molars are less developed. In other respects the teeth agree closely with those of the last species. The enamel of the upper molars is somewhat rugose, and there is a distinct basal ridge, except on the inner side.

Measurements.

Antero-posterior diameter of last upper molar,	12·mm·
Transverse diameter through anterior cones,	10·
Transverse diameter through posterior cones,	8·
Antero-posterior diameter of second upper molar,	12·
Transverse diameter, in front,	12·
Height of crown,	6·5

The type specimen of this species was found in November, 1871, in the Miocene beds of Oregon, by Mr. F. Mead, Jr., of the Yale party.

Eporeodon, gen. nov.

Among the species now placed in the genus *Oreodon* of Leidy there are two well marked genera which may readily be distinguished by the base of the skull, and apparently by other characters. In the form first described, of which *Oreodon Culbertsoni* Leidy may be considered the type, there is no indication of an auditory bulla, and for this group the name *Oreodon* may be retained. The other genus, which has a large auditory bulla, may be named *Eporeodon*. The type species is *Eporeodon occidentalis* = *Oreodon occidentalis* Marsh, from the Miocene of Oregon. The other known species of this genus are the following: *Eporeodon superbus*, = *Oreodon superbus* Leidy; *Eporeodon major*, = *Oreodon major* Leidy; and *Eporeodon bullatus*, = *Oreodon bullatus* Leidy. These species, so far as observed, occur in a somewhat different horizon of the Miocene, from the true *Oreodons*. They are, moreover, of larger size, and to this the proposed name refers.

Agriochœrus pumilus, sp. nov.

A number of specimens of a selenodont Artiodactyl, from the upper Eocene, agree so nearly with the known remains of *Agriochœrus* Leidy, that the species they represent may provisionally be placed in that genus. They indicate an animal less than one-half the size of the species already described. The teeth preserved agree in structure essentially with those of *A. latifrons* Leidy. The temporal fossæ were separated only by a sharp crest. Nothing has been known hitherto of the skeleton of this genus, but fortunately some of the more important bones were found with the teeth of the present species. These show that the feet are of the true Artiodactyl type, and somewhat resemble those of *Oreodon*. The tibia and fibula are distinct. The navicular and cuboid are separate. The metapodial bones are not united, and the second and fifth were present.

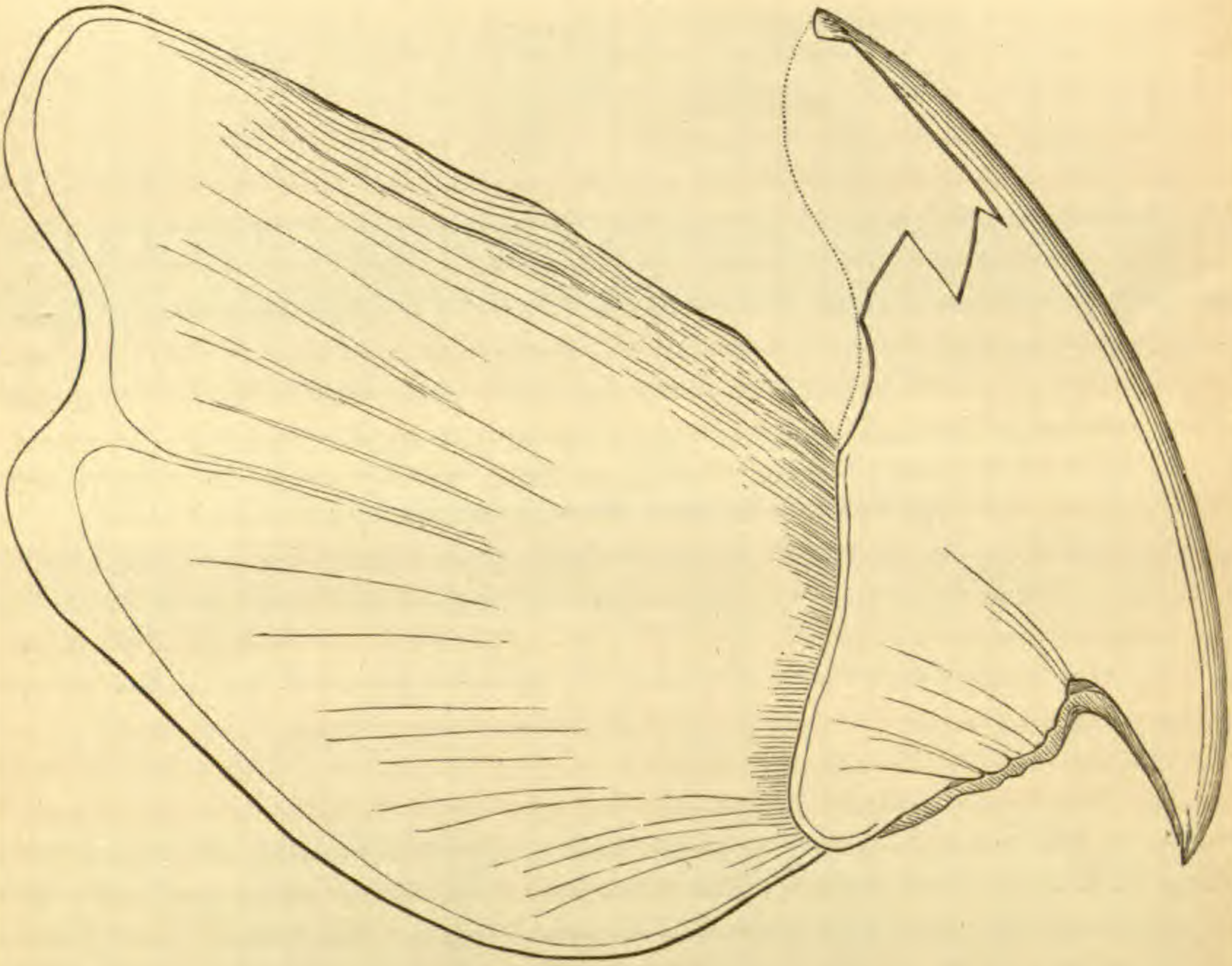
Measurements.

Extent of last three lower molars,	32· mm.
Antero-posterior diameter of penultimate lower molar,	10·
Transverse diameter,	8·
Transverse diameter of humerus at distal end,	24·
Transverse diameter of articular face,	17·
Least vertical diameter,	11·5
Transverse diameter at distal end,	16·
Antero-posterior diameter,	15·
Extent of three upper true molars (second specimen),	32·
Antero-posterior diameter of first upper molar,	9·5
Transverse diameter,	11·
Antero-posterior diameter of second upper molar,	11·
Transverse diameter,	13·

The present species was about three-fourths the size of the Collared Peccary (*Dicotyles torquatus*). The specimens described are from the upper Eocene of Utah.

Yale College, New Haven, Feb. 20, 1875.

14



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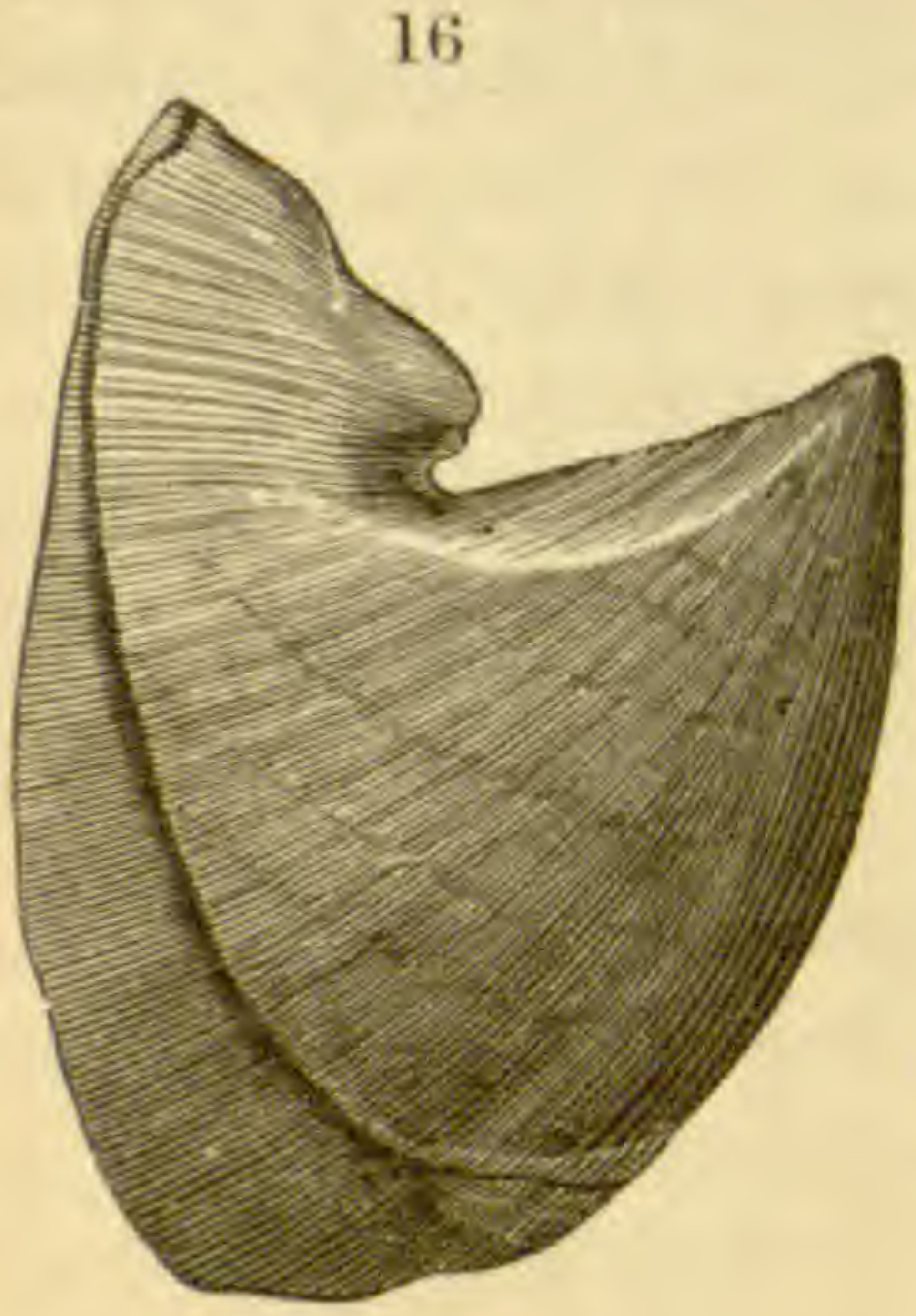

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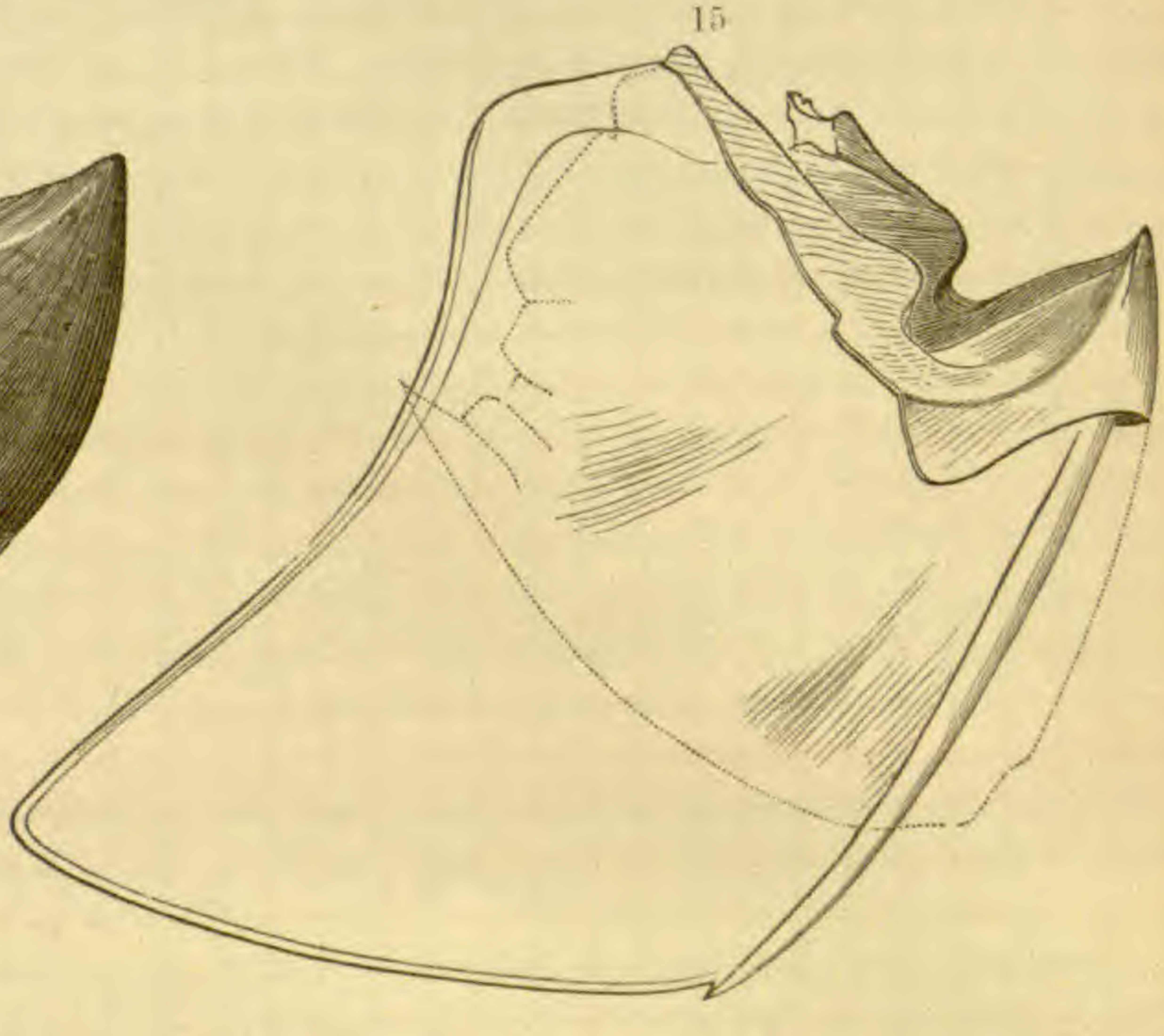


Allegheny Observatory. Dec. 23–24, 1873

Engraved by Samuel Sartain, Philadᵃ

A TYPICAL SUN-SPOT.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

Art. XXVII.—*The History of Young's Discovery of his Theory of Colors;* by Alfred M. Mayer.

The object of this communication is twofold: I desire first to give complete abstracts from the writings of Newton, Young and Wollaston, in order to put the student of science in possession of all of the early literature of Young's celebrated theory of colors. In the second place, I propose to trace the curious history of the steps by which Young was led to the final adoption of what is now known as Young's theory of color-sensation. In accomplishing the first of these objects, I shall, at the same time, attempt to show, 1st, that Young first formed an hypothesis similar to that known as Brewster's; that is, he selected red, yellow and blue as the three simple color-sensations; 2d, that he subsequently modified his hypothesis and adopted red, green and violet as the three elementary color-sensations, showing that up to the date of this change of opinion all of his ideas on the subject were hypothetical, and not based on any observations or experiments of his own or of others; 3d, that this change of opinion as to the three elementary colors was made on the basis of a misconception by Wollaston of the nature of his celebrated observation of the dark lines in the solar spectrum, and also on the basis of an erroneous observation made by Young in repeating Wollaston's experiment; 4th, that Young subsequently tested his hypothesis of color-sensation and found that it was in accord with facts reached by experiment; and that these experiments then vindicated his hypothesis and raised it to the dignity of a theory.*

Before discussing the subject proper of this article, it may be well to give the reader a clear conception of Young's theory of color, and to show in what high estimation it is at present held by men of science. This can best be done by the reading of the following short extracts from Helmholtz's "Physiological Optics" and from his "Popular Scientific Lectures."

"To speak of three fundamental colors in an objective sense would be nonsense; in fact, as long as one refers only to purely physical conditions, and while there is no reference to the human eye, the properties of compound light depend alone on the proportions in which exist lights of different wave-lengths. The reduction of light to three fundamental colors can never have anything else than a subjective signification; it consists simply in reducing all *color-sensations* to three fundamental sensations. It is in this sense that Young understood the problem, and his hypothesis gives, in fact, an exceedingly clear and simple explanation and summary of all of the phenomena found in the physiological study of colors. Young states that:

"'1. There exist in the eye three kinds of nerve fibers whose excitation respectively gives the sensation of red, of green, and of violet.

"'2. Homogeneous light excites the three kinds of nerve fibers with an intensity which varies with its wave-length.' That which possesses the greatest length of wave excites most powerfully the fibers sensitive to red, that which has an average wave-length excites the nerves sensitive to green, while that light formed of the shortest waves acts on the fibers which give the violet sensation. Nevertheless we cannot deny, but rather should admit for the explanation of numerous phenomena, that each color of the spectrum excites all three kinds of nerve fibers, but with different intensities. Imagine the colors of the spectrum arranged horizontally in going from the red, R, to the violet, V, as shown at the base of figure 1. The three curves will then represent more or less exactly the degrees of irritability of the three kinds of nerve fibers (1, the red; 2, the green; 3, the violet) for the various colors of the spectrum.

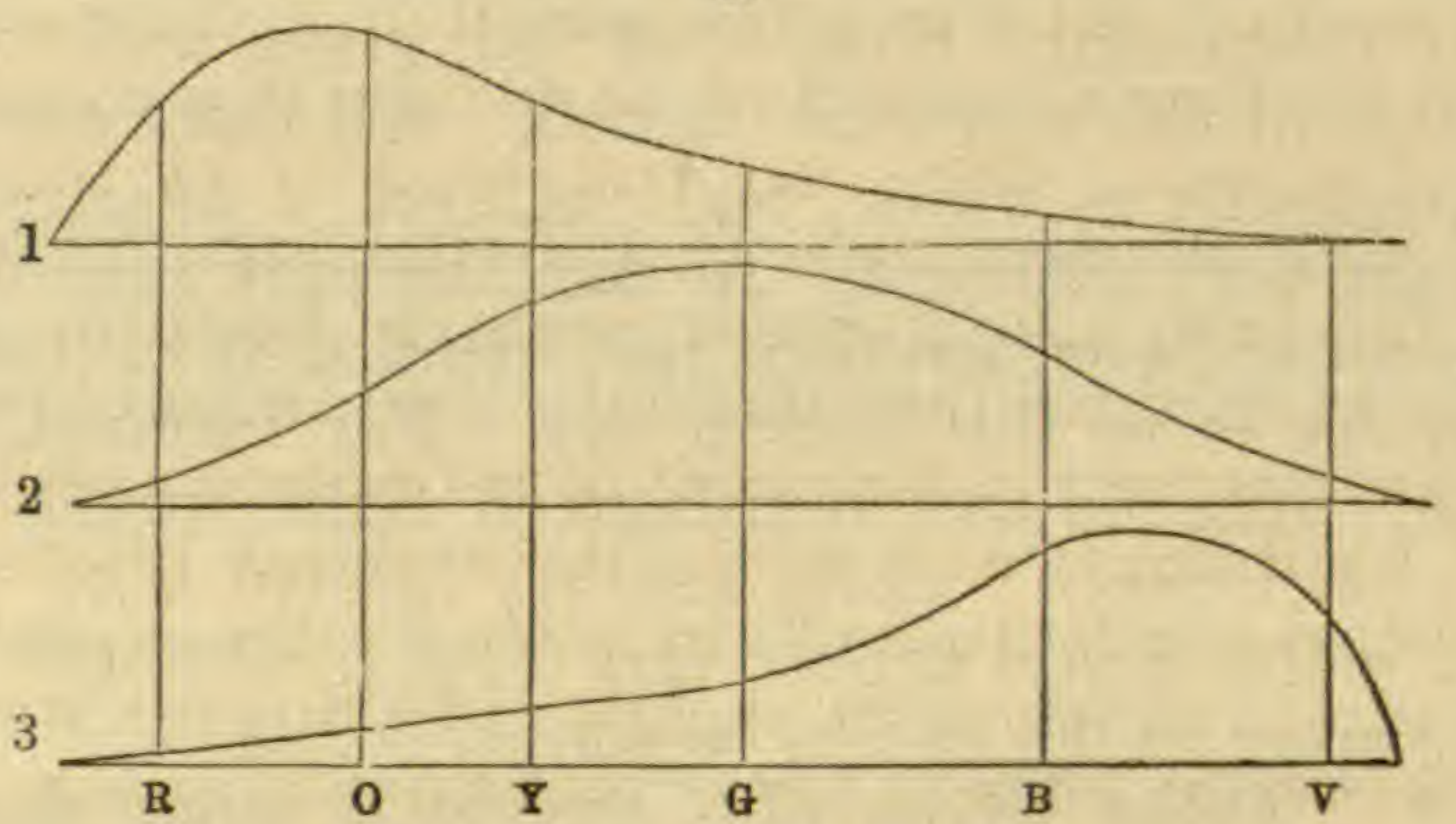
* These two terms, *hypothesis* and *theory*, are so generally misunderstood and thoughtlessly used that it may be well here to give two concise definitions; the first is by Flourens; the second is by Prof. J. Henry.

"An *hypothesis* is the explanation of facts by *possible causes*; a *theory* is the explanation of facts by *real causes*."

"A supposition or guess thus made from analogy as to the nature of the law of a class of facts, is usually called an *hypothesis* and sometimes the *antecedent probability*. When an hypothesis of this kind has been extended and verified, or, in other words, when it has become an exact expression of the law of a class of facts, it is then called a *theory*."

"Pure *red* excites strongly the fibers sensitive to red, and feebly the two other kinds of fibers ; sensation, red.

1.



"Pure *yellow* excites moderately the fibers sensitive to red and to green, feebly those fibers sensitive to violet; sensation, yellow.

"Pure *green* excites strongly the fibers sensitive to green, feebly those sensitive to red and to violet; sensation, green.

"Pure *blue* excites in a moderate degree those fibers sensitive to green and to violet, feebly those sensitive to red ; sensation, blue.

"Pure *violet* excites strongly those fibers specially destined to receive this sensation, and the other fibers are feebly affected by this light ; sensation, violet.

"The nearly equal excitation of all of the fibers will give the sensation of white, or of whitish colors."

* * * * "The choice of the three fundamental colors is to some extent arbitrary. We can choose at will any three colors whose mixture produces white. *Young no doubt was guided by the consideration that the extreme colors of the spectrum occupied the privileged positions.** If we do not choose these colors, we must take for one of the colors a purple tint, and the curve which responds to it in the figure will have two maxima: one in the red, the other in the violet. The hypothesis, without being an impossible one, will be more complicated. As far as I know of, there exists no means of determining directly the fundamental colors but the examination of persons affected with color blindness. We will subsequently see how far that examination confirms the hypothesis of Young, at least so far as the red is concerned."

* * * "In general, then, light which consists of undulations of different wave-lengths produces different impressions upon our eye, namely, those of different colors. But the number of hues which we can recognize is much smaller than that of the various possible combinations of rays with different wave-lengths which external objects can convey to our eyes. The

* The writer has italicized the above for the purpose of a future reference to it.

retina cannot distinguish between the white which is produced by the union of scarlet and bluish-green light, and that which is composed of yellowish-green and violet, or of yellow and ultramarine blue, or of red, green and violet, or of all the colors of the spectrum united. All these combinations *appear* identically as white; and yet from *a physical point of view* they are very different. In fact, the only resemblance between the several combinations just mentioned is, that they are indistinguishable to the human eye. For instance, a surface illuminated with red and bluish-green light would come out black in a photograph; while another lighted with yellowish-green and violet would appear very bright, although both surfaces alike seem to the eye to be simply white.

* * * "Other colors, also, especially when they are not strongly pronounced, may, like pure white light, be composed of very different mixtures, and yet appear indistinguishable to the eye, while in every other property, physical or chemical, they are entirely distinct.

* * * "The theory of colors, with all these marvelous and complicated relations, was a riddle which Goethe in vain attempted to solve; nor were we physicists and physiologists more successful. I include myself in the number; for I long toiled at the task, without getting any nearer my object, until I at last discovered that a wonderfully simple solution had been discovered at the beginning of this century, and had been in print ever since for any one to read who chose. This solution was found and published by the same Thomas Young who first showed the right method of arriving at the interpretation of Egyptian hieroglyphics. He was one of the most acute men who ever lived, but had the misfortune to be too far in advance of his contemporaries. They looked on him with astonishment, but could not follow his bold speculations, and thus a mass of his most important thoughts remained buried and forgotten in 'The Transactions of the Royal Society,' until a later generation by slow degrees arrived at the rediscovery of his discoveries, and came to appreciate the force of his argument and the accuracy of his conclusions."

The first publication by Young of his theory of color appeared in a Bakerian Lecture entitled, "On the Theory of Light and Colors," which Young read before the Royal Society on Nov. 12, 1801. In the opening part of this lecture he says: "A more extensive examination of Newton's various writings has shown me that he was, in reality, the first who suggested such a theory [*the undulatory theory of light*], as I shall endeavor to maintain; that his own opinions varied less from this theory than is now almost universally supposed; and that a variety of arguments have been advanced, as if to confute him, which may be found in a similar form in his own works; and this by no less a mathematician than Leonard Euler, whose system of light, as far as it is worthy of notice, either was, or might have been, wholly borrowed from Newton, Hooke, Huyghens and Malebranche.

"Those who are attached, as they may be with the greatest justice, to every doctrine which is stamped with the Newtonian approbation, will probably be disposed to bestow on these considerations so much the more of their attention as they shall appear to coincide more nearly with Newton's opinion. For this reason, after having briefly stated each particular position of my theory, I shall collect, from Newton's various writings, such passages as seem to be the most favorable to its admission; and although I shall quote some papers which may be thought to have been partly retracted at the publication of the optics, yet I shall borrow nothing from them that can be supposed to militate against his maturer judgment."

The fact that Young, the *founder* of the undulatory theory of light, in this Bakerian Lecture, in which it has been said that he laid the foundations of that doctrine, should set forth his views in a series of postulates followed by citations from the writings of Newton, to give them weight and proof, may justly surprise those who have trusted to the second-hand information derived from carelessly-complied text books and from hastily-prepared popular lectures. But then, where would be the pugilistic charm of the popular lecturer on the undulatory theory of light, if Newton, his champion, the violent defender of the emanation cause, should decline to enter as a contestant?

Under the heading of Hypothesis III, of this paper, we first meet Young's theory of color-sensation.

"Hypothesis III. *The Sensation of different Colours depends on the different frequency of Vibrations, excited by Light in the Retina.*

Passages from Newton.

"The objector's hypothesis, as to the fundamental part of it, is not against me. That fundamental supposition is, that the parts of bodies, when briskly agitated, do excite vibrations in the ether, which are propagated every way from those bodies in straight lines, and cause a sensation of light, by beating and dashing against the bottom of the eye, something after the manner that vibrations in the air cause a sensation of sound, by beating against the organs of hearing. Now, the most free and natural application of this hypothesis to the solution of phenomena I take to be this: that the agitated parts of bodies, according to their several sizes, figures and motions, do excite vibrations in the ether of various depths or bignesses, which being promiscuously propagated through that medium to our eyes, effect in us a sensation of light of a white color; but if by any means those of unequal bigness be separated from one another, the largest beget a sensation of a red color, the least or shortest of a deep violet, and the intermediate ones of intermediate colors; much after the manner that bodies, according to their several sizes, shapes, and motions, excite vibrations in the air, of various bignesses, which, according to those bignesses, make several tones in a sound; that the largest vibrations are best able to overcome the resistance of a refracting superficies, and so break through it with least refraction; whence the vibrations of several bignesses, that is, the rays of several colors, which are blended together in light, must be parted from one another by refraction, and so cause the phenomena of prisms and other refracting substances; and that it depends upon the thickness of a thin transparent plate or bubble whether a vibration shall be reflected at its further superficies, or transmitted; so that, according to the number of vibrations interceding the two superficies, they may be reflected or transmitted for many thicknesses. And, since the vibrations which make blue and violet are supposed shorter than those which make red and yellow, they must be reflected at a less thickness of the plate: which is sufficient to explicate all the ordinary phenomena of those plates or bubbles, and also of all natural bodies whose parts are like so many fragments of such plates. These seem to be most plain, genuine, and necessary conditions of this hypothesis. And they agree so justly with my theory, that if the animadversor think fit to apply them, he need not, on that account, apprehend a divorce from it. But yet, how he will defend it from other difficulties, I know not." (Phil. Trans., vii, 5088; Abr. I, 145, Nov., 1672.)

"To explain colors, I suppose, that as bodies of various sizes, densities, or sensations, do, by percussion or other action, excite sounds of various tones, and consequently vibrations on the air of different bigness; so the rays of light, by impinging on the stiff refracting superficies, excite vibrations in the ether—of various bigness; the biggest, strongest, or most potent rays, the largest vibrations; and others shorter, according to their bigness, strength, or power; and therefore the ends of the capillamenta of the optic nerve, which pave or face the retina, being such refracting superficies, when the rays impinge upon them, they must there excite these vibrations, which vibrations (like those of sound in a trunk or trumpet) will run along the aqueous pores or crystalline pith of the capillamenta, through the optic nerve into the sensorium; and there, I suppose, affect the sense with various colors, according to their bigness and mixture; the biggest with the strongest colors, reds and yellows; the least with the weakest, blues and violets; the middle with green; and a confusion of all with white, much after the manner that, in the sense of hearing, nature makes use of aerial vibrations of several bignesses, to generate sounds of divers tones; for the analogy of nature is to be observed." (Birch, iii, 262, Dec., 1675.)

"Considering the lastingness of the motions excited in the bottom of the eye by light, are they not of a vibrating nature? Do not the most refrangible rays excite the shortest vibrations, —the least refrangible the largest? May not the harmony and discord of colors arise from the proportions of the vibrations propagated through the fibers of the optic nerve into the brain, as the harmony and discord of sound arise from the proportions of the vibrations of the air?" (Optics, Qu. 16, 13, 14.

After these quotations from Newton, Young brings out his hypothesis of color-sensations, under the following:

"*Scholium.* Since, for the reason here assigned by Newton, it is probable that the motion of the retina is rather of a vibratory than of an undulatory nature, the frequency of the vibrations must be dependent on the constitution of this substance. Now, as it is almost impossible to conceive each sensitive point of the retina to contain an infinite number of particles, each capable of vibrating in perfect unison with every possible undulation, it becomes necessary to suppose the number limited; for instance, *to the three principal colors*, *red*, *yellow and blue*, of which the undulations are related in magnitude nearly as the numbers 8, 7 and 6; and that each of the particles is capable of being put in motion, less or more forcibly, by undulations differing less or more from a perfect unison; for instance, the undulations of green light, being nearly in the ratio of 6½, will affect equally the particles in unison with yellow and blue, and produce the same effect as a light composed of those two species; and each sensative filament of the nerve may consist of three portions, one for each principal color."

An attentive perusal of the above quotation will show that Young's hypothesis imagines each sensitive point of the retina to contain *particles* capable of vibrating in perfect unison to those vibrations causing three principal colors (red, yellow and blue, in this the first publication of his *hypothesis*), "and that each of the particles is capable of being put in motion, less or more forcibly, by undulations differing less or more from a perfect unison." This would suppose such a triple *molecular* constitution of each nerve fibril as to cause the three species of its constituent molecules (or the atoms forming the molecules) to be *in tune* with the three rates of vibration corresponding respectively to the undulations of the ether causing red, yellow and blue. He afterward says: "and each sensitive filament of the nerve may consist of three portions, one for each principal color." We have here a conception of the *mode of action* of an ætherial vibration on the retinal nerve fibrils which has not been described by those who have given accounts of Young's theory of color-sensation. Before reading the celebrated Bakerian Lecture, the only knowledge I had directly obtained of Young's theory was from the reading of the account of it as published in vol. i, page 439, of his "Lectures on Natural Philosophy and the Mechanical Arts," London, 1807. This account, however, contains no mention of the physiological part of his theory, and last October I published in the American Journal of Science my paper No 6 of Researches in Acoustics, in which I expressed similar views to those just quoted from Young, as follows:

"For, has modern histology given us any facts concerning the structure of the human retina which point to the establishment of Young's hypothesis of three distinct sets of retinal nerve terminations? The more we study the minute structure of the retinal rods and cones, the farther appears to remove an understanding of the mode of operation of the sensory apparatus of the eye. May not research in this direction be guided by the hypothesis that the *molecular* constitution of the retinal rods and cones is such that their molecules are severally tuned to the vibrations corresponding to the colors red, green and violet? This would lead us to look for effects of actinism on the retina as showing the link existing between the transmitting and sensory functions of the eye. Do not the facts of the known persistence of chemical action, after it has been once initiated, and the time which would be required for the retinal molecules to recombine, or rearrange themselves, after the ætherial vibrations had ceased, comport with the known durations of the residual visual sensations, and with the main facts of physiological optics, better than the hypothesis that masses of the retinal elements are set in vibration, rather than their molecules?"

It requires no argument, it is evident, that the statements made by Young in the foregoing paper, concerning his color hypothesis, were entirely hypothetical, not having been based on any observation or experiment either of his own or of others.

The next publication by Young on his theory of color takes place in the following year, and is contained in the following short paragraph, incidentally written toward the conclusion of a paper read by him before the Royal Society, on July 1, 1802, and entitled "An account of some cases of the production of colours, not hitherto described."

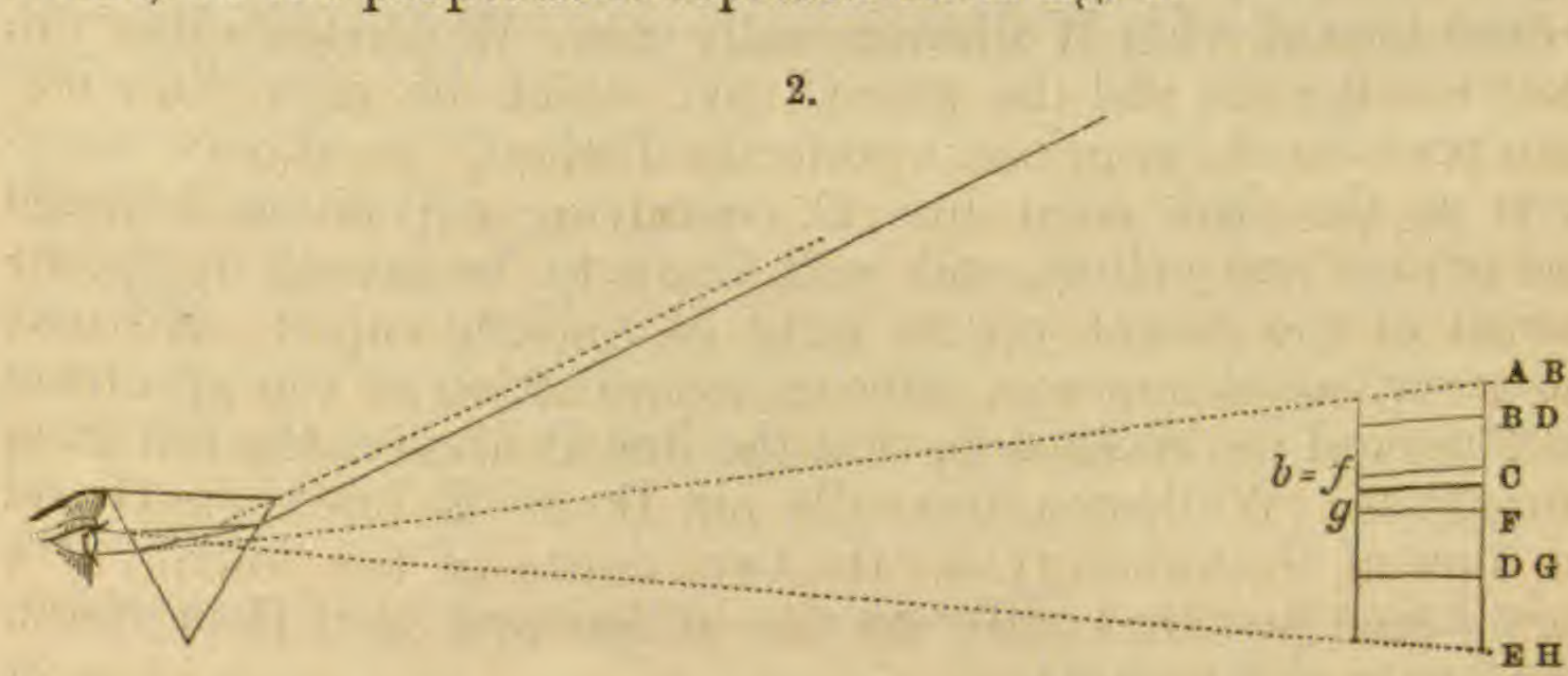
"In consequence of Dr. Wollaston's correction of the description of the prismatic spectrum, compared with these observations, it becomes necessary to modify the supposition that I advanced in the last Bakerian lecture, respecting the proportions of the sympathetic fibers of the retina; substituting red, green, and violet, for red, yellow, and blue, and the numbers 7, 6, and 5, for 8, 7, and 6."

It thus appears that Young changed his three elementary color-sensations from red, yellow, and blue, to *red*, *green*, and *violet*, "in consequence of Dr. Wollaston's correction of the description of the prismatic spectrum." In order to understand fully the ground for this modification of his hypothesis one will be obliged to read the following abstract from Dr. Wollaston's paper, published in "The Transactions of the Royal Society" for 1802; and we are pleased to detain the reader with this paper because it contains the first publication of the observation of those dark lines to which modern spectroscopic research has given such important and prominent significance.

"I cannot conclude these observations on dispersion without remarking that the colours into which a beam of white light is separable by refraction, appear to me to be neither 7, as they usually are seen in the rainbow, nor reducible by any means (that I can find) to 3, as some persons have conceived; but that, by employing a very narrow pencil of light, four primary divisions of the prismatic spectrum may be seen, with a degree of distinctness that, I believe, has not been described nor observed before.

"If a beam of daylight be admitted into a dark room by a crevice $\frac{1}{20}$ of an inch broad, and received by the eye at the distance of 10 to 12 feet through a prism of flint glass, *free from veins*, held near the eye, the beam is seen to be separated into the four following colours only, red, yellowish green, blue and violet; in the proportions represented in fig. 2.

2.



"The line A that bounds the red side of the spectrum is somewhat confused, which seems in part owing to want of power in the eye to converge red light. The line B, between red nd green, in a certain position of the prism, is perfectly distinct; so also are D and E, the two limits of violet. But C, the limit of green and blue, is not so clearly marked as the rest; and there are also, on each side of this limit, other distinct dark lines, *f* and *g*, either of which, in an imperfect experiment, might be mistaken for the boundary of these colours.

"The position of the prism in which the colours are most clearly divided is when the incident light makes about equal angles with two of its sides. I then found that the spaces A B, B C, C D, D E, occupied by them, were nearly as the numbers 16, 23, 36, 25."

In the light of the subsequent careful examinations of the spectrum made in 1814–15 by the celebrated optician Fraunhofer of Munich, we can ascertain what Wollaston really saw. Wollaston, in short, only observed *imperfectly* the dark lines of the spectrum, now known as Fraunhofer's lines, but he *imagined* he saw a spectrum so pure, that is, formed by such a degree of dispersion, that it became divided into four distinct and separated "primary divisions." He at once inferred, and erroneously, that Newton's analysis of the sun's light was false; that no *orange* or *yellow* exists in the spectrum, but between the red and the blue there exists only a "yellowish green." Further on we shall see how Young made a similar but even greater error in his description of this observation. I imagine that when Wollaston's sharp eye caught the glimpse of the divided spectrum, he naturally thought he saw in those divisions uniform colors. It was a natural mistake, and only too readily made, by reason of his mind imagining that the dark lines were *the dividing lines* of the pure simple colors of the solar spectrum.

In the figure illustrating Wollaston's observation, I have placed alongside of his lines A, B, *f*, *g*, D, and E, the corresponding Fraunhofer letters B, D, *b*, F, G, H, thus giving the reader a clear idea of what Wollaston really saw. Wollaston's line "B, between the red and the green," and which he says "in a certain position of the prism is perfectly distinct," we at once recognize as the dark solar line D, occupying a position between the orange and yellow, and well know to be caused by the reversal of the bright yellow light of sodium vapor. No one, however, could now say, after an examination of the spectrum as observed by Wollaston, that the line D divides the red from the green. Wollaston also calls his D and E lines (the G and H lines of Fraunhofer) as "the two limits of the violet;" we now know that G is really on the indigo and that H is within the limits of the violet.

For a more satisfactory comparison of the colors of the solar spectrum as observed by Wollaston and Fraunhofer, I give below the following table. Fraunhofer's results are taken from his colored figure of the spectrum. Both spectra are from flint glass, and their lengths are supposed divided into 360 equal parts.

	Fraunhofer.	Wollaston.	
Red,	56	57·6	Red.
Orange,	27		
Yellow,	27		
Green,	46	82·8	Yellowish green.
Blue,	48	129·6	Blue.
Indigo,	47		
Violet,	109	90	Violet.
	360	360	

Fraunhofer's observations are irreproachable, and are to this day in high esteem for their accuracy. They were made by placing the prism in front of a telescope, mounted on a divided horizontal circle; and viewing a distant slit through the prism and telescope, he observed spectra as pure as those given by modern spectroscopes of low power. Fraunhofer discerns orange and yellow and green where Wollaston only sees yellowish green. Also, Wollaston did not see all of the violet, as we might suspect from his having bounded its upper limits by the line H. Fraunhofer saw 109 parts of violet, Wollaston only 90.

The above discussion, I think, has clearly shown that Wollaston made a false interpretation of his observation in supposing that he had discovered a pure spectrum naturally divided by dark lines into four simple colors, and that he also erred in the proportions which he relatively gave to them. Also, I have shown that Young, in finally selecting red, green and violet as the three elementary color-sensations, was not, as Helmholtz states, guided in their choice "by the consideration that the extreme colors of the spectrum occupied the privileged positions," but selected those colors on hearing of Wollaston's supposed complete analysis of the sun's light into red, greenish blue and violet colors, separated from each other in the spectrum by dark spaces.

We hear no more from Young about his theory of colors until 1807, when he published the first volume of his celebrated work, "A Course of Lectures on Natural Philosophy and the Mechanical Arts."* On page 439 *et seq.* of this work Young gives a concise statement of his views on the analysis of the sensations of color, and supports these views with conclusive experiments with rotating colored discs; but, strange to

* "We have heard it remarked," says Dean Peacock in his Life of Young, "that no writer, on any branch of science which the lectures treat of, can safely neglect to consult them, so rich is the mine of knowledge which they contain; and it is a well-known fact, that many important propositions and discoveries have been more or less clearly indicated in them, which have only been recognized or pointed out when other philosophers discovered them independently, or announced them as their own."

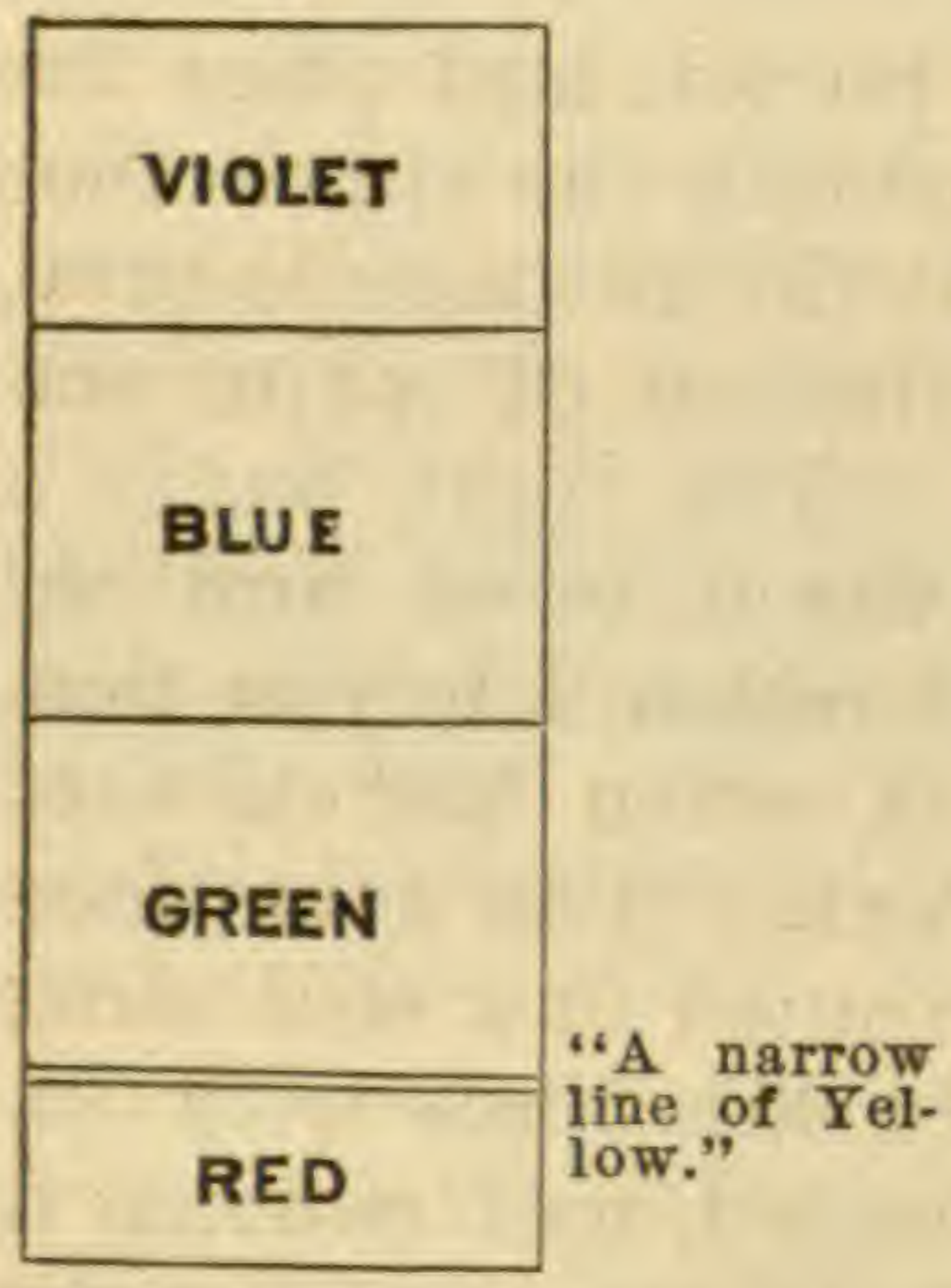
say, he omits from this account of his theory all mention of the physiological explanation of it which he gave in the Bakerian Lecture of 1801. The following extracts from the Natural Philosophy give all that it contains on the theory of colors. The italics are our own.

"It has generally been supposed, since the time of Newton, that when the rays of light are separated as completely as possible by means of refraction, they exhibit seven varieties of colour, related to each other with respect to the extent that they occupy, in ratios nearly analagous to those of the ascending scale of the minor mode in music. The observations were, however, imperfect, and the analogy was wholly imaginary. Dr. Wollaston has determined the division of the colored image or spectrum in a much more accurate manner than had been done before: by looking through a prism, at a narrow line of light, he produces a more effectual separation of the colors than can be obtained by the common method of throwing the sun's image on a wall. The spectrum formed in this manner *consists of four colors only, red, green, blue and violet*, which occupy spaces in the proportion of 16, 23, 36 and 25, respectively, making together 100 for the whole length; the red being nearly one-sixth, the green and the violet each about one-fourth, and the blue more than one-third of the length. *The colors differ scarcely at all in quality within their respective limits, but they vary in brightness;* the greatest intensity of light being in that part of the green which is nearest the red. *A narrow line of yellow is generally visible at the limit of the red and green*, but its breadth scarcely exceeds that of the aperture by which the light is admitted, and *Dr. Wollaston attributes it to the mixture of the red with the green light.* There are also several dark lines crossing the spectrum within the blue portion and in its neighborhood, in which the continuity of the light seems to be interrupted. This distribution of the spectrum Dr. Wollaston has found to be the same, whatever refracting substance may have been employed for its formation; and he attributes the difference, which has sometimes been observed in the proportions, to accidental variations of the obliquity of the rays. The angular extent of the spectrum formed by a prism of crown glass is $\frac{1}{27}$ of the deviation of the red rays; by a prism of flint glass $\frac{1}{19}$." Fig. 3.*

Fig. 3. "The spectrum produced by looking through a prism at a narrow line of light.

* These figures, 3 and 4, are copied of the exact size of those given by Young in the plates appended to his Natural Philosophy. The descriptions under the figures are those given by Young. The colors in Young's figures we have indicated in type. There are six other figures illustrating Young's account, but we have found it impossible to convey *in print* clear ideas of their tints.

3.



"In light produced by the combustion of terrestrial substances, the spectrum is still more interrupted; thus, the bluish light of the lower part of the flame of a candle is separated by refraction into five parcels of various colours; the light of burning spirits, which appears perfectly blue, is chiefly composed of green and violet rays: and the light of a candle into which salt is thrown abounds with a *pure yellow, inclining to green*, but not separable by refraction. The electric spark furnishes also a light which is differently divided in different circumstances.

"If the breadth of the aperture viewed through a prism is somewhat increased, the space occupied by each variety of light in the spectrum is augmented in the same proportion, and each portion encroaches on the neighboring colours, and is mixed with them; so that the red is succeeded by orange, yellow, and yellowish green, and the blue is mixed on the one side with the green, and on the other with the violet; and it is in this state that the prismatic spectrum is commonly exhibited.

4.

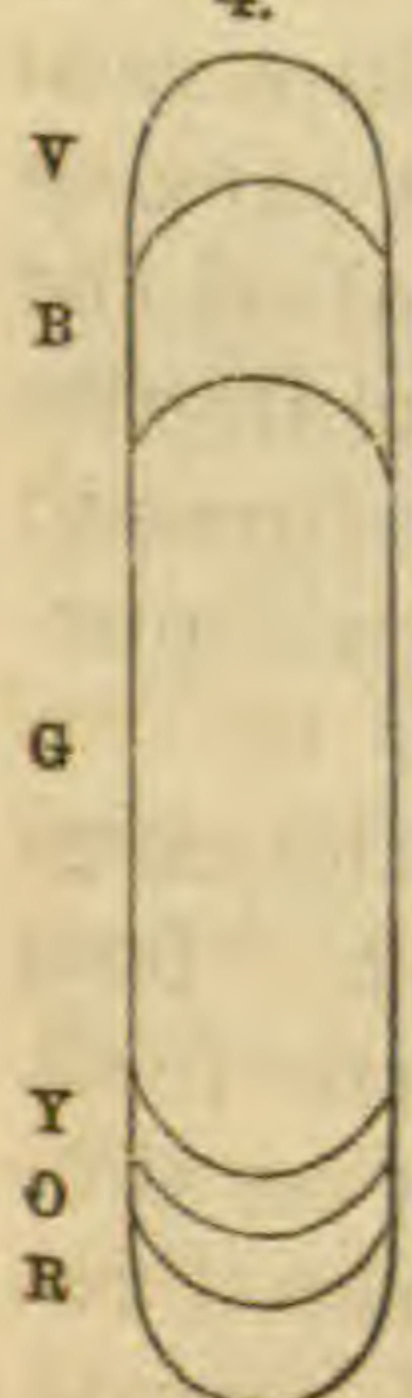


Fig. 4. "The appearance of a circular aperture, moderately large, viewed through a prism.

* * * * * * *

"Sir Isaac Newton observed that the effect of white light on the sense of sight might be imitated by a mixture of colours taken from different parts of the spectrum, notwithstanding the omission of some of the rays naturally belonging to white light. Thus, if we intercept one-half of each of the four principal portions into which the spectrum is divided, the remaining halves will still preserve, when mixed together, the appearance of whiteness; so that it is probable that the different parts of those portions of the spectrum which appear of one colour, have precisely the same effect on the eye. It is certain that the perfect sensations of yellow and of blue are produced respectively by mixtures of red and green, and of green and violet light, and there is reason to suspect that those sensations are always compounded of the separate sensations combined; at least, this supposition simplifies the theory of colours; it may, therefore, be adopted with advantage, until it be found inconsistent with any of the phenomena; and we may consider white light as composed of a mixture of red, green and violet, only, in the proportion of about two parts red, four green, and one violet, with respect to the quantity or intensity of the sensations produced.

"If we mix together, in proper proportions, any substances exhibiting these colours in their greatest purity, and place the mixture in a light sufficiently strong, we obtain the appearance of perfect whiteness; but in a fainter light the mixture is grey, or of that hue which arises from a combination of white and black; black bodies being such as reflect white light, but in a very scanty proportion. For the same reason, green and red substances mixed together usually make rather a brown than a yellow colour, and many yellow colours, when laid on very thickly, or mixed with black, become brown. The sensations of various kinds of light may also be combined in a still more satisfactory manner by painting the surface of a circle with different colours, in any way that may be desired, and causing it to revolve with such rapidity, that the whole may assume the appearance of a single tint, or a combination of tints resulting from the mixture of the colours.

"From three simple sensations, with their combinations, we obtain seven primitive distinctions of colours; but the different proportions in which they may be combined afford a variety of tints beyond all calculation. The three simple sensations being red, green and violet, the three binary combinations are yellow, consisting of red and green; crimson, of red and violet; and blue, of green and violet; and the seventh in order is white light, composed of all three united. But the blue thus produced, by combining the whole of the green and violet rays, is not the blue of the spectrum, for four parts of green and one of violet make a blue differing very little from green; while the blue of the spectrum appears to contain as much violet as green; and it is for this reason that red and blue usually make a purple, deriving its hue from the predominance of violet.

"It would be possible to exhibit at once to the eye the combinations of any three colours in all imaginable varieties. Two of them might be laid down on a revolving surface, in the form of triangles placed in opposite directions, and the third on projections perpendicular to the surface, which, while the eye remained at rest in any one point, obliquely situated, would exhibit more or less of their painted sides, as they passed through their different angular positions: and the only further alteration that could be produced in any of the tints would be derived from the different degrees of light only. The same effect may also be exhibited by mixing the colours in different proportions, by means of the pencil, beginning from three equidistant points as the centers of the respective colours."

On certain portions of the above extracts, which I have italicized, I will venture a few observations. In the first passage, thus indicated, Young says: "The *spectrum formed in this manner consists of four colours only, red, green, blue and violet.*"

Young then replaces Wollaston's "yellowish green" by "*green*," and farther on he adds, "The colours differ scarcely at all in quality within their respective limits, but they vary in brightness; the greatest intensity of light being in that part of the green which is nearest to the red," thus confirming our view that both Young and Wollaston were of the opinion that when a narrow bright crevice is observed through a prism, that the spectrum so viewed consists of only four colors, red, green, blue and violet, "differing scarcely at all in quality within their respective limits;" which limits they supposed naturally existed in the dark spaces which, as they imagined, bounded these elementary colors. Young, however, somewhat modifies this opinion in the next sentence, when he says: "A narrow line of yellow is generally visible at the limit of the red and green, but its breadth scarcely exceeds that of the aperture by which the light is admitted, and Dr. Wollaston attributes it to the mixture of the red with the green light." It would, indeed, appear from the last portion of this sentence that Young obtained directly from Wollaston one of the main facts on which his theory was founded, namely, that yellow can be reproduced by the mixture of red and yellow lights. But Wollaston, in his paper of 1802, from which we have cited, makes no such statement as to the composition of yellow light, and it is therefore probable that Wollaston communicated orally this view of the subject to Young. Every student of optics now knows that the description, already given, of Fraunhofer's observation on the color composition of the spectrum is the correct one; yet the errors of observation of Wollaston and of Young were errors which led to a great discovery, as we shall see on the further examination of the history of this beautiful and comprehensive theory of color.

Farther on in the Natural Philosophy we read that, "The sensations of various kinds of light may also be combined in a still more satisfactory manner by painting the surface of a circle with different colours, in any way that may be desired, and causing it to revolve with such rapidity, that the whole may assume the appearance of a single tint, or of a combination of tints, resulting from the mixture of the colours." These experiments were evidently first made by Young; and are fully described in the text and perfectly illustrated in the colored discs in the plates of Young's work. These experiments have been carefully repeated by Helmholtz, Maxwell and others, and of their general accuracy there is no doubt. We can readily imagine the delight with which Young must have viewed these beautiful experiments, which, however, together with other truths unfolded by him, were destined to remain unnoticed, "until a later generation, by slow degrees, arrived at the *discovery* of his discovery."

It must now recur to the reader to inquire, *when* were made these experiments which first confirmed Young's hypothesis and placed it among the best established truths of optical science; and why it was that Young should for so long a time have been satisfied with a hypothetical statement of his views on the color-sensations, and should have deferred to bring those views to the test of experiment. For reasons already stated, Young, in July, 1802, changed his three elementary color-sensations, red, yellow and blue, to red, green and violet. The experiments with the rotating colored discs were first published in 1807. Young printed the syllabus of his first course of lectures on January 19th, 1802, in a volume of 250 pages. I have not been able to procure a copy of this syllabus, but evidently it does not contain even the corrected statement of his theory of color, for that was based on Wollaston's observation, which appeared subsequently to the syllabus, on June 24th, 1802. It is therefore evident that unless Young made the experiments with the rotating colored discs during the latter part of his course of lectures, he must have made them during the interval between his retirement from the professorship at the Royal Institution and the publication of his lectures on Natural Philosophy in 1807. Young delivered his first lecture before the Royal Institution on January 20th, 1802, and was very busy with his lectures until July 4th, 1803, when he retired. I think that we may fix the date of these remarkable experiments as somewhere between 1803 and 1807, and it is highly probable that the theory was never given to the public in a lecture before the Royal Institution, but first appeared in the publication of his Lectures on Natural Philosophy.

That Young should have delayed to bring to the test of experiment a plausible hypothesis, when other men would at once have appealed to the instruments in their laboratories, is explained by the fact that Young "at no period of his life was fond of repeating experiments or even of originating new ones. He considered that, however necessary to the advancement of science, they demanded a great sacrifice of time; and that, when a fact was once established, that time was better employed in considering the purposes to which it might be applied or the principles which it might tend to elucidate." Indeed, this peculiarity receives abundant confirmation from his own words; thus, in the Bakerian Lecture, already so often referred to, he says, "Nor is it absolutely necessary in this instance (in speaking of the proofs to be adduced in support of the undulatory theory of light) to produce a single new experiment; for of experiments there is already an ample store;" and in a letter written in November, 1827, to his sister-in-law, Mrs. Earle, on the respective honors given by Herschel, in his Optics, to Young and Fresnel, he says: "And acute suggestion was then, and indeed always, more in the line of my ambition than experimental illustration." Young carried his opinion of the secondary importance of experiment so far as even to object to the increase of the fund left by Wollaston to the Royal Society to aid experimental inquiries, in these words: "For my part, it is my pride and pleasure, as far as I am able, to supersede the necessity of experiments, and more especially of expensive ones."

ART. XXVIII.—*A redetermination of the Constants of the Law connecting the Pitch of a Sound with the Duration of its Residual Sensation*; by ALFRED M. MAYER.

IN my "Researches in Acoustics, Paper No. 6," published in this Journal in October, 1874, I gave the result of many experiments on the durations of the residual sonorous sensations, and embodied those determinations in this law:

$$D = \left(\frac{53248}{N+23} + 24\right) \cdot 0001,$$

in which D = the duration of the residual sonorous sensation corresponding to N number of vibrations per second.

The precise determination of the durations of the residual sonorous sensations are difficult by reason of the complex character of the sound perceived when the vibrations of a tuning fork are sent intermittently into a resonator by means of a revolving perforated disc; and the difficulty of the determination is increased by the fatigue and deadening of the sensitiveness of the ear produced by the beats which enter it from the resonator.

The important applications that have been made of this law in the physiology of audition, and in the elucidation of the fundamental laws of musical harmony, have made me desire to have my determinations reviewed by ears more highly cultivated than mine in the appreciation of pitch and of musical intervals, and more skilled in the direct analysis of composite sounds into their simple component tones. Since my publication in October last, I have had the good fortune to have elicited in Madame Emma Seiler and in her son, Dr. Carl Seiler, a profound interest in my researches. They have spent considerable time in the redetermination of the durations of the residual sonorous sensations; making use, under my directions, of the same apparatus which I employed in my original experiments. Madame Seiler assisted Helmholtz in the experiments contained in his renowned work on physiological acoustics, and unites to educated musical perceptions a thorough knowledge and appreciation of all recent advances in physiological acoustics. I have, therefore, great confidence in the following results, which I desire my

S	N	D	L
UT_1	64	$\frac{1}{25}$ = ·0395 sec.	2·5
UT^2	118	$\frac{1}{45}$ = ·0222 "	2·8
UT_3	256	$\frac{1}{70}$ = ·0142 "	3·6
SOL_3	384	$\frac{1}{102}$ = ·0098 "	3·7
UT_4	512	$\frac{1}{130}$ = ·0076 "	3·9
MI_4	640	$\frac{1}{153}$ = ·0065 "	4·1
SOL_4	768	$\frac{1}{166}$ = ·0060 "	4·6
UT_5	1024	$\frac{1}{180}$ = ·0055 "	5·6

readers to substitute for those contained in the table given on page 244 of vol. viii of this Journal.

From the above data the law given on page 146 becomes

$$D = \frac{3{\cdot}2}{N+31} + {\cdot}0022.$$

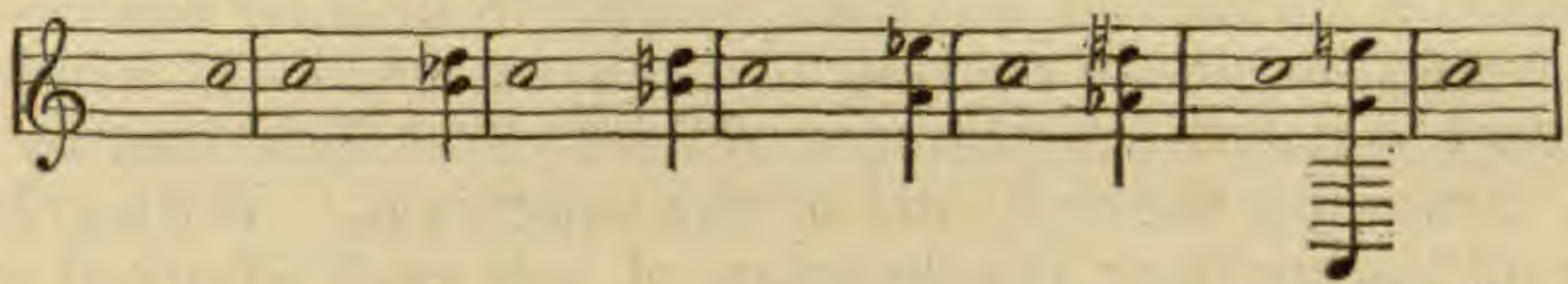
The adoption of the law with these new constants requires the following corrections to be applied to my paper:

Page 246, *dele* "The ordinate of MI_4," &c., to end of paragraph.

"	249,	line	19	from bottom,	for $\frac{1}{11}$	read	$\frac{1}{20}$.
"	"	"	17	" "	" $\frac{1}{500}$	"	$\frac{1}{438}$.
"	250,	"	1	" top,	" $\frac{1}{10}$	"	$\frac{1}{18}$.
"	"	"	3	" "	" "	"	"
"	"	"	6	" bottom,	" $\frac{1}{227}$	"	$\frac{1}{291}$.
"	"	"	5	" "	" $\frac{1}{29}$	"	$\frac{1}{53}$.
"	"	"	3	" "	" $\frac{1}{58}$	"	$\frac{1}{126}$.

The corrections under "5. *Quantitative applications of the Laws to the fundamental facts of Musical Harmony,*" can be readily applied from the law as given above. Suffice it here to say that on the table on page 252 the nearest consonant interval in the octave of C_1 is a Fourth + $\frac{2}{3}$ of a semitone; while in the octave of C_6 the nearest consonant interval of two simple sounds has contracted to only one tone.

In the opening part of this communication I spoke of the difficulty of the determination of the residual sonorous sensations by reason of the complex character of the sounds perceived when the vibrations of a tuning fork are sent intermittently into a resonator by means of a revolving perforated disc. I will now describe the character of the successive sensations experienced when, starting from rest, we gradually increase the velocity of rotation of the disc until the separate beats blend into a smooth continuous sensation. When the disc is stationary, with one of its openings opposite the mouth of the resonator, it is evident that the ear will experience a simple sonorous sensation when a tuning fork is brought near the mouth of the resonator; on revolving the perforated disc, two additional, or secondary, sounds appear; one slightly above, the other slightly below the pitch of the fork. An increased velocity of rotation causes the two secondary sounds to diverge yet farther from the note of the beating fork, until the velocity reached is so great that the two secondary sounds become separated from each other by a major sixth, while, at the same moment, a resultant sound appears, formed by the union of the sound of the fork with the upper and the lower of the secondary sounds. This resultant is the second octave below the note given by the fork. On further increasing the velocity of the disc, the two secondary sounds and the resultant disappear, and the ear has alone the sensation of the simple sound produced by the beats of the fork; which, at this stage of the experiment, blend into a smooth continuous sensation. These successive and gradual changes, as they happen with a UT_4 fork, we have indicated in steps of semi-tones in the appended musical notation. The sound of the fork is given in the semibreve; the crochets represent the secondary sounds and the resultant sound. In the fourth bar the upper note E flat proceeds to D sharp in the fifth bar. This is so because, in the natural scale, D sharp is higher in pitch than E flat.



In conclusion, I request my readers to transfer the comma from after *Dissonanz* to after *continuirliche*, in the quotation from Helmholtz at the beginning of my paper (vol. viii, p. 241).

ART. XXIX.—*On the Action of the Less Refrangible Rays of Light on Silver Iodide and Bromide;* by M. CAREY LEA, Philadelphia.

IT will be the object of the present investigation to show:

1st. That silver iodide and bromide are sensitive to all the colored rays of the spectrum.

2d. That silver iodide is to all the less refrangible rays more sensitive than silver bromide.

3d. That the theory of M. E. Becquerel as to existence of "exciting rays" and "continuing rays" is not supported by a careful examination of the phenomena in question.

The first of these positions differs from those generally accepted in extending farther to the less refrangible end of the spectrum the sensitiveness of both the compounds in question, especially of silver iodide.

The second of these positions, that in reference to the comparative sensitiveness of AgI and AgBr, differs essentially from the views hitherto accepted, according to which AgBr has been held to be by far the more sensitive to the less refrangible rays. I shall endeavor to show that the contrary is the case.

In these investigations I have confined myself to studying the effects obtained upon the silver compounds as formed in the body of pure paper, applying in all cases the silver solution after that of the alkaline haloid, and immediately washing out the excess of silver nitrate.

The colored light was separated by means of colored glasses. Without wishing to detract from the value of observations made with the prismatic spectrum, I am inclined to believe that those obtained with colored glasses, whose absorption spectra have been carefully and exactly made out with the aid of spectroscopic analysis, are at least equally reliable, and in some cases, certainly more decisive. It is also to be remarked that prismatic solar spectra, as usually obtained, are open to the suspicion of not being absolutely pure, but liable to admixture of rays coming from light falling upon the prism outside of the true image of the slit, by reason of diffraction, and also possibly from other sources. A very careful prismatic analysis of the spectrum itself would be necessary to detect the presence of faint violet light cast by any such means on the red end of the spectrum. With colored glass, on the contrary, the detection of any such admixed color may be accomplished by a simple inspection of its absorption spectrum. If it be suspected, for example, that a given piece of red glass, or any number of pieces, permit the passage of a trace of violet light, the spectroscope gives us at once a decisive answer, because we can project any such violet light that may be present against an absolutely dark field of view, and decide positively on its presence or absence. Another serious difficulty with the spectrum arises from the very long exposure which is necessary to make apparent the effect of the less refrangible rays, and which long exposure can be less advantageously managed with the solar spectrum than with colored glass.

Still another advantage in the use of colored glass is that the pieces used can be of any desired size, so that one can operate over a large space and can simultaneously expose several preparations to identical influences, and thus obtain a more accurate comparison than is possible with the successive exposures necessary with the solar spectrum. By interposing a suitable glass negative between the colored glasses and the paper, the effects of the exposure are rendered much more marked: the distinctness of the reproduction of the image of the negative serves in each case as a measure of the degree of sensitiveness. This has a particular importance when a development process is used, because even with the utmost care, there will sometimes be a discoloration arising from the action of the development bath. And if the arrangements are such that the action of light produces a flat tint only, it may easily become impossible to distinguish between the effects due to the development of an impression of light and those depending upon a spontaneous deposit from the bath ; moreover, this spontaneous deposit is most apt to occur, in the case of a very weak impression, exactly where it is most able to induce error. The employment of a negative avoids this difficulty, and if its image has a great variety of tones, the observer is able to measure very closely the relative extent to which it is reproduced on the sensitive surface.

Direct or Developed Images.—A certain amount of ambiguity has been introduced into what has been published on the subject of the sensitiveness of silver salts, by not distinguishing in all cases whether the sensitiveness spoken of relates to images which appear during the exposure, or are subsequently evoked by development. The capacity to form developable images is in all cases the true test of sensitiveness: any other criterion would lead to most erroneous conclusions. In this paper it will always be understood, except when otherwise mentioned, that the sensitiveness referred to is that which is exhibited under a development by means of gallic acid and silver nitrate, controlled by acetic acid.

The papers used were first floated on weak solutions of potassium iodide and bromide respectively, using them in equivalent proportions, so that each might take up an equal quantity of silver from the silver bath. This last was always made of the same strength, viz: 30 grains to the ounce, and a fresh solution was used for every piece, because, as silver iodide and bromide are soluble in solutions of silver nitrate, there might otherwise result a transfer and the formation of appreciable quantities of silver iodobromide, the reactions of which substance are different, and so energetic that the presence of the least trace would destroy all value in the results obtained. For the same reason the potassium salts employed must be pure. Therefore the KI and KBr, which were exclusively used, were submitted to careful examination at the outset. The results subsequently obtained as to sensitiveness of AgI were so different from what has hitherto found acceptance, that it was deemed advisable at the close to submit the KI to a second rigorous examination for bromine. This examination fully confirmed the first conclusions as to the absolute purity of the specimen used.

The papers were next blotted off in clean filtering paper (because if hung up to dry, the lower end becomes more richly charged than the upper), and after complete removal of the surface moisture were floated on the silver nitrate solution. They were next thrown into a large vessel of water, washed with running water and dried. In a few cases specially mentioned, the silver solution was allowed to dry on the paper for comparative experiment.

Red Rays.

Examination of the Glass.—The ruby glass of commerce differs very much in different specimens; some pieces, though appearing to the eye to be of a strong, pure red, nevertheless transmit a good deal of green light, and show in the spectroscope a strong green band. Other pieces are of a much purer color, but I have never met with any, even the darkest, which did not, with a critical examination, show in their absorption spectrum traces of the more refrangible rays. The band which represents the proper color extends from very near the extreme red end to a point a little beyond the double sodium line D.

When two such pieces are superposed, the trace of more refrangible light is excluded. The proper band of color is also shortened at its more refrangible end, and recedes to the other side of D. Two pieces, a dark red and a medium red, gave as their limit a wave-length λ 594. Two dark pieces, superposed, had a limit of λ 600. A large number of experiments were made with the combination last mentioned. But, as it was my desire to make these investigations, as far as possible, absolutely correct, all my results were revised, and confirmed by final trials with light filtered through *three* thicknesses of ruby glass. These showed as the limiting wave-length of their absorption spectrum, λ 605, a limit which totally excludes the yellow, and represents the red rays with at most a slight admixture of orange, as the light at and near this limit of λ 605 was extremely feeble, and the whole strength of the band found its place beyond. The measures here given were repeated a number of times on different days, with concurrent results.

Result.—With *two red plates*, having a limit of λ 594, a strong, *direct* image was obtained upon the iodide paper by an exposure of 15 minutes to bright sunshine. The bromide paper, exposed under the same glasses and negative, simultaneously, showed nothing. By a very long development, exceedingly faint traces of an image were rendered visible. The contrast between these two was very striking.

With *two stronger red plates*, having a limit of λ 600, and of course a diminished illumination, no trace of an image by development could be obtained on the silver bromide paper, after exposures of various lengths up to an hour and a half of brilliant sunshine (from 12.15 to 1.45 P. M., Jan. 30, 1875, bright sunshine on snow).

On the contrary, silver iodide gave, after 20′ exposure, a developed image showing some detail, and with 40′ exposure, a faint, *direct* image, visible without development.

With *three red plates*, having a limiting wave-length λ 605, there was necessarily a further great diminution of illumination. Nevertheless, silver iodide gave, with 30 minutes' exposure (middle of the day, bright sunshine on snow, Feb. 1, 1875), a faint, and with four hours' exposure, a full image. Feb. 2d, three hours' exposure gave an image showing considerable detail. Feb. 5th, same result. These were of course all developed images.

The corresponding bromide papers, receiving identical exposures under the same glasses, side by side with the iodide, absolutely failed to develop anything. These developments were prolonged for several hours, in order that the faintest traces, if present, might render themselves visible. But in no case did silver bromide, when exposed under the three red glasses, show the faintest trace of any image, even with a four hours' exposure. That silver bromide is not wholly destitute of sensibility to red rays, was shown by the previous experiments; but this sensibility is small, and when the red light is not only very pure, but very faint, it may be exerted for a very long time without result. Still, I believe that with a day's exposure under a strong summer sun, an impression capable of development could be produced. On the other hand, in no case, even with exposure as short as half an hour to a winter sun, did silver iodide fail to give an image, under these three ruby glasses, whose faintest light terminated at λ 605. It appears, therefore, certain that both silver iodide and silver bromide prepared on paper, with excess of silver nitrate removed, are distinctly sensitive to red light, and that silver iodide is, under these conditions, at least ten times as sensitive as silver bromide.

Yellow Rays.

It is by far more difficult to isolate yellow rays than either red or green, because almost all media that transmit yellow rays also transmit red, and many also transmit green. The yellow glass that is found in commerce lets through the whole spectrum, except the extreme violet end, and for a time I thought that the isolation of the yellow rays by colored glass would be impracticable. I finally succeeded very well by combining a deep brown glass with a dark green. The brown glass transmitted the yellow and red, absorbing the rest, and the dark green admitted principally green and yellow, cutting off the orange and red.

A spectroscopic analysis gave the following results:

Extreme limit of wave-length at less refrangible end of the spectrum, ... λ 638
At more refrangible end, ... λ 527
Point of maximum illumination, ... λ 570

The limits here given are extreme limits at which the absorption spectrum ended. It was estimated that *at least* nineteen-twentieths of the illumination was pure yellow, with perhaps a very faint admixture of orange, and of the less refrangible green rays, bordering on the yellow (any close observation of the spectrum will show how little pure yellow light it contains).

Result.—Silver iodide showed itself also more sensitive to yellow light than silver bromide, but the difference was greatly less than in the case of red light, and the results were more variable. Feb. 4, 1875, with exposure to bright sunlight from 12 M. to 3 P. M., distinct images were got by development on silver iodide, whilst with four trials of equal length on bromide paper, nothing was got. On the following day, with an exposure of about equal length, but before midday, well marked images were obtained on silver bromide. Those obtained at the same time on silver iodide, exposed side by side, developed to an equal strength in one-third the time.

I conclude, therefore, that silver iodide and bromide are both sensitive to yellow light, and the iodide more so than the bromide.

Green Rays.

Much of the green glass found in commerce admits nearly the whole spectrum except the red rays. There exists, however, a very dark shade of green, which narrows the transmitted band very much. When two such pieces of dark green were superposed, their absorption spectrum was as follows:

Extreme limit toward red end, ... λ 601
Extreme limit toward blue end, ... λ 488

This last limit corresponds very nearly with the solar line F, whose wave-length is 486, and which approximately separates the green from the less refrangible blue. For exact experiments, however, a narrower band is desirable. Accordingly, three plates were superposed. This involved such a reduction of illumination that the sun could be viewed through the glass without inconvenience. This combination gave the following measurement:

Extreme limit toward red end, ... λ 581
Extreme limit toward blue end, ... λ 497

Near these limits the light was extremely faint. To ascertain the rays of really effective strength transmitted by this combination of plates, another measurement was taken, resulting as follows:

Effective limit toward red end, ... λ 569
Effective limit toward blue end, ... λ 517

The portions of the band which lay between λ 569 and λ 581 on the one side, and λ 497 and λ 517 on the other, were so extremely faint as to have no appreciable agency in affecting the result.

It will be observed that even the limit of the faintest rays does not extend as far as the solar line F ; the blue is therefore absolutely excluded. Toward the yellow side, even the faintest rays do not extend so far as the sodium double line D and the effective rays terminated at λ 569. The yellow is therefore virtually excluded.

Result.—With two dark green glasses (λ 488–601). A powerful image was developed on silver iodide after three minutes' exposure. On silver bromide the same exposure gave faint traces of an image only. The exposure of an hour and a half failed to produce on silver bromide as strong an impression as did the three minutes on the iodide.

An exposure of forty minutes gave on silver iodide a plain, direct image. With ninety minutes, no direct image was produced on silver bromide. Other exposures and degrees of exposure gave concurrent results.

With three dark green glasses (extreme limit λ 497–581, effective λ 517–569). Silver iodide gave the following results: Two and a half minutes, faint image developed. Six minutes, distinct; fifteen minutes, strong; thirty, very full exposure; three hours and a half, completely overdone.

Silver bromide: two and a half, and six minutes, nothing; fifteen, faint trace; thirty, a little stronger; three and a half hours, moderately strong.

Comparing the above: AgBr with fifteen minutes about the same as AgI with two and a half; AgBr with thirty minutes not quite so strong as AgI with six: AgBr with three and a half hours much the same as AgI with fifteen minutes, if anything less strong. Other trials gave conformable results.

The conclusion seems, therefore, irresistible that AgI and AgBr both are sensitive to pure red, yellow and green rays; and that AgI, at least under the conditions of these experiments, show to yellow rays a slightly superior, and to green and red rays a markedly superior sensitiveness.

AgI and AgBr together.—Although the scope of this investigation was directed to the action of pure AgI and pure AgBr, a few experiments were made on the two used together. They were used in equivalent proportions and in such quantity that the paper containing the two salts together should take up exactly as much silver as the papers prepared with AgBr and AgI separately. The result demonstrated a materially greater sensitiveness to both red and green light than with either used separately. The experiment was not extended to the yellow, but it would doubtless have given similar results, as also the more refrangible rays of the spectrum.

[It may be worth mentioning, in passing, that the result of this part of the investigation led to the making of a series of experiments on the introduction of silver iodide into the "emulsion process" for preparing photographic dry plates. The result was that when either equal or equivalent quantities of AgBr and AgI were employed, nothing material was gained, but when the quantity of AgI was much reduced, and especially when AgCl was added, plates were obtained possessing a degree of sensitiveness much beyond anything heretofore attained by any collodion method, either wet or dry. A fully exposed image was obtained by an exposure under a negative to a gas flame for one second. The details necessary to the production of this result have been communicated to the Photographic Society of Philadelphia.]

Sensitivensss to White Light.—Although this investigation was directed to the action of certain colored rays, a few experiments were included upon the comparative action of white light on AgI and AgBr. There was found a moderate superiority of sensitiveness in AgI, though much less marked than in the case of the red and green rays. Exposure under a negative for three seconds to a weak diffused light sufficed to produce a strong latent image on both the AgI and AgBr papers, but most strong upon AgI.

Influence of Free Silver Nitrate.—The presence of free silver nitrate in a film of AgBr considerably increased the capacity to receive a latent image, but its agency in producing a direct image was still more marked. Thus an exposure of ninety minutes under two green glasses (limits λ 488–601) failed to produce any visible image on washed AgBr, whereas when the paper contained free silver nitrate, a plainly visible direct image was obtained in forty minutes.

As respects silver iodide, my opinions have always differed from those which have prevailed among photo-chemists. Many years ago I proved the opinion that silver iodide, absolutely isolated, was insensitive to light, to be erroneous. I covered glass plates (preferably ground glass, for better adhesion) with thin specular films of silver, and then iodized these through and through by means of a solution of iodine, and succeeded without difficulty in developing images received on such films.

The opinion also that silver iodide, in the absence of free silver nitrate, is comparatively insensitive, receives its disproof from the foregoing investigation, which decisively shows that washed films of silver iodide possess a high degree of sensitiveness to white light, and some sensitiveness to the less refrangible rays: in either case a higher degree than silver bromide.

Exciting and Continuing Rays.

More than thirty years ago, M. E. Becquerel published his well-known theory of the existence of two classes of rays, the "exciting" and the "continuing" rays. According to it, the more refrangible rays had alone the power of originating an impression; the less refrangible were powerless to commence, but capable of continuing and re-inforcing an impression which had been commenced by the more refrangible rays. This view is still maintained by M. Becquerel in his comprehensive work "La Lumière," published a few years since, and is adopted by Jamin, Ganot and others in their treatises on physics, though the acceptance has been far from universal.

The foregoing results are evidently quite incompatible with this theory, for they prove the existence in the less refrangible rays of the power to impress both silver iodide and bromide. In only one way could this testimony be set aside, namely, by the allegation that these papers might have received, in the course of their preparation, some chance effect of light sufficient to lay the foundation of an impression, and that this was afterward continued only, not originated, by the colored light to which the papers were subsequently exposed.

It would seem to be a sufficient answer, that all due care was taken to avoid this danger, and, as the experiments themselves showed, successfully. Such an uncertainty might exist with experiments made with the spectrum, but not where, as in these investigations, a negative is interposed. For, according to Mr. Becquerel, the preliminary impression of light which is necessary in order to enable the less refrangible rays subsequently to exert their continuing power on AgBr, AgI or AgCl formed on paper, is that which would enable them to receive a development by gallic acid, etc. When this impression has been received the less refrangible rays can continue this commencement, and this result may be obtained either with the spectrum, or with colored glass.*

But as in my experiments the latent images were always developed with gallic acid, it follows that, had the images evoked

* La Lumière, vol. ii p 76.

been due to a continuing power of the colored light upon an original impression caused by light accidentally admitted during the preparation, then the papers must have darkened all over by the agency of gallic acid, instead of developing an image. So that the system of experiment adopted was in itself incidentally a precaution against any such source of error.

Nevertheless, wishing to obtain a result that would be entirely decisive, paper was prepared for this special purpose under conditions of exceptional care. It was prepared at night, using light, not only most carefully guarded by colored glass, but as little of it as was possible to manipulate by. Even this faint light was carefully excluded from the preparations. The paper was covered whilst being sensitized on the silver bath and was then washed with special precaution and dried in absolute darkness. As soon as dry it was placed in the frames and under the glasses under which it was to be exposed next day. The precautions taken enable me to say that most certainly the paper received in its preparation no effect of light capable of influencing a development in any way. Its action proved to be precisely the same as that of the paper prepared in my usual way, thus demonstrating that all the rays of the spectrum possess the power of originating an impression on silver iodide and bromide.

In the foregoing pages, I have briefly given the result of one hundred and sixty experiments. The results, with such slight and altogether unimportant variations as necessarily arise from slight differences of preparation and differences in the character of the sun's light, were remarkably concordant, and may be summed up as follows:

1. AgBr and AgI are sensitive to all the visible rays of the spectrum.

2. AgI is more sensitive than AgBr to all the less refrangible rays and also to white light.

3. The sensitiveness of AgBr to the green rays was materially increased by the presence of free silver nitrate.

4. AgBr and AgI together are more sensitive to both the green and the red rays (and probably to all rays) than either AgI or AgBr separately.

5. There do not exist any rays with a special exciting or a special continuing power, but all the colored rays are capable both of commencing and continuing the impression on silver iodide and bromide.

Philadelphia, March 6, 1875.

ART. XXX.—*On the Silurian age of the Southern Appalachians;* by FRANK H. BRADLEY.

1. *Introduction.*

EMMONS, in his American Geology, refers most of the rocks along the western line of North Carolina* to his Taconic system, and says (vol. i, pt. 2, p. 24) that "the locality at the Warm Springs [Madison County, N. C.] is a good exhibition of the development of the Lower Taconic rocks in the Southern States;" but he also states (p. 25) that, in Cherokee County [near Murphy], the system is separated [divided] a few miles, by the interposition of a ridge of primary schists with staurolite.

Safford, in his Geology of Tennessee, 1869 (pp. 177–8), says, of the metamorphic rocks of the eastern border of that State: "A portion of the beds are certainly referable to the Ocoee group: the remainder, although conformable, may be older, and most likely are. * * The question of the greater age of [these] other parts is not so easily settled, and must remain open for the present. I know of no sufficient reason for referring any of these rocks to the Huronian or Laurentian series of Canada." Again (p. 193): After the Ocoee, the Chilhowee sandstones reappear and continue up the [French Broad] river to the State line. * * In North Carolina, a short distance beyond the line, the Ocoee group sets in again, and is the formation to within a mile of the Warm Springs. Then follows a Knox belt. The Springs are located on the Knox dolomyte. * * Beyond the Springs follow Chilhowee sandstones, then Ocoee rocks, and finally gneiss." The Knox group, here referred to, includes the Quebec group and the Calciferous: the Chilhowee sandstone is the typical Potsdam; and the Ocoee is the Lower Potsdam or Acadian group.

Professor Kerr has just issued a new geological map of North Carolina, which shows a strip of "Huronian" along the western line of the State, apparently covering the whole area there assigned by Emmons to the Taconic, even including the Warm Springs region. As the text of his report has not yet appeared,

* Since taking residence in Knoxville, in 1869, the writer has had his attention particularly drawn to the local features of the Lower Silurian rocks of East Tennessee and of the metamorphic strata which occupy the adjoining portions of North Carolina and Georgia. Most of the data given in this paper have been gathered incidentally, in connection with trips for the examination of mining properties; though, the clew to the Blue Ridge puzzle having thus been secured, a final trip was made solely for the purpose of completing its solution. Thus much to explain what some will regard as a trespass upon the preserves of the State geologists of North Carolina and Georgia, though neither of these officers has yet been able to make other than very hasty visits to the region in question. Without an opportunity of examining all the literature of the subject, reference can be made only to the works of Emmons, Safford and Kerr.

we cannot fairly criticize his non-adoption of the conclusions of Safford, although that geologist had followed the strata so connectedly, from their less altered and more fossiliferous regions, and was therefore least of all liable to be in error.* East of this Huronian is marked a belt of "Laurentian," the southern part of which is included in the area in question. The writer would here express an opinion, long held as a suspicion, but latterly confirmed by the results of the recent examinations of the crystalline rocks by Dana, Irving, Brooks and others, that the typical Huronian strata of the lake region, as well as large areas elsewhere so named, are simply metamorphic Silurian. It is pleasant to know, from correspondence, that some eminent geologists have reached the same conclusion.

The writer's conclusion, briefly stated, is that the rocks of that portion of North Carolina south and west of the Little Tennessee, together with the metamorphic area of Georgia, north of a line parallel with and ten miles south of the Chattahoochee (and *probably* that south of this line), and the entire metamorphic area of Alabama, are *Silurian or newer*, with the possible exception of two or three small patches not over ten miles in diameter. To the northeast of the Little Tennessee, there are large areas of rocks of the same age, but of undetermined boundaries, and including some patches which are pretty certainly Archæan. One of these latter forms and surrounds the "Bluff," on the borders of Cocke County, Tenn., and Madison County, N. C., where there are extensive outcrops of protogine and unakyte, with heavy beds of porphyritic hematite. This area—probably of the same age as the iron-bearing rocks of Missouri—adjoins the Warm Springs region before mentioned; and it may be well to say here that in Emmons' figure (l. c.) of the section there exposed, No. 15 is Chilhowee sandstone; 14 and 13 are Ocoee, separated by a fault from 12, which is Knox dolomyte, and whose cavernous structure give vent to the waters warmed by flowing through the deep fissures of the fault to the heated substrata; No. 11 is Knox shale; 10 is Chilhowee sandstone; 9 to 1 are Ocoee, probably resting upon Archæan. If this is "typical Lower Taconic," it is typical Lower Silurian as well. It is perhaps pertinent to note here that Emmons's Upper Taconic (l. c., pp. 62–68) is plainly only the slightly (or not at all) metamorphosed Silurian of the Great Valley.

* It is but justice to Professor Safford to say here that, during five years of frequent reference to his Report, in connection with field-work upon nearly all parts of the geological series exposed in East Tennessee, the writer, while recognizing many *local* deficiencies and some errors, such as are unavoidable in rapid work, has been constantly gratified and surprised at the thoroughness of the Report in all its *general* features. It has been and continues to be a great loss to Tennessee, as well as to science, that Professor Safford has not been employed to complete the detailed survey of the State.

Before giving further details of observations, it may be well to mention briefly the characters of the unaltered portion of at least the lower part of the series supposed to be represented by the metamorphic strata in question, beginning with the upper layers.

2. *Silurian of East Tennessee.*

Throughout East Tennessee the Cincinnati group is composed chiefly of shales, more or less calcareous, but includes generally two marked beds of limestone—the upper a red, compact, crinoidal marble; the lower, called by Safford the "iron-limestone," a strongly ferruginous rock, and so siliceous as to leave in many cases a tolerably solid skeleton, after its lime has all been removed by percolating waters, though in others, again, it decays entirely to a sandy clay. This lower bed is quarried, near Knoxville, as a flagging-stone, and proves very satisfactory, though its surfaces are quite irregular. Fine specimens of ripple-marks are common on these slabs; and the false-bedding of beach-sands is often well shown upon weathered edges of layers. The lowest beds of this group are generally shales. The total thickness has been estimated by Safford at about 1,850 feet.

The Trenton group is represented by heavy-bedded, red, gray and variegated marbles, of an estimated thickness of 380 feet, certain layers of which are extensively quarried and shipped for both building and monumental purposes.

The Chazy—"Maclurea beds" of Safford—consists of about 500 feet of bluish, impure limestone, generally very shaly, though at some points quite solid. The usual *Maclurea magna* is quite abundant, as are also various undescribed species of Sponges.

This is followed, below, by the Knox group, consisting of three members—a limestone, a shale and a sandstone. The limestone is mainly a very impure dolomyte, though with some purer layers, and includes also two or more thin beds of sandstone, one of which is probably the equivalent of the Saccharoidal sandstone of Missouri. The middle and lower portions are especially siliceous, being commonly crowded with cherty nodules and bands, the layers sometimes showing a thickness of five feet or more of solid chert. These are so numerous that the outcrops of this series are constantly marked by vast quantities of cherty masses, large and small, and more or less disintegrated, according to the varying percentage of included dolomyte. This included mineral is often crystallized, and its removal by weathering leaves numerous rhombohedral cavities, which Safford has noted as peculiar to chert of this horizon. Perhaps, a still more constant mark is the oölitic structure, which is often very perfect throughout large masses. This structure also frequently occurs in the lower layers of the limestone, where the upper graduates into the middle member, or Knox shale. This upper member carries a greater variety of ores than any other bed in all this region; but, as yet, it appears doubtful whether any of them are in sufficient quantity and of such purity as to be of much practical value. Pyrite, galenite and sphalerite are of frequent occurrence in small quantities; and, at a few points, there are indications of considerable bodies of lead and zinc ores, the weathered portions of the latter showing much calamine and smithsonite. Barite is also quite abundant, though often impure. Fluorite also occurs in small quantities. These mainly occur at the filling of cavern-like chambers irregularly following the "joints" of the strata; but little is yet known of their extent, and nothing as to any law of their distribution. They also occur in grains disseminated through the mass of the rock. The most abundant ore along the outcrop of this series is limonite, which occurs in immense beds, both compact and ochreous. It is plainly a surface accumulation, resulting from the decomposition of pyrite and siderite in the limestone, and varying greatly in degree of purity, according to local conditions. Some beds are so filled with larger or smaller masses of chert as to be worthless: while others are almost entirely free from such impurities. Most of this ore contains more or less manganese ore, partly in the form of wad, partly as psilomelane. The very general dissemination of iron through the limestone, as sulphide, as oxyd, or as carbonate, is evidenced by the color of the heavy beds of reddish-brown clay accompanying every outcrop, which have been formed from the impurities of the rock, as the lime and magnesia salts have been dissolved away.*

* These immense beds of debris, along the outcrops of all but the very hardest and most siliceous rocks, are the constant characteristic of all this southern region, and, with the entire absence of drifted material above the level of the old river-terraces, afford the best of evidence that no glaciers have ever existed in the region. The immense amounts of river gravel, however, which bestrew the slopes of the valleys, up to from 170 to 200 feet and more above the present stream-levels, would indicate vast accumulations of snow upon the higher parts of the mountains; and it is not improbable that traces of glacial action may yet be found about their summits. These deposits indicate that, about Knoxville, the Holston was 170 feet above its present level, and filled a valley at least four miles wide, while its discharge was by the valley of the Coosa River, directly to the Gulf of Mexico, instead of by the present valley of the Tennessee. The Clinch must then have formed the main source of the Tennessee, and possibly this may also have found a southwestern outlet after passing Chattanooga.

The deep disintegration of the rocks will also account for the *entire absence of lakes* in this region, since any body of water, if ever formed here, would find little difficulty in cutting down its outlet so as to drain its bed. The most southern body of water in the Appalachians is said to be at Mountain Lake, Giles County, West Virginia, which is not far from the region, on the Greenbrier River, where Stevens recently reported finding glacial markings. (This Journal, III, vi, 371).

The middle member of the Knox series is the Knox shale, which in the neighborhood of Knoxville is a nearly pure clay shale; but it is said to become more calcareous to the northeast, forming at some points a pretty solid limestone, not readily distinguished from the Knox dolomyte proper. The Knox sandstone is ferruginous and quite commonly very argillaceous and glauconitic. The Knox group, as a whole, represents the Quebec group and the Calciferous sandrock; and the plane of division is not readily determined. The thin bands of limestone at the top of the shale contain numerous trilobites, mostly of species as yet undescribed, which appear to be closely related to those occurring at the base of the Quebec group in Canada. The maximum thicknesses are stated by Safford as: Dolomyte, 4,000 feet; shale, 1,500 to 2,000 feet; sandstone, 800 to 1,000 feet. At some points, the two lower members are very thin or even wanting.

Next comes the Chilhowee sandstone, generally a heavy-bedded rock, occasionally white, generally ferruginous, often pyritous. This, at most of its outcrops, is metamorphosed into an extremely compact quartzyte, though commonly interlaminated with some few thin beds of sandy shale. *Scolithus* borings occur abundantly in this rock at some points; but, instead of this being the universal rule, as stated by Safford, it is the exception at outcrops thus far examined by the writer. Thickness, 2,000 feet or more. As already stated, this is considered to be the typical Potsdam sandstone.

Lowest of all the recognized Silurian, we have the Ocoee group, of the Acadian epoch, or Lower Potsdam. The beds are all more or less metamorphosed, and consist mainly of slates and conglomerates. As these are of very uniform character, and outcrop in the region of greatest disturbance and most numerous faults, it would be extremely difficult, if not impossible, to determine their actual thickness. Safford says that this *may* be 10,000 feet.

While the Chilhowee and Ocoee groups, within the Tennessee line, may especially be considered semi-metamorphic, the sandstones of the former having been well cemented without concealing or even confusing the granular structure, the shales of the latter having been squeezed into smooth slates, but showing no crystallization, and the pebbles of its conglomerates well combined with the finer paste by a sort of aqueous fusion while yet plainly showing their pebbly character; yet lesser degrees of metamorphism are plainly to be traced in many of the higher layers, far out into the Great Valley. Good examples of this are abundant in the "iron-limestone" about Knoxville, where the lines of original stratification are often much contorted, while the mass is most thoroughly compacted.

3. *From Athens to Murphy.*

As was long ago stated by Rogers, the dips, throughout large portions of the Appalachians, are mainly to the southeast, the upward displacement along the numerous lines of faults being generally on their southeastern sides. As a consequence, it is at many places difficult to recognize the successive outcrops of the different beds, until one has become somewhat familiar with their local features and forms of metamorphism. In tracing the section, however, from the railroad at Athens, Tenn., across to Murphy, N. C., and thence to Clarkesville, Ga., there appears to be less than usual of this faulting; and the equivalencies of the beds are determined with comparative ease. At Athens, the shaly, calcareous beds, with some of the heavier and more compact ones of the iron-limestone, of the Cincinnati group, form the hills, with moderate northwesterly dips. About two miles southeast, these are suddenly cut off by a fault, the Knox dolomyte abutting against them, though still showing northwesterly dips. Two miles farther on, at the crossing of Middle Creek, we pass an anticlinal, along whose back the erosion has cut slightly into the Knox shale. Knox dolomyte follows, with southeast dips, until, about two miles farther, at Jesse Dodson's, another anticlinal of the shale appears, after which regular southeast dips bring in the complete series for about four miles, the light-colored Trenton marbles appearing about nine miles out, and ten miles bringing us into a gap of a line of high red knobs formed of the iron-limestone beds. These include many thin streaks of hematite, partly in the compact "specular" form, partly oölitic, partly in a powdery or scaly condition, which has been locally mistaken for cinnabar. The hard ore can sometimes be traced, within short distances, from the "specular" condition into the unaltered oölitic "dyestone," inclosing corals and other fossils in perfect preservation, or again into a ferruginous sandstone. The ores of this belt have not yet been found in sufficiently thick beds to pay for mining, though many carloads of good ore have been gathered from the accumulations along the weathered outcrops. These iron-limestone beds recur, in several successive waves, for about four miles, one of the synclinals bending low enough to show a considerable mass of the overlying "red marble." Finally, thirteen miles out, the layers rise in sharp northwest dips, as we approach the foot of the southwestern section of the Chilhowee Mountain range. The Knox group forms the base and northwestern face of the mountain; and the heavy beds of the Chilhowee sandstone form its crest, in bold cliffs overlooking the valley to the southeast, 1,100 feet below. White Cliff Springs, of chalybeate and sulphur water, are a favorite summer resort, near the summit, and sixteen miles from Athens. Such springs are frequent along the outcrop of this sandstone, resulting from the decomposition of the pyrite therein contained.

Looking northeastward, toward the other section of this mountain, to be hereinafter described, we see no intervening ridges and no apparent outcrop of the sandstone, but only a confused cluster of low, rounded, shale hills.

Descending the southeastern face of the mountain, we find its foot composed of the Ocoee slates, semi-metamorphosed, dipping northwest. In the middle of the valley is a knob of the Ocoee conglomerate, apparently occupying the axis of the anticlinal, since southeast dips at once recur, the slates forming the ridge bounding the valley on the southeast. The second and third ridges show small synclinal patches of the Chilhowee sandstone on their crests, with slight intervening anticlinals, while the fourth is a sharp anticlinal in the slates, which brings us to the Coca Creek waters, where the outcrop of these slates, with some small quartz veins, has yielded small amounts of placer gold. At one point here, I saw a small outcrop of the Chilhowee, dipping southeastward, and apparently cut off by a fault. Indeed, slight faults are frequent in the slates which here form the mass of the Smoky Mountains along the State line. These disturbances, however, though preventing any accurate determination of the true thickness of the beds, in no way interfere with the continuity of the mass and the constancy of the general southeasterly dips. These dips continue for about five miles beyond the State line, the beds showing more and more thorough metamorphism, the slates becoming micaceous and talcoid schists, and the inclosed beds of conglomerate becoming gneisses, more or less pebbly or even porphyritic. Here, on the eastern slope of Long Ridge, just beyond Hennegar's, northwest dips set in again, and continue about nine miles, to Davidson's, in similar beds: at this latter point, an anticlinal of softer hydromica schists and gneisses, partly staurolitic, with thin quartz veins and much iron sand, appears for half a mile, and represents the copper-bearing beds of Ducktown, the ores of which are said to be exposed in the bed of the Hiwassee, perhaps three miles west of this point. The beds appear to lie conformably beneath the true Ocoee, on both sides of the anticlinal; and there seems to be no reason for referring them to a distinct group, as was done by Emmons; and here Kerr has not followed him. The series shows a much wider outcrop at Ducktown, a dozen miles southwest, where, as is well known, rich copper mines have been developed.* The ore-deposits here are irregular masses of "stock-work," though filling crevices which run

* Still more extensive deposits would doubtless have been located, had more convenient access made mining more profitable. In the present condition of affairs, the Ducktown works, though economically managed, return hardly a living profit, and await the coming of a promised railroad for lower freights and cheaper fuel.

nearly parallel with the inclosing strata, in consequence of schistose structure especially favoring splits in that direction. At many points, they *look* like *regularly interstratified beds.* Conditions have here favored most thorough metamorphism, probably by reason of a more open and porous condition of the material, allowing more abundant percolation of the heated mineral waters. The wall-rock, at some points, is of the toughest possible quartzyte; at others, a micaceous gneiss; again, a tremolyte or hornblendyte. Both the walling and "horses" of the same material are often permeated with copper, iron and zinc sulphids. The true gangue is quartz, at some points very abundant, at others scarce.

Passing on from this belt, the southeast dips bring in again the schists and gneissoid conglomerates of the Ocoee, and the gneisses and gneissoid quartzytes of the Chilhowee and the Knox sandstones. Above this latter bed, which is here, of course, undistinguishable from the Chilhowee, the Knox shale is represented by fine-grained blue mica slates speckled with mica crystals; and, within a quarter of a mile of Murphy, we find the Knox dolomyte, in white, speckled, gray, dove-colored and nearly black marbles. These materials being so much more easily eroded and dissolved than most of the quartzose rocks, have caused the formation of a long line of valleys, and are themselves generally covered. Before treating of them in detail, or passing on to more easterly outcrops, let us review the strata along another line of approach.

4. *From Knoxville to Murphy.*

At Knoxville, just north of the railroad track, a line of fault, essentially the equivalent of, and probably continuous with, that noticed just southeast of Athens, separates the upper shales of the Cincinnati group from the Knox dolomyte, both having southeast dips. The dolomyte, with its characteristic cherts and sandstones, forms the ridge upon which the main part of the city of Knoxville stands, and extends across to the south bank of the Holston, where it is regularly overlaid by the shaly limestones of the Chazy, the fine quarry-marbles of the Trenton, and the shales and iron-limestones of the Cincinnati, which latter form a line of high red knobs, with thin streaks of compact and oölitic hematite. About three miles out, a low rounded hill, between flat shale valleys, shows a synclinal of the upper "red marble." The iron-limestone, in successive waves, then occupies the surface nearly to Rockford—say for six miles—and then yields place to the Knox dolomyte, which continues to beyond Maryville. This town, sixteen miles from Knoxville, stands near the crown of a low arch, which appears to be the equivalent of the sharp anticlinal in the valley southeast of White Cliff, though here somewhat farther out from the main mountains. The northeastern section of the Chilhowee Mountain, indeed, is still nine miles beyond us. In approaching it, we pass over all the upper beds of the Lower Silurian, together with the shales and oölitic hematites of the Upper Silurian (Clinton, or Safford's "Dyestone group"), and the Black shale and soft gray calcareous shales of the Lower Subcarboniferous, and suddenly reach a fault of perhaps 10,000 feet, where the last-named beds abut against the Ocoee slates and conglomerates. The slates, at some points in this neighborhood, are quite chloritic, and so nearly black as to have been frequently mistaken for *anthracite*. Above the Ocoee, the mass of the mountain consists of the heavy beds of the Chilhowee sandstone, with high southeast dips. Montvale Springs, a favorite summer-resort, nine miles from Maryville, are near the foot of the mountain, and derive their chalybeate waters from the decaying pyrite of this formation. Several other strong chalybeate springs occur at various points along the mountain, but have not been similarly improved. Passing the summit, we find the southeastern foot-slopes faced with imperfect slates, representing the Knox shale, and the hollows beyond occupied by the Knox dolomyte, much disturbed and altered. The rough form of the country does not favor a full understanding of the disturbances without a thorough study of details; but it is at least evident that the dolomyte finally abuts against the Ocoee group, across a fault of several thousand feet, near the foot of the State line range, here called the Smoky Mountains. The Ocoee continues, with southeastern dips, for several miles up the Little Tennessee; but, at Rocky Point ferry, three miles beyond the line, let us cross the river, pass over a high spur to Cheowa River, and ascend the valley of that stream. The slates and conglomerates here pass rapidly into schists and gneisses. About fifteen miles from the ferry, we encounter the Chilhowee, in the form of a heavy-bedded, fine-grained gneiss, occupying, for a mile or so, the axis of a synclinal. It is reported that, on Snow Bird Creek, a western fork of Cheowa, a bed of limestone, which must be the Knox dolomyte, occupies a considerable area on the line, joining this outcrop with the synclinal noticed at Long Ridge on the other route. Northwestern dips of the Ocoee now continue on to the head of the river, consisting of hydromica schists and gneisses with staurolites and garnets, chlorite schists with garnets and quartz veins, and some bands of gneiss and quartzyte. As we approach the summit gap, toward Valleytown, we find an irregular anticlinal, equivalent to that at Davidson's on the other route, followed by very confused dips, as though the mountain bed suffered a tremendous squeezing in this region. These disturbed foldings continue even down to the valley-level, where sharp anticlinal folds occur in the micaceous gneiss, just before it dips beneath the Knox marble. It is not improbable that careful examination might detect small patches of the marble caught and held in some of the folds high up on the mountain-side. The point at which we have now struck this formation is about seventeen miles northeast of Murphy, along the direct line of outcrop.

If, instead of crossing at Rocky Point and ascending Cheowa, we follow up the Little Tennessee, we find heavy-bedded, gray, Chilhowee quartzytes exposed as, near Hazelnut Creek, we approach and pass the synclinal just noticed as running from Long Ridge across Cheowa. Hereabouts are also laminated micaceous sandstones and chloritic slates, with veins of milky quartz. These and similar beds continue to above the mouth of the Tuckaseege, whose dip is at first pretty regularly northwest, but soon becomes irregular, turning to southwest and even to south, as if some transverse axes of fold were developed, not far to the northeastward. As we approach and pass the mouth of Nantahala River, the same beds come down again, after we pass the axis of an anticlinal about a mile below Ashe's Mill: the dips, at first nearly east, soon become S. 20° E. Along the axis of the anticlinal, which is the equivalent of that running from Ducktown past Davidson's, there are said to be copper ores in schist along Stekoa Creek. Five or six miles above the Nantahala, near Wm. Dehart's, we are supposed to reach the range of the Valley River marble, though its outcrop has not yet been reported quite so far northeast.

(To be continued.)

Knoxville, Tenn., Jan. 25th, 1875.

ART. XXXI.—*Bentham, On the recent Progress and present State of Systematic Botany.**

HAD Mr. Bentham remained a little longer in the presidential chair of the Linnean Society, his recent elaborate paper would substantially have been the staple of the last of that series of annual addresses, most of which have been noticed and several reprinted in this Journal. The present report is too long to reprint, and very difficult to abridge. A sketch of the progress of the science as regarded by a botanist who personally conversed with an active correspondent of Linnæus (Gouan of Montpellier); who received useful hints on the method of botanical study from A. L. de Jussieu, the founder of the Natural System; who was in intimate relations with the elder DeCandolle, Brown, Lindley, and Hooker; who has studied in all the Euro-

* A Report made to the British Association for the Advancement of Science, 1874, separately issued, pp. 54, 8vo.

pean herbaria, and been in correspondence with all and in personal acquaintance with most of the notable botanists of the last forty or fifty years, and, finally, who is at the present time the most productive and the soundest of systematic botanists, cannot be otherwise than replete with interest.

We will pass over Mr. Bentham's retrospect of the first great movement of modern botany over the Linnæan thoroughfare to a knowledge of genera and species, and also of that of his and our own days, by which we have ascended a higher platform of ordinal classification along the path, once so difficult, but now made available and easy through the labors and genius of Jussieu, Brown, DeCandolle, and other but less illustrious pioneers; and we come down to "the next period in the progress of systematic botany, the seventeen years that elapsed from 1832 to 1859."

"The change from the technical to the scientific study of plants, which, during the preceding period, had been working its way through so many obstacles, was now complete. The Linnæan platform, established on the relations of genera and species, had now been so long and so universally adopted as the basis or stand-point, that the credit due to its founder was almost forgotten in the triumphant destruction of the sexual scaffolding he had erected for the ascent of the higher stages, and now completely superseded by the progress of the Jussiæan roads, although it was chiefly by the consistent following out of the principles laid down by Linnæus himself that the change had been effected. No would-be botanist was allowed any longer to eschew the labor of the methodical study of plants, or to indulge in the belief that their technical sorting constituted the science. * * * * *

"It would seem that at this advanced stage of our progress the guide-posts of the principal paths had become so firmly established, the principles upon which plants should be scientifically classed so clearly laid down, and so far carried into practice, that little remained to be done toward completing the survey of the territory—toward a general distribution of species according to their natural affinities—beyond the more accurate delineation of details and the interpolation of newly-discovered species; and that the systematic botanist could already look toward that summit upon reaching which his labors in aid of the general advance of the science might come to a close.

"But there was a rock ahead which had long been looming in the distance, and which on a nearer approach opposed a formidable obstacle. What is a species? and what is the meaning of those natural affinities according to which species are to be classed? were questions which in 1859 it was generally thought vain to discuss, or the answers to which, given to us by doctrinal teachers, unsupported by or independent of facts, it was considered as sacrilegious to doubt. We were taught, and some may still believe, that every species, such as we now see it, was an original creation, perpetuated through every generation within fixed limits which never have been and never will be transgressed. We were less authoritatively told that resemblances of different species were owing to their having been formed upon one plan variously modified. To the question why they were so modified, the ready answer was, such was the will of the Creator; and in order not to suppose that that will was influenced by mere caprice, it was suggested that the modifications were either to suit the plant to the circumstances it was placed in, or to remedy defects in the original plan, or we were simply told that the subject was beyond our powers of comprehension.*

"One consequence of this apparent impossibility of proceeding further in the investigation of the causes of affinities and of this necessity of taking species as separate creations in enormous numbers, with resemblances and differences in endless variety according to the inscrutable will of the Creator, was the encouragement it gave to arbitrary classifications and interminable disputes as to the limits of individual species. It was, indeed, generally admitted that plants should be arranged in genera, orders, &c., in groups of higher and higher grades according to the importance of the characters they had in common, and that the test of species was the persistence of its characters through two or more generations; but there were no means of estimating the importance or value of characters except by such vague standards as the number of species in which they had been observed to prevail, no means of determining what degree of variation and persistence actually distinguished the species from the variety. The botanist who affirmed that *Rubus fruticosus*, *Draba verna*, or *Sphagnum palustre* were each one very variable species, and he who maintained that they were collective names for nearly four hundred, for at

* "In my frequent intercourse during the above period with foreign botanists, I heard more than one German Professor affirm that a type-form was created for each natural order (the common clover, for instance, being that for Papilionaceæ), that Nature set to work to modify this type-form in framing species of a more complicated structure, till, tired of the exertion, she next produced new species by the simple omission of some of the complications. A French botanist of great eminence, to account for the number of plants in cultivation which are not known to exist in a wild state, observed that we could not suppose that man would have been created without a simultaneous creation of plants for him to cultivate for food, quite independent of the wild vegetation which existed before him for the food of animals. And many other still wilder theories were propounded to account for facts inconsistent with the presumed independent creation and absolute fixity of species. The best authorities went no further than defining affinity as correspondence of characters, physiological or structural, and estimating the value of characters and the importance of peculiarities or modifications of character according to their known connexion with the phenomena of life."

least two hundred, or for some twenty separately created and invariably propagated species, had each arguments in their favour to which no definite reply could be given; and systematic botany was in too many cases beginning to merit the reproach of German physiologists, that it was degenerating into an arbitrary multiplication and cataloguing of names and specimens, of use to collectors only, and serving as impediments instead of aids to the extension of our scientific knowledge of the vegetation of the globe.

"It is true that long before the period under consideration some indications by which this great obstacle to further progress might be surmounted had been vaguely given, and the theory of a common descent of modern species had been broached, or generally proposed as a solution of some of the difficulties; but not in a manner sufficiently plausible to overcome the prejudices against following up any such track, nor supported by facts and observations sufficient to awake the attention of the most anxious pursuers of the science. It was reserved for the publication of the 'Origin of Species' in 1859 to mark out a practicable path by which the higher summits might be attained. The doctrine of evolution of species, according to laws originally fixed, instead of arbitrary intervention upon each and every occasion, was in this remarkable work clearly traced out, supported by powerful arguments, and founded upon facts and observations the accuracy of which no one could doubt; and a way was thus opened up to a pinnacle, which in a wonderful degree enlarged the range of vision of those who had the courage to follow its propounder up the giddy height. It was immediately and successfully taken to by several of the most eminent of our naturalists accustomed to philosophical deductions from ascertained facts; it was blindly accepted, but misused, by some German and Italian speculators, who, in their hurry to adopt Darwinism before they well understood it, and in their eagerness to go beyond the point to which the road had been securely marked out by the author, or to diverge into by-paths which led to precipices and pitfalls, added to the alarm of the timid; whilst it was not only shunned, but denounced as fraught with the utmost danger by the great majority who were accustomed to place tradition above reasoning. We systematists hesitated at first to advance in a direction so contrary to that which we had determinately followed for so long a period; but after a careful study of the facts and arguments upon which the new course was founded, and of the guide-posts which had been set in it, we most of us have felt but little doubt of its safely leading us over difficulties, which we had so long reckoned as insurmountable, into a vast and entirely new field of observation, calculated to give a stability to the results of our labours, of which we had hitherto formed no conception. The last of the eminent observers of nature who persistently maintained the independent creation and absolute fixity of species (the late distinguished Professor Agassiz) has recently gone from among us; and it may now be given as a generally received doctrine, that all natural methods must be founded on affinities as dependent on consanguinity. Fifteen years have sufficed to establish a theory, of which the principal points, in as far as they affect systematic botany, may be shortly stated as follows:—

"That although the whole of the numerous offspring of an individual plant resemble their parent in all main points, there are slight *individual* differences between them.

"That among the few who survive for further propagation, the great majority, under ordinary circumstances, are those which most resemble their parent, and thus the *species* is continued without material variation.

"That there are, however, occasions when certain individuals with slightly diverging characters may survive and reproduce races in which these divergences are continued even with increased intensity, thus producing *Varieties*.

"That in the course of an indefinite number of generations circumstances may induce such an increase in this divergency, that some of these new races will no longer readily propagate with each other, and the varieties become *New Species*, more and more marked as the unaltered or less altered races, descendants of the common parent, have become extinct.

"That these species have in their turn become the parents of groups of species, i.e., *Genera*, *Orders*, &c., of a higher and higher grade according to the remoteness of the common parent, and more or less marked according to the extinction or preservation of unaltered primary or less altered intermediate forms.

"As there is thus no difference but in degree between a variety and a species, between a species and a genus, between a genus and order, all disputes as to the precise grade to which a group really belongs are vain. It is left in a great measure to the judgment of the systematist, with reference as much to the use to be made of his method as to the actual state of things, how far he should go in dividing and subdividing, and to which of the grades of division and subdivision he shall give the names of Orders, Suborders, Tribes, Genera, Subgenera, Sections, Species, Subspecies, Varieties, &c., with the consequent nomenclature. In the limitation of his orders, genera, species, &c., he must carefully observe those cases where the extinction of races has definitely isolated groups having a common parentage; and in other cases where the preservation of intermediate forms has left no such gaps, he is compelled to draw arbitrary lines of distinction wherever it appears to be most convenient for use. In the pre-Darwinian state of the science we were taught, and I had myself strongly urged, that species alone had a definite existence, and that genera, orders, &c., were more arbitrary, established for practical use, and founded on the combination of such characters as appeared the most constant in the greater number of species, and therefore the most important. We must now test our species, as well as genera or other groups, by such evidences as we can collect of affinity derived from consanguinity.

"In valuing these evidences, in estimating the comparative value of characters, a new difficulty has arisen, that of distinguishing the two classes of characters to which Professor Flower has appropriately given the names of *essential* and *adaptive*,—the former the result of remote hereditary descent, the latter the more recent effect of external influences. This distinction is often the more difficult, as the essential ones are often only to be found in embryos, in the early stages of organs, or are merely indicated by slight rudiments requiring close observation to detect them; whilst the adaptive ones, of comparatively small systematic importance, are often developed in external form, in ramification, spinescence, foliage, &c., and are the most striking to the eye. One consequence is, that the systematist of the present day sees more and more the necessity of preparing a double arrangement of his genera, species, and other groups—a natural one according to the best evidences of affinity for the purpose of scientific study, and an artificial clavis by which the student can be led to identify genera or species by the more readily observed characters, which may only form part, or be but chance accompaniments, of the essential ones. The greatest change, however, which the adoption of the doctrine has effected in the methodical study of plants is the having rendered it necessary, in the case of every genus or other group, to take into account and specially to estimate the value of all the characters observed—no one can be taken as so absolute as to obviate the need of considering others, no one can be passed over as theoretically worthless; and whilst this adds immensely to the labour of the systematist and to the calls on his judgment, it gives equal increase to the value of the results obtained."

The above statement, as we believe, clearly expresses the general view of the leading systematic botanists of our time, as to the derivation of species, as well as some of the grounds which have inevitably led to it. As by Mr. Bentham in England, so also here, such views were early reached, not through general theorizing nor under partizan predilection, but upon sober consideration of the facts that we knew most about, and to which years of impartial study have been given. Long-continued conscientious work in systematic botany, upon copious materials, gives excellent training; and it is pretty sure to lead most minds to the conclusion that the present forms came by way of derivation and diversification. The results of the study of the Tertiary and Cretaceous fossil botany of the northern hemisphere bring confirmation which every year makes stronger; and the riddles of geographical distribution finding easy solution thereby, the adoption of the hypothesis as the practical one seems unavoidable, if there is to be any science in botany.

[To be continued.]

ART. XXXII.—*Spectroscopic Examination of Gases from Meteoric Iron;* by ARTHUR W. WRIGHT.

THE well-known investigation of Professor Graham, upon the gases occluded by meteoric iron, showed that the Lenarto meteorite contained at least 2·85 times its volume of gaseous substances, consisting of hydrogen, carbonic oxide, and nitrogen.* The percentages of the several gases were: hydrogen, 85·68; carbonic oxide, 4·46; nitrogen, 9·86. As he had observed that it is difficult to produce an absorption by iron of more than its own volume of hydrogen under a pressure of one atmosphere, he concluded that the Lenarto iron had derived this gas from an atmosphere containing it in abundance, and at a pressure much greater than is found at the surface of the earth, such, for instance, as must exist near the surface of the sun or of the larger fixed stars.

Similar results were obtained subsequently by Professor J. W. Mallet,† in experiments upon a meteoric iron from Augusta Co., Virginia, in which he found the same gases present, in a somewhat different proportion, with the addition of a small amount of carbonic di-oxide, the percentages being: hydrogen, 35·83; carbonic oxide, 38·33; carbonic di-oxide, 9·75; nitrogen, 16·09. The percentage of hydrogen in the first portion of gas collected was greater than in the portions obtained later. The volume of the gases was 3·17 times that of the iron.

On the supposition that the meteoric iron has received its hydrogen and other gases from an extra-terrestrial source, if not from the sun, possibly from some other body having a similar atmosphere of great density, it seemed probable that the unknown gaseous elements, assumed to be present in the solar corona and chromosphere, might be detected in the gases

* Proc. Royal Soc., xv, 502. † Ibid., xx, 365.

yielded by meteorites; and this investigation was undertaken in the hope that the spectroscope would reveal them if present, though their small amount or peculiar character should render their discovery by the ordinary chemical means difficult or impossible.

The mode of obtaining the gas was similar to that pursued by Graham and Mallet, with the exception, that the iron, instead of being a single solid mass, was in the form of fine chips, prepared by boring into the meteorite with a steel drill upon a lathe, those portions which came from near the exterior being rejected, with the observance of suitable precautions to prevent the admixture of foreign matter. The fine particles of the iron were placed in a thick tube of very hard glass, which had been carefully cleaned, and were pressed into it with a glass rod. It was found possible to bring the glass tube, thus partially filled, to a red heat, without its yielding very much to the atmospheric pressure.

For the exhaustion a very efficient Sprengel pump was used, provided with a U-gauge, the limbs of which have an internal diameter of about six millimeters, and which is capable of giving accurate readings to a fraction of a millimeter. The mercury is supplied to the fall-tube by a recurved tube, the branches of which are thirty-two inches long, an arrangement which effectually prevents the entrance of air. The pump is capable of carrying the exhaustion to such a point that it becomes difficult to estimate the difference of level of the mercury surfaces in the gauge, and the electric discharge through a vacuum-tube exhausted by it becomes very feeble. That there was no leakage was shown by the fact that, after the exhaustion had been carried to the extreme, the gauge maintained its position unchanged for days.

To the exhaust-tube of the pump was attached a horizontal glass tube having two branches at right angles to its length. To one of these a vacuum-tube of the form ordinarily employed for spectroscopic work was attached, so as to have a vertical position. The other was closed by a stop-cock by which air or any gas could be admitted. The outer end of the horizontal tube was also provided with a stop-cock, and beyond this the tube containing the iron was firmly attached with cement.

It was important to know what lines would appear in the spectrum from an ordinary tube exhausted by the pump, and containing air, in order to judge correctly as to the presence or absence of any gaseous bodies coming from the iron. It is well known that the lines of hydrogen, and bands due to carbon compounds,* appear when the air in the tube is rarefied to a high degree. A number of preliminary trials showed that

* Plücker and Hittorf. On the Spectra of Ignited Gases and Vapors, Phil. Trans. Royal Soc., vol. 155, p. 1.

these lines, with very faint carbon bands, probably due to fatty matters employed in lubricating the stop-cocks, invariably appeared toward the limit of the exhaustion, while lines due to the mercury were generally visible during the later stages of the rarefaction, having greater or less brilliancy according to the temperature of the room. The red hydrogen line is frequently dimly visible when the tension has fallen to four or five millimeters, but is neither distinct nor relatively bright until the pressure is much less than that, while the other hydrogen lines appear distinct only after a much higher degree of rarefaction is attained.

The first trial was made with a piece of meteoric iron, which is a fragment of the great Texas meteorite, in the cabinet of Yale College. This meteorite, of which a description has been published,* is a large mass weighing 742 kilograms, having the following composition: Fe, 90·91; Ni, 8·46; insoluble portion containing some carbon, 0·50.† The chips produced by the borer were mostly very small particles. Much of the metal was reduced to powder, and the coarser portions were crushed in the process of boring, so as to destroy the solidity of the iron and break up its structure. A quantity of the borings representing 0·384 cubic centimeter of the solid iron were placed in the glass tube, which was then fastened in its place. The stop-cock was closed and the pump set in operation. When the gauge stood at 17 mm. the cock was momentarily opened, and was then closed. The gauge rose to about 100 mm., and when the pump had brought it down again to 17 mm. the spectroscope was applied to the vacuum-tube. The red hydrogen line was seen bright, the rest of the spectrum having the ordinary banded structure due to nitrogen and oxygen. As the exhaustion proceeded the other hydrogen lines appeared, and when the tension was reduced to 4 mm. both H_α and H_β were bright and distinct. H_γ was visible, though less prominent. The carbon bands also were distinctly seen. At 2·5 mm. pressure the stop-cock was opened, causing the gauge to rise 12·5 mm., after which it remained nearly stationary for fifteen minutes, although the pump was in action. A simple calculation shows that the first rise of 12·5 mm. is just what should have been produced by the air contained in the tube with the iron. But the fact that the gauge maintained this position for a considerable time, while the pump was continually withdrawing the air, shows that the iron gave off a portion of its gas without the application of heat, and it was repeatedly observed, in other experiments, that when the stop-cock was open, and the pump not in action, the gauge continued to rise very slowly, sometimes as much as two millimeters in an hour or two.

* Profs. B. Silliman and T. S. Hunt, this Journal, II, ii, 370. † Loc. cit.

A gentle heat was now applied to the tube containing the iron, by means of a Bunsen burner. This brought the gauge in a few minutes to about 6 mm., and produced a marked change in the appearance of the vacuum-tube, which before had the appearance of an ordinary hydrogen tube. The light in the broad portion became a straight, hazy stream of a dull greenish-white color, very similar to that given by a tube containing either of the oxides of carbon. After the tube had been exhausted to 2 mm., heat was again applied rather more strongly than before, but still below redness, carrying the gauge to 9 mm. in about ten minutes, the effect upon the spectrum being merely to increase the intensity of the carbon bands. The tube was now wrapped with copper foil, and the temperature, by means of a Bunsen flame, carried to low redness, so that the glass softened and began to yield. But a small quantity of gas was given off, the gauge at the end of ten minutes standing at 5 mm. The stop-cock being closed, the exhaustion was continued to 1·5 mm. At this point the spectrum was nearly the same as before, but was somewhat less brilliant. Certain other lines appeared in the spectrum, of which mention will be made in a later paragraph.

A second set of experiments was made with a specimen of meteoric iron from Tazewell County, Tennessee. The meteorite, of which this was a portion, weighed when found twenty-five kilograms, and has the composition, Fe, 83·02 ; Ni, 14·62 ; other substances, 1·93. No carbon was found in it.* The iron was found to be softer than the previous specimen, and was bored with comparative ease, the fragments produced being coarser than those from the Texas iron. The experiments were made in the same manner as in the previous examination, 0·634 cubic centimeter of the iron being placed in the glass tube upon the pump, and the stop-cock closed. After exhausting to one millimeter, the cock was opened for a moment to withdraw the air from the specimen-tube, and then closed. This produced a rise in the gauge of 104 mm. On again exhausting to one millimeter, and opening the stop-cock, the gauge rose 20 mm., not coming to rest immediately, but continuing to ascend slowly for some time. From calculation it appears that air at a tension of 105 mm. in the tube containing the iron would raise the mercury in the gauge about 15 mm. only, the remaining effect evidently arising from evolution of gas from the iron. This the spectroscope confirmed, as the red and green hydrogen lines were brilliant, even before the pump had further reduced the pressure, and they increased in relative intensity as the rarefaction increased. The carbon bands, if present, were not especially noticeable, as there is no record of them in the notes of the experiment.

* Prof. J. L. Smith, this Journal, II, xix, 153.

The tube containing the iron being strongly heated, gas was given off, which brought the gauge to 29 mm. in about 15 minutes. The heat was such as to redden and soften the glass. The vacuum tube, when the discharge was passed through it, appeared like an ordinary tube containing carbon compounds, and the spectrum gave the hydrogen lines very brilliantly, with the four chief carbon bands in great strength. The cock was again closed and the pump set in operation, the spectrum being observed from time to time throughout the process of exhaustion. As the tension of the gas decreased, the hydrogen lines became relatively stronger, and the carbon bands grew narrower; the one in the red beginning to be resolved into lines when the pressure was much reduced. At 1 mm., the carbon bands were still prominent, and some narrow bands belonging to nitrogen were observed.

In the first of the specimens of iron thus far examined, the proportion of carbon found by chemical analysis was very small, and in the second none at all was detected. The third series of experiments was made with an iron containing a larger amount of carbon. This was a fragment of the well-known meteorite from Arva, in Hungary, which has the following composition: Fe, 90·471; Ni, 7·321; residuum containing carbon, silica, and cobalt, 1·404.* On attempting to bore into this iron, as had been done with the others, great difficulty was experienced, as the metal has nearly the hardness of steel. After the expenditure of much labor, a sufficient quantity of the iron was obtained for the examination, representing 0·224 cubic centimeter of the solid metal. It was in a state of minute subdivision, being almost entirely reduced to fine powder. After it was placed in the tube connected with the pump, the air was exhausted from the latter as long as any change was visible in the gauge, bringing it finally very nearly to zero. The stop-cock had been closed from the first. The work having been interrupted for several days, the gauge was found, on resuming it, not to have suffered the slightest change, showing that the joints of the pump were perfectly tight. The gauge rose, on opening the stop-cock, to 98 mm. As the gases were rarefied by the pump, the hydrogen lines shone out very brilliantly when the pressure was reduced to a few millimeters, and at 2 mm., the vacuum tube had to the eye the appearance of an ordinary hydrogen tube while the electric discharge was passing through it. At this pressure, the second and third carbon bands, counting from the red end, were quite bright. The pump was stopped when the tension was reduced to 1·5 mm., but the gauge rose very slowly, gaining about a millimeter in three hours. The spectrum was as before except that

* Analysis of A. Löwe. Notice in this Journal, II, viii, 439.

the first carbon band was now visible, and the others were stronger. There could be no question as to the evolution of both hydrogen and the carbon gases, without the application of heat, by simple diminution of the atmospheric pressure.

A very gentle heat was applied to the tube for a few minutes, making it hardly warm enough to give pain when touched by the hand. This had the effect to raise the gauge to 28 mm. in fifteen minutes, and cause an entire change in the appearance of the vacuum-tube, which became greenish in the broad part, like those in the former experiments. The spectrum, when the pressure was reduced to a few millimeters, showed the carbon bands quite bright, and as the pressure decreased the first one became clearly resolved into five fine lines nearly equidistant, upon a faintly luminous background.

A somewhat stronger heat was now brought to bear upon the tube, but far less than would have been necessary to bring it to redness, as it was desired to avoid the possibility of error from the oxidation of the carbon by traces of oxygen left in the tube. The gauge rose to 50 mm., sinking to 47 mm. as the tube regained its ordinary temperature, doubtless from the contraction of the gas on cooling; for, on subsequently exhausting, it was found that the gauge continued to rise, though with extreme slowness. The spectrum did not differ essentially from that before observed, except in the greater intensity of the carbon bands. A few cubic centimeters of the gas, collected during the second heating, when tested qualitatively, gave evidence of the presence of hydrogen, carbonic oxide, and carbonic di-oxide. The proportion of the latter did not appear to be more than three or four per cent, that of the carbonic oxide being probably greater. The gas burned with a flame like that of hydrogen. The tube was subsequently heated to redness, and kept at that temperature until the gauge became very nearly stationary, the change in it being so slow as to be scarcely perceptible. Enough gas was given off to raise the mercury to 33 mm., after which the heat was discontinued.

For the sake of comparison, a trial was made with borings from a ball of soft iron. The ball had a diameter of three centimeters, and was solid. The exterior was covered with rust. The examination was made in the same manner as in the previous cases, excepting that the stop-cock remained open during the process of exhaustion. When the tension was reduced to 9 mm. the red and green hydrogen lines were brilliant, and the carbon bands appeared, with feeble intensity, as the rarefaction increased. On heating the tube strongly, though not to redness, gas was given off in abundance, raising the mercury in the gauge to 28 mm. in a few minutes, and causing the vacuum tube to assume the appearance of an ordinary CO or CO_2 tube.

The spectrum also showed a great increase in the intensity of the carbon bands. It was in every way similar to that observed in the case of the meteoric irons, except that the relative intensities of the parts due to hydrogen and the oxides of carbon were different, indicating a much smaller proportion of the former. The hydrogen lines neither appeared so early, nor were they so bright as in the former experiments.

Although foreign to the main purpose of the investigation, it seemed of interest to determine the amount of the gaseous products yielded by the three specimens of meteoric iron. By measurement it was found that, when the tubes containing the iron borings were attached to the pump, the gauge was lowered 10·4 millimeters for every cubic centimeter of gas carried out by the mercury. It was thus easy to find the amount of gas given off by simply observing the reading of the gauge. From calculations made in this way it was ascertained that the Texas iron gave off 4·75 times its volume of the mixed gases, and the Tennessee iron 4 69 volumes. Although it was evident that the greater portion of the gas had been driven off by a comparatively moderate elevation of temperature, the whole amount was by no means exhausted, as the heat was withdrawn before the evolution of gas had entirely ceased. These volumes, it will be observed, are considerably larger than those obtained by Graham and Mallet from the specimens examined by them. This is probably due to the minute subdivision of the iron, which would favor a more rapid and complete evolution of the gas. It was found, in their experiments, where the iron was in a single solid mass, that gas was still given off after the high temperature had been continued for several hours.

In the case of the iron from the Arva meteorite, which was in the state of fine powder, the yield was very much greater, a little more than thirty volumes of gas being given off in the experiments already described, in which the highest temperature was far below a red heat. On subsequently heating the tube and its contents to low redness fourteen volumes more came off, making the whole amount somewhat more than forty-four volumes, not reckoning the additional quantity gained in a subsequent experiment. It seemed not impossible that a portion of this large amount of gas might be atmospheric air condensed upon the fine particles of iron, but it was difficult to determine this point with certainty. After the last heating just mentioned, the iron was removed from the tube, exposed to the air for several hours, and then replaced. On re-heating it very strongly a considerable amount of gas was evolved, but the spectroscope, when applied to the vacuum-tube, showed the presence of hydrogen and the carbon compounds as before, making it probable that the increase due to condensed air was not large. The recent experiments of M. Cailletet* show that ordinary iron, under certain conditions, as when electrolytically deposited, may absorb nearly two hundred and fifty times its volume of hydrogen.

The descriptions of the spectra thus far given have reference to those lines and bands which were caused by the presence of hydrogen and the oxides of carbon. The vacuum-tubes exhibited differences depending chiefly upon the relative proportions of these gases present, and which have already been sufficiently noted. In the spectra from all the tubes there appeared a number of other lines, which were found to belong, for the most part, to oxygen. The tube containing gases from the Tennessee meteorite gave also several lines due to nitrogen. The latter were somewhat different, as to the order of their relative intensities, from those observed with nitrogen alone. None of them were very bright, and it was a matter of some difficulty to fix their positions with entire accuracy by measurement. The observations were made with a spectroscope of six prisms, with a repeating prism, giving the dispersion of twelve in all. One of the lines appeared to coincide with the chief coronal line 1474 K., but it is not so sharp as the latter appears in the solar spectrum. A narrow and rather faint band appears at this point also in the spectrum of the electric spark between platinum points in air. Of the oxygen lines, one falls some distance below 1474, having the position 1462 K., very nearly. This, though not brilliant, is the strongest line in that region of the oxygen spectrum as obtained from a vacuum-tube. It falls very near the position assigned to a bright coronal line by the Italian observers, Denza and Lorenzoni, of the eclipse of Dec. 22, 1870.† The former gives 1463 K. as the approximate position, while the latter assigns the same number, with the remark that the probable error of the reading is four divisions of Kirchhoff's scale. A second line of oxygen, less bright, but sharp and distinct, has the position 1359 ± 1 K. A coronal line, which also appears in the auroral spectrum, has, from Prof. Young's observation, the position 1350 ± 20 K., but the limits thus stated are too wide to give the supposition of a coincidence between it and the oxygen line anything more than a doubtful probability.

These lines of oxygen and nitrogen in the spectra observed are somewhat variable in their character, doubtless owing to the presence of the hydrogen, for the same appearances can be reproduced substantially by employing a mixture of these gases. Several experiments were made with a tube containing at first only air. When this was exhausted the bands arising from

* L' Institut, Nouv. Sér., Ann. 3, p. 44.

† Rapporti sulle Osservazioni dell' Ecclisse totale di Sole, dell 22 Dicembre, 1870. pp. 62, 106.

the compounds of nitrogen and oxygen appeared as usual, but on admitting a little hydrogen the spectrum was completely changed, and lines appeared, belonging to oxygen and nitrogen, the one or the other, or both, according to the amount of the gases present, and varying with the temperature and pressure. Lockyer and Frankland, in their experiments upon mixtures of hydrogen and nitrogen,* found that the result was not a mere superposition of the spectra of the two gases, but that the presence or absence of lines, and their relative intensities, depended upon the proportions of the two gases, as also upon the degree of rarefaction, and the energy of the electric discharge.

It will be seen, then, that the investigation, so far as the presence of new substances in the gases of meteoric iron is concerned, gives only a negative result. But the fact, incidentally observed, of the varying character of the oxygen and nitrogen lines in the presence of hydrogen, and the near coincidence of two of them with prominent coronal lines, with the possible coincidence of a third line, goes to show that the characteristic lines in the spectrum of the corona, so far from indicating the presence of otherwise unknown elements, are due simply to hydrogen and the gases of the air, namely, oxygen and nitrogen.

Yale College, March 18, 1875.

Art. XXXIII.—*The Discovery of the duplicity of the principal Star of* Σ 1097; by S. W. Burnham.

The naked-eye star, B A. C. 2470, is given in *Mensuræ Micrometricæ* as a wide pair, the secondary being of Struve's 8·7 magnitude. The following measures have been made:—

Struve	(1832·1)	D = 20″·20	P = 312°·1
Smyth	(1834·1)	20·00	315·0
Radcliffe	(1863·1)	20·52	311·2

Sir John Herschel subsequently noted another companion of the 12th magnitude at an estimated distance of 25″. A short time since I examined this with my 6-inch Clark refractor to get the position angle of the third star, which Herschel has not given, and perceived at once that the bright star of the group was itself a close double. The components are separated only about 0″·7, and considerably unequal, being 6 and 7½ magnitudes. No suitable opportunity has since occurred to measure the angle, but the close pair and the distant companion appeared to be almost exactly in the same line. Taking the latest measures of Struve's pair, with the estimated distances and angles

* Solar Physics, p. 530.

of the new and distant companions, the system would stand as follows:—

A and B	D = 0″·7 ±	P = 160°· ±
AB and C	20·52	311·2
AB and D	30· ±	160· ±

The star, D, is very nearly one and a half times the distance of C. With a power of 400, my instrument just separates the close pair.

Chicago, March 13th.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

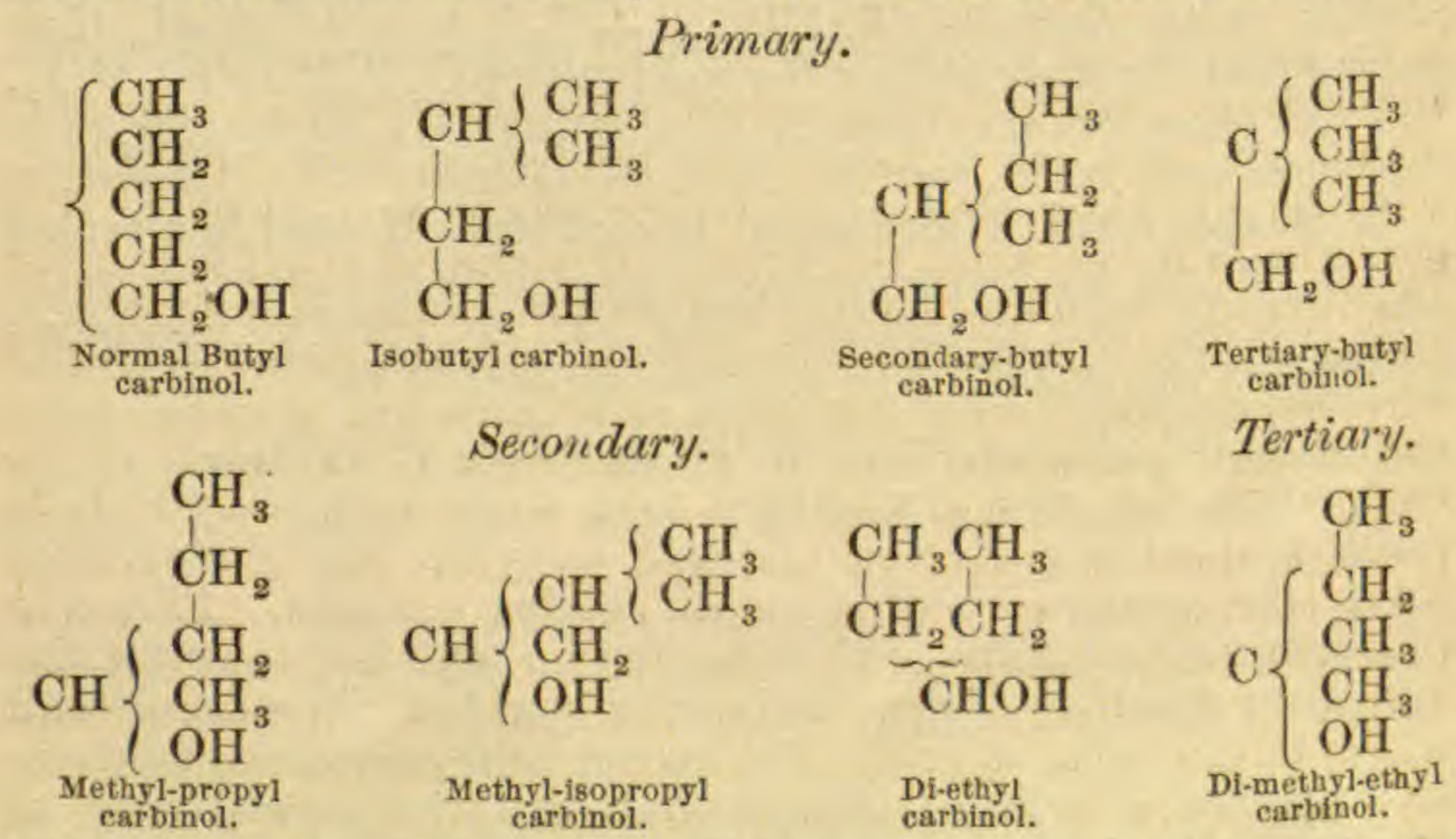
1. *On Ethyl Phosphite and the Constitution of Phosphorous Acid.*—Under the direction of Professor Wislicenus, Zimmermann has made some experiments upon ethyl phosphite, with a view to unravel the constitution of phosphorous acid. The ether was prepared by a modification of Railton's method, i. e., by acting upon sodium ethylate with phosphorous chloride, special precautions being taken to ensure the dryness and purity of the materials. The yield was from 65 to 70 per cent. The properties of the ethyl phosphite agreed with those described by Railton; it was a disagreeably smelling liquid of 1·075 sp. gr., boiling in the air at 191°, soluble in water, alcohol, and ether, and slowly decomposing in contact with the air. On analysis it yielded numbers corresponding to the formula $PO_3C_6H_{15}$. Upon saponification and precipitation with barium chloride, a barium phosphite corresponding to the formula $(BaHPO_3)_2+H_2O$ was obtained, thus proving that the ether had not the composition $C_2H_5PO(OC_2H_5)_2$. No ethyl phosphite was formed. Oxidation with nitric acid gave phosphoric and oxalic, but no ethyl-phosphoric acid. Oxidation in the air converted it into ethyl phosphate. Heated in a sealed tube to 250° for ten hours, hydrogen phosphide and ethylene gases were evolved, and phosphoric acid, but no triethyl phosphine remained in the liquid. The reaction appears to be

$$(P(OC_2H_3)_5)_4=(PO(OH)_3)_3+PH_3+(C_2H_4)_3.$$

On treating the pure crystallized acid with sodium hydrate in excess, and adding absolute alcohol, a syrup was precipitated which, after washing, showed a weak alkaline reaction. Placed in a vacuum over sulphuric acid, it showed no tendency to crystallize even after months. Upon analysis it yielded phosphorus and sodium in the ratio of 1:3. The author believes consequently in the existence of tribasic phosphorous acid, the normal acid of trivalent phosphorus, and a trihydroxyl derivative.—*Liebig's Ann.*, clxxv, 1, Dec. 30, 1874. G. F. B.

2. *New Salts and Reactions of Cæsium and Rubidium.*—Some time ago GODEFFROY described the precipitate produced in cæsium solutions by antimonous chloride. (To this he now assigns the formula $(CsCl)_6SbCl_3$.) He has continued his investigation and now announces that not only antimonous chloride, but the chlorides of many other metals give, with cæsium salts, crystalline precipitates, difficultly soluble in hydrochloric acid. He mentions of these: iron-cæsium chloride $Fe_2Cl_6(CsCl)_6$; bismuth-cæsium chloride, $BiCl_3(CsCl)_6$; zinc-cæsium chloride, $ZnCl_2(CsCl)_2$; cadmium-cæsium chloride, $CdCl_2(CsCl)_2$; mercuric-cæsium chloride, $HgCl_2(CsCl)_2$; copper-cæsium chloride $CuCl_2(CsCl)_2$; manganese-cæsium chloride $MnCl_2(CsCl)_2$; and nickel-cæsium chloride, $NiCl_2(CsCl)_2$. These salts fall readily as precipitates when the metallic chloride, dissolved in concentrated hydrochloric acid, is mixed with a similar solution of cæsium chloride. The double salts are very soluble in water and in dilute hydrochloric acid, but crystallize out easily on evaporation. An investigation was then made into the behavior of the other alkali-metals and of ammonium with the metallic chlorides above mentioned, but no results were obtained with any of them except rubidium, which gave with the chlorides of antimony, bismuth, iron, zinc, cadmium, mercury, copper, manganese and nickel, beautifully crystallized double salts, completely analogous with the cæsium double chlorides in composition. Since these cæsium salts are not perfectly insoluble except in concentrated acid, only the platino-chloride can be used for its separation.—*Ber. Berl. Chem. Ges.*, viii, 9, Jan., 1875. G. F. B.

3. *On Diethylcarbinol, a new Isomer of Amyl alcohol.*—The present theory of chemical constitution points out the existence of eight isomeric amyl alcohols, of which four are primary, three are secondary and one is tertiary. These are constituted as follows:—



Of these alcohols, the first discovered and the best known is the one produced during the fermentation of grain, potatoes, beet roots, etc., and known as fusel oil. It was discovered by Dumas in 1835 and its constitution was fixed by Erlenmeyer in 1867, by proving that it yielded on oxidation a valeric acid identical with one prepared by him from isobutyl cyanide, and also with the isopropylacetic acid of Frankland. It is therefore the second of the alcohols above given, viz., isobutyl-carbinol. Wurtz, in 1862, prepared a second amyl alcohol from amylene, which was proved subsequently, both by himself and Kolbe, to be the sixth alcohol above given, viz., methyl-isopropyl-carbinol. The third amyl alcohol was produced synthetically by Popoff in 1867, by acting with zinc ethyl on propionyl chloride. This synthesis, as well as its oxidation products, proved it to be the eighth, or tertiary, alcohol given above, viz., di methyl-ethyl-carbinol. Wurtz in 1868 produced a fourth isomer, which he called ethyl-allyl-hydrate, since it was prepared by the action of zinc ethyl on allyl iodide. It corresponds to formula number five in the above list, being methyl-propyl-carbinol. The fifth isomer was prepared in 1870 from normal butyl cyanide, by Lieben and Rossi. Its mode of preparation as well as its oxidation product, normal valeric acid, prove it to be the first of the series, or normal butyl-carbinol. Only three of the possible amyl alcohols remain, therefore. WAGNER and SAYTZEFF now communicate the discovery of one of the two remaining secondary amyl alcohols, viz., di-ethyl-carbinol. The method by which this was accomplished, which is general, was suggested by the fact discovered by Frankland and Duppa, that, while the action of an organo-zinc compound upon oxalic ethers caused the substitution of a hydrocarbon radical for oxygen in one of the carboxyl groups, a further similar substitution in the second carboxyl group could not take place; a condition being produced by the first substitution, which is unfavorable to the second. Hence the facility of substitution of the oxygen of a carboxyl group by a hydrocarbon radical belongs only to those ethers in which the carboxyl group is not in combination with any radicals, the carbon and hydrogen being directly united. For these reasons, zinc ethyl should act upon ethyl formate to produce a compound which, acted on by water, should yield a secondary amyl alcohol. Experiment fully confirmed this view. A series of trials led to the adoption of the following method of procedure: In a flask connected with an inverted condenser are placed four molecules of ethyl iodide, one of ethyl formate, a small quantity of zinc-sodium, and enough granulated zinc to fill the flask to the level of the liquid. The whole was heated on the water bath, under slight pressure, until it ceased to boil and no more gas was evolved. After cooling the crystalline mass was treated with iced water, then with hydrochloric acid to dissolve the zinc hydrate, and submitted to distillation. From the distillate the diethyl-carbinol was obtained, as an imperfectly mobile liquid, having the irritating odor belonging to common amyl alcohol. Its sp. gr. is 0·822 at 0°, and it boils at 116°–117°. On oxidation it yields diethylketone. Several of its derivatives are described. The authors have also produced secondary butyl alcohol by the new method.—*Liebig's Ann.*, clxxv, 351, Jan., 1875. G. F. B.

4. *Production of Allyl alcohol in the dry Distillation of Wood.*—ARONHIEM has discovered allyl alcohol among the products of the dry distillation of wood. The crude wood spirit—which owes its penetrating odor to this substance—after distillation of the methyl alcohol, leaves a residue having a density of 76° to 78° Tralles. This, upon repeated fractioning over caustic lime, affords a distillate boiling at 88–89°, possessing the odor of allyl alcohol. The low boiling point is due, however, as analysis showed, to the presence of a molecule of water, which could not be removed by fractional distillation. When dehydrated by chemical means, the boiling point rose to 96–97°, which is that of the pure allyl alcohol. The identity of the product was further established by direct conversion into bibromhydrin, boiling at 217° and into allyl iodide, boiling at 101°.—*Ber. Berl. Chem. Ges.*, vii, 1381, Nov., 1874. G. F. B.

5. *On the Gases evolved from Apples.*—BENDER has made an examination of the gases evolved from ripe apples. The fruit cut in pieces was placed in water free from air contained in a flask furnished with a delivery tube. On raising the temperature to 60°, the gas began to come off, and at 100°, the evolution was rapid. Four moderately sized apples afforded about 100 c.c. of gas. Upon eudiometric analysis this gas—great care having been taken to exclude the air—was proved to consist of 59·37 per cent of nitrogen, and 40·20 per cent of carbonic acid, the remaining 0·43 per cent being oxygen. In a subsequent experiment, 31·07 per cent of the gas was carbonic acid and 68·93 per cent of nitrogen. The author believes that the carbonic acid comes from a fermentation within the fruit, the ferment being produced at the time of ripening.—*Ber. Berl. Chem. Ges.*, viii, 112, Feb., 1875. G. F. B.

6. *On the Influence of Light upon Cane Sugar.*—KREUSLER has made a series of experiments to test the assertion of Raoult that pure cane sugar in aqueous solution, both air and ferments being completely absent, underwent an inversion solely through the influence of light. While Raoult used only a solution containing 10 grams of white sugar to 50 grams of water, Kreusler employed solutions of various strengths. These were sealed up in glass tubes, after careful exhaustion, and with the exception of one, were exposed, in a window facing the southeast, to the direct sunlight for eleven months; more than twice the time given by Raoult. On opening the tubes, they still showed a good vacuum, and the liquid was clear and free from microscopic vegetation of any sort. But when tested with Fehling's solution, neither the liquid exposed to the light nor that preserved in darkness gave the slightest reaction. Upon repeating the experiment, however, taking care to introduce a small quantity of air into the tubes before sealing, organic ferments were found present, and the liquid reduced strongly the copper test; that exposed to light being the more active. The author believes therefore that an imperfect exhaustion in Raoult's tubes was the cause of the results he describes.—*Ber. Berl. Chem. Ges.*, viii, 93, Feb., 1875. G. F. B.

7. *Reflecting Lever.*—M. Cornu has devised an extremely simple but ingenious substitute for the spherometer which he calls the reflecting lever, or reflecting spherometer. Suppose a short lever like the beam of a balance supported on four points, one at each end, and two replacing its central knife-edge; also that a vertical plane mirror is attached above it in a plane perpendicular to its length. If now the four points lie in one plane and a thin plate is placed under the two central ones, the lever will be in unstable equilibrium, and will rock from side to side. Viewing with a telescope the reflection of a distant scale, the thickness of the plate is readily deduced from the angular motion. For, calling i the inclination of the beam, p the thickness of the plate, and l the half length of the lever, we have $\sin i = \frac{p}{l}$, or if i is small, $p = il$. The motion of the beam is double this, and the reflected ray travels twice as rapidly as the mirror; hence calling n and n' the two readings, and D the distance of the scale, we have $p = il = \frac{n-n'}{4D} l$. If the four points do not lie in one plane a correction is readily applied. Comparing the results, he concludes that while this instrument is very easily made and absolute measures readily obtained within a tenth of a per cent, it compares favorably, even in accuracy, with the best spherometers.

This instrument is also readily applicable to the measurement of curvatures and for many other purposes where a minute change of position is to be noted.—*Journ. de Phys.*, iv, 7. E. C. P.

8. *Maps of the Solar Spectrum.*—Mr. Lockyer laid before the Royal Society, at a recent meeting, a portion of a new map of the solar spectrum. The scale is four times that of Angström and includes the portion between the wave-lengths 39 and 41. A photographic print of the spectrum was employed, and from it curves were constructed by which the wave-lengths of the new lines were obtained graphically. In Angström's map (spectre-normal) 39 lines are given within these limits; Angström and Thalen's map, 185; Cornu's new map, 205; and in the present map, 518.

The spectra of the following metals are also given: Fe, Co, Ni, Mn, Ce, U, Cr, Ba, Sr, Ca, K, Al, representing 416 lines.—*Nature*, 238. E. C. P.

9. Mr. J. H. N. Hennessey has also prepared a map of the atmospheric lines drawn on the same scale as that of Kirchhoff. The observations were made at an elevated point, and the spectrum, when the sun was high, compared with that at sunset. Observations were also made to ascertain whether any of the lines which appeared, when the sun was low, were due, not to specific atmospheric absorption but to the general weakening of the light. The intensity of the spectrum was reduced in various ways, but the best results were obtained by observing the sun through a haze, with the result that none of the additional lines appeared to have any other origin than elective atmospheric absorption.—*Nature*, 278. E. C. P.

10. M. Cornu has prepared a map of the ultra-violet portions of the spectrum, to form a continuation of that of Angström and Thalen. It includes, in common with their map, the portion from *h* to *H*, but contains about four times as many lines. Compared with the plate of Mascart, it has the double advantage of being a normal map, that is, the position of the rays are proportional to their wave-length, and that the general appearance of the lines is represented more faithfully. Three series of photographs were taken with a ruled plate of Nobert, a flint-glass prism and a prism of Iceland spar, using the ordinary ray. From the first of these, Cornu determined the wave-lengths of 36 of the more marked lines which serve as a basis for the rest. The prismatic spectra are more distinct and of greater extent, and from them he has deduced over six hundred additional rays between *N* and *O*, or between the wave-lengths of 4100 and 3637. The agreement of the principal lines with the measurements of Mascart is complete.—*Bib. Univ.*, ccv, 62. E. C. P.

11. *Index of Refraction of thin plates.*—M. Wiedemann describes a new method of determining indices of refraction applicable in certain cases where the ordinary methods fail. The light of a gas-burner passes through the slit of a collimator and is rendered parallel. It then passes through a tank formed of plates of glass cemented together, and filled with oil of cassia. In this tank is immersed the plate of glass to be tested. It is fixed to the axis of a theodolite, whose limb serves to show the angles through which it is turned. The light is then dispersed by a prism and the spectrum thus formed is observed by a telescope. As oil of cassia has an index much greater than that of most kinds of glass, there may be produced a total reflection at the surface separating the oil and glass. Then on turning the plate, at first normal to the light, either to the right or left, a gradual extinction of the spectrum is effected, commencing with the more refrangible rays. The spectrum is extinguished as if a black curtain was drawn over it, the edge indicating the limit of the total reflection. Calling a the angle between the two symmetrical positions of the glass corresponding to the limit of extinction of a particular ray, $\sin \frac{1}{2}a$ will be the index of refraction of the oil with regard to the glass. Multiplying this by the index of the oil gives the index of the glass. The thinner the plates the more exact are the results given by this method. The index of refraction of liquids may be determined by a similar method. Two plates of glass are cemented together, leaving between them a thin layer of air. When this is too thin the limit of total reflection is not clearly marked, because a portion of the light penetrates the layer of air and enters the second plate. If, on the contrary, the layer is too thick, the limit of total reflection also loses its clearness, in consequence of the numerous interference bands. By interposing sheets of mica, whose thickness is gradually reduced, the best thickness is readily obtained. On turning the plates so that the angles of incidence become smaller and smaller, starting from a position a little beyond that of total reflec-

tion, interference rays are observed which pass over the spectrum from the red toward the blue. The angles of incidence having become smaller than the limiting angle, the direction of the displacement of the rays alters, and they move from the blue toward the red. These last are the interference rays ordinarily produced by thin films.—*Bib. Univ.*, cciv, 340. E. C. P.

II. Geology and Natural History.

1. *The Elevation of certain Datum-points on the Great Lakes and Rivers and in the Rocky Mountains;* by Jas. T. Gardner, Geographer. Washington, 1875. (Annual Rep. U. S. Geol. and Geogr. Survey of the Territories, for 1873, pp. 629–659.)—As Geographer in the Rocky Mountain Expedition under the charge of Dr. F. V. Hayden, Mr. Gardner found it necessary to fix upon some datum-point to serve as a base for the reckoning of altitudes, and met with a first difficulty in the different altitudes assigned to Denver, Colorado, they diverging between 200 and 300 feet. To eliminate the error, he undertook the "reconstructing of all possible lines of levels from the ocean to the Rocky Mountains, using only official reports by engineers, and checking them by personal examinations of their note-books and working profiles whenever practicable." The chapter here published contains the results of his long labor. Difficulty was found in the fact that railroad surveys from the Atlantic border had not started from the same stage of tide level, in errors from careless computation, and from other causes. The final results have proved that the elevation of the Great Lakes and the surrounding country is about *nine feet* more than previously reported by the State Geologist of Ohio; that St. Louis is 23 feet higher than made by Humphreys and Abbott; that Kansas City and the surrounding country for many hundred miles south and west is more than 100 feet higher than heretofore reported; Omaha 31 feet higher; Indianapolis about 100 feet. The following are a few of the levels ascertained:

Mean level of Lake Ontario above mean tide level	249·99 ft.
" Lake Erie	573·08
" Lake Huron	589·99
" Lake Michigan	589·15
Low water in Ohio at Cincinnati	440
Cairo city base, ordinary low water	291·23
Saint Louis directrix	429·29
Omaha, low water base of U. P. R. R.	977·90
" Depot grounds	1,060·40
Denver, Col., O. P. & K. P. R. R. passenger depot	5,196·58
Cheyenne, U. P. passenger depot	6,075·28
Golden, Colorado	5,728·98
Ogden, Utah, depot track	4,303·30
Pike's Peak	14,146·68

The level of mean tide at Albany, N. Y., above mean tide at New York City, was taken at 4·84 feet, as ascertained by the Coast

Survey. The mean height of Lake Erie was arrived at by means of levelings (1) on the Erie Canal from Albany to Buffalo; (2) from Philadelphia by railroad through Harrisburg, Pittsburg, Crestline to Cleveland; (3) from Albany by railroad to Buffalo; (4) by the North Central Pennsylvania R. R.; (5) by the Erie R. R. to Dunkirk and Cleveland; (6) by the Canadian Grand Trunk R. R. The results obtained by these six routes respectively are the following: 573·08, 572·037, 572·670, 570·750, [581·20], 571·67 feet. This example illustrates the method used for obtaining the true elevation, and shows also the high degree of confidence that may be placed in them; and further that Mr. Gardner makes in his memoir a contribution to North American topography of extreme importance.

A few others of the heights ascertained are: Quebec, mean tide level, 15·37 feet; Montreal, summer water-level, 30 feet; Lake Champlain, mean level at Whitehall, 100·84; Pittsburg, Pa., low water in river, 699·20; Louisville, Ky., low water above Falls, about 404; New Albany, Ind., low water in 1857, 379·75, and the depot of L. N. A. & C. R. R., 451·75; Rock Island, Ill., high water in Mississippi in 1852, 566·68; Terre Haute, Ind., high water in Wabash, 485·55, and ordinary water, 467·45; Mount Lincoln, Colorado, 14,296·66 feet. J. D. D.

2. *Geological Survey of Canada*, ALFRED R. C. SELWYN, Director. *Report of Progress for the year* 1873–4. 268 pp. 8vo. Montreal, 1874. (Dawson Brothers.)—No annual Geological Reports on this side of the Atlantic exceed in value those of the Canada Geological Survey. The volume recently issued contains, besides an introductory report of 16 pages by Mr. SELWYN, observations in the Northwest Territory, from Fort Garry to Rocky Mountain House, by the same; Report on the country between Red River and the South Saskatchewan, with notes on the Geology of the region between Lake Superior and Red River, by Mr. R. BELL; Report on Geological explorations in British Columbia, by Mr. JAMES RICHARDSON; Report on explorations and surveys in Frontenac, Leeds and Lanark Cos., with notes on the graphite of Buckingham and apatite of Templeton and Portland townships, Ottawa Co., by Mr. H. G. VENNER; Reports on the survey of the Coal Field of Cumberland Co., Nova Scotia, by Mr. S. BARLOW and Mr. W. McQUAT; on explorations and surveys in Cape Breton, Nova Scotia, by Mr. C. ROBB; on the iron ores of Canada and their development, by Dr. B. J. HARRINGTON; and notes on the Cretaceous fossils collected at Vancouver and the adjacent islands, from the coal series, by Mr. J. F. WHITEAVES. A Report by Mr. Billings on fossils from Gaspé, and another by Mr. Weston are in progress; and also a Report by Prof. Bailey and Mr. Ells, on New Brunswick Geology.

Mr. Selwyn states, in his Introduction, that the facts gathered tend to prove that *lithology* among crystalline rocks is not a safe test of geological age, observing that this conclusion is favored by the recent researches of Mr. Richardson in British Columbia, which show that "epidotic, chloritic and serpentinous rocks, with crystalline limestones and magnetites, are as characteristic of Upper Paleozoic, and perhaps also of even later formations, where they have been subjected to an equal amount of plication and folding, as they are of the oldest Paleozoic and protozoic strata, such as those of Eastern Canada and the New England States." He observes that Sir William Logan has been carrying forward extended and thorough investigations in Canada on this point, connected with a study of the true stratigraphical relations of the rocks, and that he will give a full report as soon as "the necessary examinations have been completed."

The Report also states that *boring for water and coal* in the Northwest Territory with a diamond-pointed drill was undertaken the past year, but that there was not time after receiving the apparatus for obtaining any important results. The boring will be resumed this season.

In his Report on the Northwest Territory, Mr. Selwyn states that, going westward from Fort Garry (or Winnipeg), the capital of Manitoba, lat. 49° 52′ N., long. 96° 50′ W., *only drift*—sand, clay and gravel—was seen along their course for a distance of 885½ miles. The first terrace plain in that direction has an average breadth of 120 miles, is 75 to 100 feet above Lake Winnipeg, and but 700 or 800 feet above the sea level. The drift of its surface is apparently underlaid at no great depth by Silurian and Devonian strata. Its western limit is marked by a range of low hills extending from Pembina Mountains by the Riding, Duck and Porcupine Mountains, to the Basquia Hills. Here there is a rise to a *second* prairie level, which is undulating or hilly and "attains an average elevation of 1600 feet." A *third* prairie level commences at the Thickwood Hills, 20 miles west of Carleton; it is 1900 to 2000 feet above the sea; the limestone boulders on it do not reach farther west than the longitude of Fort Pitt. Sand is the material of the deposits, and it is mostly unstratified, becoming imperfectly stratified and calcareous to the westward. At Fort Ellice, the valley of the Assiniboine (as stated by Dr. Hector) is 240 feet deep: the upper 100 feet consist of this drift deposit, and the rest of Cretaceous beds.

The watershed between the Qu' Apelle to the southwest and the Saskatchewan and Assiniboine to the northwest, is mostly a great salt plain, with many pit-holes and some large salt lakes.

On the North Saskatchewan River, between Edmonton and Rocky Mountain House (138 miles), several horizontal *coal beds* were observed, one of them 18 to 20 feet thick, and favorable for working. The coal is hard and bright, jet-like, and much superior to that found farther south along the boundary line and in the Qu'Appelle valley. The age of the latter is pronounced probably Tertiary; of the former, it is stated to be yet uncertain. The plants in the two are the same. The coal-field is stated to extend at least to the Athabasca River on the north, and Red Deer River on the south, and to have an area of 25,000 square miles. Analyses of the coals by Dr. B. J. Harrington are given on pages 63, 64.

Mr. Bell states that the valley of Red River from Fort Garry to Lake Winnipeg is underlaid by Lower Silurian magnesian limestone, and that above are Devonian rocks, which are exposed on various points and islands in Lakes Manitoba and Winnipegoos. Coal was found among sandy and clayey strata in the Dirt Hills, 96 miles southwest of Fort Qu'Appelle, and at the Woody Mountains in the intermediate region. At the latter place, where the formation is 200 feet thick, eight seams were counted, one of them eight and another five feet thick. Mr. Bell, adopting the view that the coal-bearing strata above the *Inoceramus* shales and sandstones of the Souris are probably Tertiary, states that the line between the Tertiary and the Cretaceous formation enters British territory in the neighborhood of the Roche Percè, and thence runs northwestward to the Elbow of the South Saskatchewan, passing about 40 miles north of the Dirt Hills. The greater part of the area between the two branches of the Saskatchewan is occupied by the "coal-bearing Tertiary." The coal beds are partly true lignite.

With regard to the *Drift*, Mr. Bell states that *the direction of the striæ* to the north and northwest of Lake Superior is in general *southwestward*, and that the same course prevails as far east as the Ottawa River; and "there is little doubt that the same course prevails for some distance to the north and west of Lake Winnipeg; for the plains west of the lake and of West River are covered with the debris of rocks derived from the east of the lake."

These observations on the scratches northeast of Lake Huron confirm the statements of others, and sustain the conclusion of the writer therefrom*—that the greater height of the ice-surface in Canada was over the watershed between the St. Lawrence and Hudson Bay. The facts from the vicinity of Lake Winnipeg show further that a line of *greatest height* was continued from this region northward or northwestward. It does not follow that the height along this line to the northward was as great as over the watershed; but only that the greatest height for those latitudes was there, or that it was great enough to determine a southwestward movement in the ice. The greatest height would have been where there was the greatest amount of precipitation, supposing the melting the same; and this, as the writer observes in the same article,† would have been toward the southern and coastward limit of the glacier. Over the interior of the continent, both the small amount of precipitation and the high degree of heat in summer would have put the southern limit of the ice north of the limits of the United States. The summer isotherm of 72° F., which passes over southern Ohio—the south limit there of the drift,—extends in the interior, about the meridians 98° to 105°, northward to latitude 47°; and over this area and also its extension far north and likewise far west to a line passing by Sierra Nevada and the Dalles in Oregon, the amount of annual precipitation, according to Schott's Rain Chart, is *sixteen inches and less.*

* This Journal, III, ii, 324; v, 204. † Ibid, v, 206, 208.

Mr. Harrington's report on the rocks and minerals is an important one. It contains analyses of oligoclase, hornblende, magnetites, hematites, limonites and other species, besides observations on the associations of the species. J. D. D.

3. *An Essay concerning important Physical Features exhibited in the Valley of the Minnesota River and upon their signification;* by G. K. WARREN, Major of Engineers and Bvt. Maj. General, U. S. A. 22 pp., 8vo., with several maps. Engineer Dept., U. S. Army. —Major Warren draws attention, in this Report, to the width and extent of the valley of Minnesota River (one of the head tributaries of the Mississippi) a feature continued even to its source in Lake Traverse, and to the great disproportion between its size and that of the stream now occupying it. He next states facts, derived from Prof. H. Y. Hind and other observers, respecting the great extent of the level region and stratified drift deposits about Lake Winnipeg, and the uninterrupted continuation of the deposits to Lake Traverse. The conclusion deduced is that in the Glacial era the land to the north about Lake Winnipeg was more elevated than now, so that the drainage from that lake was to the south, instead of, as now, through Nelson's River, to Hudson Bay; and that Lake Traverse was really the south end of Lake Winnipeg, and Minnesota River the outlet by which the great flood of waters passed south to the Mississippi. The Mississippi River would then have had its head waters in the streams that enter Lake Winnipeg from the west and north.

The highest part of the region about Lake Traverse is 995 feet above the sea, while that of Lake Winnipeg is about 630; so that a rise of but 365 feet to the north would produce the change of course. He observes that the height of the lake terrace above the ancient bed west of Pembina, as given by Mr. Owen, is 210 feet; that the lake bed there is about 50 feet above Red River, and this river at this point is about 100 feet above Lake Winnipeg; and hence he adds, "this lake terrace is 360 feet above the level of Lake Winnipeg—a height sufficient, as I have shown already, to extend the present Lake Winnipeg to Lake Traverse." Professor Hind, as quoted, says that "the Pembina Mountain [but 210 feet high] is *par excellence* the ancient beach in the valley of Lake Winnipeg. Dr. Owen thus describes it as it presents itself a few miles south of the 49th parallel."

When the southward slope of the surface came to its end through a northern subsidence, Nelson's River became the outlet —a narrow gorge abounding in water-falls. J. D. D.

4. *An examination of the Theories that have been proposed to account for the Climate of the Glacial Period;* by THOMAS BELT, F.G.S. (Quart. J. Sci., Oct., 1874.)—After a discussion of the merits of various theories for accounting for the cold climate of the Glacial period, Mr. Belt argues strongly for the old theory of a change in the obliquity of the ecliptic. He admits that the decision of astronomers is against it, but he holds that "until astronomers have reconsidered this question with the light of our

present knowledge of the figure of the earth, geologists should not be prevented from speculating on the probability of great changes in the obliquity of the ecliptic having caused former great variations of temperature." Mr. Belt also touches on the lowering of the sea-level by the accumulation of ice over the land, and says that, on the supposition that the ice was equal in the two hemispheres at the same time (the view he sustains), the lowering of the sea-level "could not have been less than 2000 feet, and may have been much more."

Since any lowering of the water line of the ocean by the abstraction of water to make the Glacial ice would have been alike on all the coasts of the world, Mr. Belt's estimate of the amount in the Glacial period is open every where to demonstration. On the Atlantic border of North America, such a change—which is equivalent to a rise of the land of 2000 feet—would have led to an immense amount of valley-excavation along the many rivers; and such valleys, so recently made, should still intersect the alluvial, Tertiary, and Cretaceous deposits of the very wide coast region of the continent, or be but partially obliterated. Instead of this, this coast region is remarkably flat and even and is intersected only by narrow river channels. There is nothing comparable in any part to the fiords of Glacial latitudes; and, more than this, there is little evidence of recent excavation very much below the present sea-level. The same fact is true of other continents.

A source of cold not considered by Mr. Belt is suggested in the writer's Geology (new edition), viz: that there was *an elevation of Arctic lands sufficient to exclude the Gulf Stream from the Arctic regions.* If these tropical waters—which now distribute over the northern latitudes, according to Mr. Croll, 154,959,300,000,000,000,000 foot-pounds of energy in the form of heat per day—were thus prevented from making their circuit over the polar regions north of the continents, the flow northward by Iceland would be stopped, and, owing to the northeastward trend of the American coast from Florida to the southeastern cape of Newfoundland, the Gulf stream would be mostly confined to a circuit within the tropical and warm-temperate zones.

This cause, in addition to the direct cold-producing effect of an increased amount of Arctic land, would thus have been sufficient to produce all the lowering of temperature needed for a Glacial period. And it would have made an epoch of cold in any period of the globe. Moreover, the deep submergence of Behring's Strait (now but 180 feet in depth), and of the region around, by letting in the Pacific tropical current, would at any time, as in the Miocene period, have made a warm Arctic. This explanation of the warm Arctic climate in the Miocene, which is presented in the Geology,* was suggested to the writer, as there stated, by Professor F. H. Bradley; and the other respecting Glacial climate may be considered a corollary from it.

Professor A. E. Verrill has recently called the attention of the writer to another effect from this confining of the Gulf Stream to

* Manual of Geology, 2d edit., p. 541.

the Atlantic: that the heat which is now carried to the north would then be kept mainly within the warm temperate and tropical latitudes of the ocean, and that, consequently, the other requisite of a Glacial era, *very abundant precipitation, would have existed concurrently with that of unusual cold over the land*—conditions, as Professor Verrill states, that would make a storm region of tremendous effects over the ice within 300 or 400 miles of the warm sea limit. All the conditions demanded are therefore met by this theory.

The high-latitude changes of level here appealed to may have produced effects at intervals through all geological time, though of feeble intensity in the Paleozoic. Agassiz, in 1840, in his *Études sur les Glaciers*,—a work that made an epoch in geology by its demonstrations of the glacier origin of the Drift,—suggested also that the principal epochs of life-extermination in geology were epochs of cold—"que les plus grands froids ont terminé chaque epoque géologique,"—cold being a cause of extermination; and there is reason to believe that he was right as to some at least of the epochs. The writer recognizes two such in his Geology, one at the close of the Carboniferous, and another at the close of the Cretaceous (the latter in the 1st edition of the work); and he alludes to the subject here in order to give the credit of first bringing forward the principle to Agassiz. "The indications of floating ice which Ramsay has found in the British Lower Permian may be a mark of the slow approach of such an era of cold"* at the close of Paleozoic time; and the Triassic rocks of eastern North America seem to bear, in their large rounded stones and the nature of the beds, evidence that the excessive precipitation and also the cold of such an epoch had then not yet passed.† J. D. D.

5. *On the Submergence during the Glacial period.*—Professor Croll, in the Geological Magazine for July and August, 1874, presents the following as the cause of the apparent subsidence, or rise in the water level, which took place before the disappearance of the ice of the Glacial period; or, as he has it, the submergence during the Glacial period, he holding that the whole period was a period of lower level of the land than now. He proceeds on the supposition, before argued for by him, that the cold of the Glacial period was due to the eccentricity of the earth's orbit, and that it affected the northern and southern hemispheres alternately.

The removal of two miles of ice from the Antarctic Continent would displace the center of gravity 190 feet, and the formation of a mass of ice of one-half this thickness in the Arctic regions would carry the center of gravity 95 feet farther in the same direction. Further, the area of the Antarctic ice-cap being $\frac{1}{23\cdot46}$ of that of the ocean, therefore, allowing 0·92 for the density of ice, the melting of 25½ feet of ice from the cap would raise the general level of the

* Manual of Geology, 2d edit., p. 431.

† The agency of ice in the deposition of the Trias of Eastern North America has been suggested by T. A. Conrad, and also by H. Wurtz, and by both in 1869.

ocean one foot; and a mile of ice, 200 feet. The other mile of ice melted is balanced by the abstraction of water to add a mile of ice to the Arctic. These numbers added, says Mr. Croll, give 485 feet for the amount of submergence that would be thus occasioned at the North Pole, and 434 feet for that in the latitude of Edinburgh; or if the ice had twice the supposed thickness, the amount of submergence would have been twice this amount.

The facts from Eastern North America do not appear to favor Mr. Croll's conclusion. The amount of subsidence indicated by raised shell-beds on the St. Lawrence at Montreal, near latitude 45°, was about 500 feet; on the coast of Maine, near latitude 44°, only 200 feet, when it ought by the theory to have been but a few feet less than at Montreal; and along the southern shore of New England, near latitude 41°, only 50 to 100 feet, the larger of which numbers is much less than a fourth of what the theory requires. It seems hence to follow that the curve of submergence did not correspond with the curve which would have been produced in the ocean's surface by a change of the center of gravity.

The Coral Island subsidence over the Pacific, which affected a very large portion of the tropical part of that ocean, must have been in progress through the Glacial period, and the amount of it was certainly several thousand feet. Here was a great change of level *in the tropics*, which no change in the earth's center of gravity could have produced. It was in a sense local, the continental lands adjoining not sinking with the ocean's bottom, nor all parts of the ocean alike. It is evidence that the cause of the great change of water level during the Quaternary age, as well as in earlier time, resides in the crust itself. The facts from the shell beds of the St. Lawrence and the coasts of New England appear to be equally evidence of a *bona fide* subsidence, which no cause affecting the ocean as a whole will account for. J. D. D.

6. *Recent Changes of Level on the Coast of Maine, with reference to their origin and relation to other similar changes;* by N. S. SHALER. (20 pp., 4to, 1874, from the Mem. Bost. Soc. Nat. Hist., ii, 322.)—The evidence of the changes of level here discussed was gathered from the Quaternary deposits of Maine and of the coast south. Professor Shaler concludes that the evidence sustains the view that there was a subsidence or "depression" of the land increasing in amount, though somewhat irregularly, to the northward, after "the first division of the Glacial period;" and that subsequently there was "a return of the ice in the shape of a set of local glaciers which covered the shore at Mt. Desert, and along most of the territory at least as far as New Brunswick, and persisting until the final re-elevation of the land to near its present level."

The cause of the depression is discussed in the closing pages. He remarks that the only hypothesis as yet advanced to account for it is one proposed by Adhémar; overlooking the fact that the writer, first in 1856,* offered another, referring the great Quater-

* Amer. Jour. Sci., II, xxii, 346. The same conclusion is involved in his earlier paper in 1846, 1847.

nary movements of the crust,—the *upward* for the Glacial period, the *downward* for the Champlain or Fluvial period, and then a succeeding *upward* rise—like the other great movements, to the lateral pressure in the earth's crust due to contraction from cooling.

Adhémar's hypothesis, as explained by Mr. Shaler, supposes a displacement of the center of gravity in consequence of the unequal accumulation of ice at the poles, much like that recently proposed by Mr. Croll. Professor Shaler rejects this explanation, chiefly because the Glacial phenomena of the two hemispheres have not yet been proved to be alternate, and because the amount of depression does not increase with regularity over the whole northern hemisphere; and then presents his own hypothesis, which attributes the depression to *the weight of the ice-mass over the land.* After speaking of the continents as having their positions determined by "constant tensions" (meaning, perhaps, to include *lateral pressure*, which far exceeds tensions in importance) and the weight of the mass, he says, "it seems evident enough that we may more reasonably look to the weight of the ice accumulated on the continents during the Glacial period for the depression of the land-areas it occupied, than to any other cause."

This theory assumes that a cap of ice "a mile or more thick," equivalent, as the author states, to half this thickness in "ordinary rock," depressed the earth's crust 500 feet and upward over the area from the St. Lawrence and great lakes to the Arctic, notwithstanding that the arched crust had a thickness of probably 100 miles. There is no doubt that such a weight—equal to a cap of rock, say one hundredth as thick as the earth's crust—would tend to cause a depression, for this tendency exists even under any small weight. But, considering the form and nature of the crust, and the lateral or tangential pressure existing throughout it, shown by Mallet to be enormous, it seems to be far from probable that mere weight can account for so great a movement. Lateral pressure has been the chief agent in oscillations of level and mountain-making over the earth; since Archæan time, making (1) the Green Mountains, (2) ridges in Nova Scotia and New Brunswick, and (3) the Alleghanies, on the *eastern* border of the North American Continent, at long intervals; and *subsequently*, after other long intervals, raising (1) the lofty Wahsatch Mountains and Sierra Nevada, (2) ranges of Cretaceous mountains, and (3) Tertiary ridges, on the western side of the Continent; besides (4) elevating, during the Cenozoic, the great Rocky Mountain mass 8,000 to 10,000 feet, —an effect that no weighting was employed to produce. And even in the Quaternary, though perhaps the work was begun before, there was the great subsidence over the tropical Pacific—the coral island subsidence (and another similar, probably over the tropical Atlantic), which the weighting of the islands by coral growths was certainly inadequate to produce, and which is naturally another consequence of the uneasiness of the crust owing to lateral pressure.

Here are vast results — elevations and subsidences — accomplished by lateral pressure. Now, that elevation of the land over the higher latitudes which brought on the Glacial era, is a natural result of the same agency, and a natural, and almost a necessary, counterpart of the coral island subsidence, which must have been then in progress. The accumulating, folding, solidification and crystallization of rocks attending all the rock-making and mountain-making through the Paleozoic, Mesozoic and Cenozoic eras, had greatly stiffened the crust in these parts, and hence, in after time, the continental movements resulting from the lateral pressure necessarily appeared over the more northern portion of the continent, where the accumulations and other changes had been relatively small. To the subsidence which followed the elevation the ice-cap may have contributed in some small degree. But the great balancing movements of the crust of the continental and oceanic areas then going forward must have had a greatly preponderating cause in the oscillating agency of all time, lateral pressure within the crust. J. D. D.

7. *Age of the Lignitic Coal Formation of Vancouver Island.* Letter to the editors, from Alfred R. C. Selwyn, F.R.S., Director of the Geological Survey of Canada, dated March 3d.—I wish to record my dissent from the statement made by Professor Lesquereux, page 365 of Dr. Hayden's Report on the U. S. Geological and Geographical Survey of Colorado, 1873, to the effect that the coal of Nanaimo, Vancouver Island, is referable to the lower American Eocene.

Careful surveys have now been made by the Canadian Geological Survey of the Nanaimo coal basin, and it is proved beyond the possibility of a doubt that the coal beds there are overlaid by a succession of strata, shales, sandstones and conglomerates, having a thickness of nearly 4000 feet, and holding from base to summit marine Cretaceous fossils, *Ammonites*, *Baculites*, *Inocerami*, and others.

Maps and sections showing the relative position of these beds and of the coal seams are given in the Report of the Geological Survey of Canada, 1872–'73; and I would beg to refer Professor Lesquereux to them for information concerning the coal rocks of Vancouver Island. As he makes no reference to the report named, I conclude he has not seen it.*

8. *Note on the genus Opisthoptera* Meek, 1872, *and Anomalodonta* Miller, 1874. (Communicated.)—Mr. S. A. Miller, in a reply to my note on the above mentioned genus,† published in the September number (1874) of the Cincinnati Journal of Science, endeavors to defend his substitution of the name *Anomalodonta* for Meek's earlier name. This he does on the ground (1) that *Megaptera*, having been previously used for a genus of whales, could not stand; (2) that although Mr. Meek had subsequently

* The facts are briefly mentioned from the Canada Geological Report for 1872–1873 in vol. vii of this Journal, pp. 517, 518, 1874.—Eds.

† See this Journal, viii, 218, 1874.

(but previous to the publication of Mr. Miller's name) proposed to substitute for it the name *Opisthoptera*, he did it only *provisionally*, and had not himself adopted it in the subsequently published Ohio report; and (3) that neither Meek and Worthen jointly, nor Mr. Meek alone, had fully defined the generic characters of their type.

No further notice would be taken of the matter, were it not that silence might be construed into acquiescence in views and practices that it is the interest of all working naturalists to discountenance. In the first place, it is by no means a *settled* question among naturalists that the same name may not be used for genera in different sub-kingdoms, or even in different classes of the same sub-kingdom. This is the practice of some of the best and most renowned naturalists. *Troglodytes* is constantly used for a genus of apes, and also for a genus of birds, and many other cases might be mentioned. I think, however, with Mr. Meek, that it would be better to change the latter name, but he seems to have deferred to the high authority mentioned in only provisionally proposing to change it in the case of *Opisthoptera*. That he did not himself formally adopt the latter name in the Ohio Report has no bearing on the question. By repeating there the previously published note on *Opisthoptera*, he manifestly repeats the proposal to substitute the latter name on precisely the same ground that he did at first, namely, in case it should be found generically distinct from *Ambonychia* and the name *Megaptera* should be objected to. But it would not have altered the case if he had there said nothing about it, or even if he had proposed to retract both *Megaptera* and *Opisthoptera* entirely. As soon as the name was published it became the property of science, and he had no more right to dispose of it than any other person.

Mr. Miller's argument that both *Megaptera* and *Opisthoptera* should be discarded because *full* generic descriptions of them were not published, is not, and cannot be, sustained by general usage. Even in recent zoology, where it is possible to ascertain clearly all the characters, no such rule is generally followed. Such a rule would be utterly inadmissible in the department of fossil shells, because of the exceeding rarity of specimens that are even approximately perfect; for even in the best specimens the most important features (as, for example, the internal markings and teeth in bivalves) are generally obscured. Consequently, many of the genera of the latter kind of fossil shells have been proposed mainly or entirely upon external characters. The rule would endanger the name *Anomalodonta*, because nothing is yet known of the pallial line and pedal muscular scars of that shell, to say nothing about the extraordinary position of the adductor impression in Mr. Miller's figure. Hundreds of cases might be mentioned of genera established upon external characters.

Unlike some other genera, *Opisthoptera* has its more conspicuous characters external, namely, its form and surface ornamentation, which when taken together are quite sufficient to distinguish it from related types, even from the broad types of *Myalina*, from which the hinge characters shown by Mr. Miller would not separate it. As Meek and Worthen, and still later, Mr. Meek alone, have fully described and illustrated these external characters of their type, they have given sufficient means for its identification, which even Mr. Miller found no difficulty in doing. To Mr. Miller's other remarks it is hardly necessary to reply.

As to the affinities of *Ambonychia* with the *Aviculidæ*, which Mr. Miller refuses to admit, on account of the equality of the valves, I need only to remark that to make such family distinctions as that proposition, would require us to divide well defined genera, some species of which would fall in one family and some in another, the genus *Inoceramus* being an example. The true (Triassic typical) *Monotis*, *Halobia*, and others are included by the highest authorities among the Aviculidæ, and yet they are equivalve. He refers to McCoy as the first to refer *Ambonychia* to the Aviculidæ, being evidently unaware of the fact that in 1833 Goldfuss in his great work, *Petrif. Germ.*, did the same. Conrad, Woodward, Brown, Dr. Carpenter, and Dr. Stoliczska all have done the same, the latter even placing it near *Avicula* in the section Aviculinæ.

Returning to *Opisthoptera*, I will state its synonymy thus:

Genus Opisthoptera Meek. *Megaptera* Meek and Worthen, 1866 —not *Megaptera* Gray, 18—. *Opisthoptera* Meek, 1872. *Anomalodonta* Miller, 1874. C. A. W.

9. *Costa Rica Geology.*—Mr. W. M. Gabb, in a letter dated San José, Costa Rica, February 1st, corrects his former calculation of the height of Pico Blanco, stated on page 199 of this volume, making it 11,877·8 feet. The error came from a slip in the use of a formula.

Mr. Gabb also states that on the 26th of January he ascended the volcanic peak Irazu, and obtained barometrically for its height 11,356·5 feet. The volcano is extinct, excepting a little smell of sulphur in the crater. He further remarks that the peak of Turrialba, nine or ten miles from Irazu, is so nearly equal to the latter in height that much difference of opinion exists as to which is the highest. This volcano "sends out a constant small cloud of vapor."

10. *The Gulf of Mexico in the Miocene.*—Prof. Hilgard has suggested, in view of the absence of marine Miocene beds over the Eocene of Louisiana, Mississippi and Alabama, and the presence there of the beds of the Grand Gulf group without remains of marine life, that the Mexican Gulf was fresh or only brackish in the Miocene, and made so by the elevation of a barrier across from Yucatan.* Mr. W. M. Gabb, in letters to the writer, states that his observations among the West India Islands lead him to believe, in view of the distribution of marine Miocene beds, that "in the Miocene period, Cuba, like Jamaica and Santo Domingo, was much smaller than at present, and may even have

* This Journal, II, ii, 397.

been only a string of small islands; while Yucatan, the Bahamas, Bermudas and much of Florida did not yet exist, and their surface beds had not yet been deposited."

He remarks: "The additional facts I have acquired in Costa Rica geology go strongly to sustain the opinion I have already advanced, that no sedimentary rock older than the Miocene is found here. The Carboniferous formation is Miocene; and wherever it is unaltered it contains coal-beds, some of which are two yards thick. Now I have seen this coal, as the green streaks show, all the way around from near San José to the end of Talamanca, and we know that heavy beds occur in Chiriqui *on the Atlantic side*. And all along the coast, as at Boca Brava, Punta Uvita, Pirris, Tarcoles, etc., coal is found. The existence of these Miocene beds on the Atlantic side proves that the gulf was occupied by marine waters as now. J. D. D.

11. *On the Earthquakes of Southern Italy;* by EDWARD SUESS. 32 pp., 4to, with three plates. Vienna, 1874. (From vol. xxxiv, Denkschriften der Kaiserlichen Akademie der Wissenschaften.)—Professor Suess first describes with some detail the geological structure of Sicily, and of the neighboring districts of Italy, to the knowledge of which he has contributed so much by his personal labors. It is shown that in this region there is, in the crystalline rocks, a zone of granite and gneiss, and a bordering zone of schists, both more or less interrupted, an association closely resembling that so common in the Alps. The facts displayed warrant the conclusion, previously advanced by the author, that these older rocks of Southern Italy, with the isolated portions observed on the western coast, are the continuation of the Alps by Genoa, while the western side of the peninsula is to be regarded as an immense area of subsidence.

A careful discussion follows of the important earthquake phenomena which have been observed in Southern Italy. The main conclusion reached is, that the earthquake-shocks of Sicily and Calabria may be separated into three classes:

1. Eruptive-shocks, having their center in a volcano, and involving in general only the immediate region about the mountain, such as have often accompanied the eruptions of Mt. Etna.

2. Radial shocks, which also have their origin in a volcano, but are sent out from it along definite lines. Examples of these are afforded by the many earthquakes which have come to Southern Italy from the Lipari Islands.

3. Peripheral shocks, those which have not a volcano as their center, although there may be a certain connection between them and neighboring volcanoes. The line of these shocks may be traced from Cosenza southwest through Oppido and Reggio, and is probably continued through Mt. Etna toward Palermo, thus forming a complete semicircle concentric with the Lipari Islands. These shocks differ from the radial shocks in that they are propagated forward or backward on this line, so that they may visit the same place within a short time from different directions.

Another line of shocks is shown to have the direction from Mt. Vultur southwest through Potenza to Papasidero.

From the facts presented, Professor Suess shows that there is a close connection between the volcanoes and the earthquakes. He concludes, moreover, that the volcanic phenomena of the Italian peninsula are parts of one system, and that they are to be regarded not as the cause of the mountain elevation, but as accompanying phenomena resulting from fractures that have been produced through other means. E. S. D.

12. *Distinctive optical properties of the Feldspars.*—DesCloizeaux has recently investigated the optical properties of the triclinic feldspars (C. R., lxxx, Feb. 8, 1875). The principal results obtained by him are contained in the following table, in which *Bx* stands for *bisectrix.*

	ALBITE.	OLIGOCLASE.	LABRADORITE	ANORTHITE
Acute bisectrix	always +	generally − sometimes +	always +	always −
Angle made by the + Bx. with a normal to *i*-ĭ (*g*)	15°	18° 10′	30° 40′	Position of the Bx. has no
Same, with a normal to *O* (*p*)	78° 35′	68°	56°	simple relation to the
Angle made by the line in which the plane of the optic-axes cuts *i*-ĭ, with edge *i*-ĭ | *O*(*g*′|*p*)	20°	Line parallel to the edge *O* |*i*-ĭ.	27°–28°	planes observed on
Same, with edge *i*-ĭ|*I*(*g*′|*m*)	96° 28′(front)	" "	37°25′–36°25′	the cryst'ls.
Ordinary dispersion	$\rho<v$(+ Bx.)	$\rho<v$(+ Bx.)	$\rho>v$(+ Bx).	$\rho<v$(− Bx.)
Dispersion parallel or perpendicular to plane of polarization	*Inclined;* probably also slight *horizontal.*	*Crossed;* also slight *inclined.*	*Crossed;* also slight *inclined.*	*Inclined.*
Appar'nt optic-axial angle (in air)				
—— for red rays	80° 39′	89° 35′	88° 15′	84° 58′
—— for blue rays	81° 59′	88° 31′	87° 48′	85° 59′
	(Roc tourné)	(Sunstone. Tvedestrand)	(Labrador)	(Somma)

The axial divergence is quite constant for albite, labradorite and anorthite, but varies for oligoclase even in different sections taken from the same specimen. DesCloizeaux concludes from his observations that labradorite and oligoclase have an equal right with albite and anorthite to be considered independent species, contrary to the views presented by Tschermak. Andesite he concludes to be altered oligoclase, while tschermakite is identical with albite. E. S. D.

13. *Insects and other fossils from the Permian of Weissig in Saxony.*—Mr. Eugene Geinitz, in a second paper on the carbonaceous shale of the Permian at Weissig, near Pillnitz, mentions the occurrence there of four species of Blattina, one a nearly perfect specimen of the *B. didyma* Germar, another a new species, the *B. porrecta?* Geinitz, and the others the *Blattina Carbonaria* Germar and the *B. Mahri* Goldenberg. The same locality has afforded also, *Uronectes* (*Gampsonyx*) *fimbriatus* Jordan, *Estheria tenella* Jordan; the fishes, *Acanthodes gracilis* Beyrich, *Palæoniscus angustus* Ag., *P. Vratislaviensis* Ag.; the Articulate, *Gyromyces Ammonis* Göpp. (*Spirorbis Carbonarius*); and several plants of the genera

Annularia, *Asterophyllites*, *Sphenopteris*, *? Hymenophyllites*, *Odontopteris*, *Neuropteris*, *Dictyopteris*, *Cyatheites*, *Alethopteris*, *Tæniopteris*, *Walchia*, besides some others.—*Jahrb. f. Min.*, 1875.

14. *Batrachians in bituminous shales of the Permian at Millery, France.*—M. A. Gaudry states that a single slab of shale from Millery, France, has on it seven little Batrachians, resembling the species which had been obtained by M. Roche at Igornay. He names the species from the two localities *Salamandrella Petrolei*, because of the affinities to the Salamanders, and their occurrence in oil-yielding shales. They are very small, the largest 35 mm.; and yet they were probably adults. No traces of scales were found. The fore and hind limbs are four-toed and nearly of the same size.—*Ann. Mag. N. H.*, IV, xv, 233.

15. *Coal in Patagonia.*—On the Peninsula of Brunswick, in the Straits of Magellan, at a place called Vaqueria by Capt. Corey, rich beds of coal have been opened. The place is not far from the Chilian Colony of Punta-Arenas, lat. 53° 10′ S. and long. 70° 54′ W. (from Greenwich). The Chilian Government has conceded it to a French company. A detailed report has been published by M. F. Arnal, Civil Engineer. The coal is very compact, black, inflames easily and burns without odor. There are three beds, having an aggregate thickness of about 26 feet. The age of the beds is not stated; but as the coal is spoken of as related to the lignites, it is probably Tertiary or Mesozoic.—*L'Institut*, Feb. 17.

16. *Icones Muscorum, or Figures and Descriptions of most of those Mosses peculiar to North America, which have not yet been figured;* by the late WILLIAM S. SULLIVANT, LL.D. *Posthumous Supplement;* with 81 copper plates. Imp. 8vo. Cambridge: Charles W. Sever. London: Trübner & Co. December, 1874.—To give an idea of the nature of this volume, and of the circumstances under which it has been produced and published, we append the brief preface, written by the author of this notice. His biographical sketch of Mr. Sullivant, published by the American Academy of Arts and Sciences, is prefixed to the volume. The mosses which form the subjects of the present series of incomparable plates, are partly Californian, from the indefatigable Bolander and others, or from the Rocky Mountains, &c., and partly new discoveries in the Atlantic States, by Messrs. James, Austin, Peck, Ravenel, &c. Only a small edition is printed and put on sale. Its price, as of the original volume, is fixed—at least for the present—in reference to the ordinary means of students and devotees of Bryology, rather than to the actual cost of the work. Even if all the copies were sold at the price ($10 for this supplement, and $14 for the original volume, which is still to be had), the gift of the lamented author to his fellow-botanists would yet be large. If desired, copies will be supplied from the Herbarium of Harvard University.

"Since the publication of the Icones Muscorum, in the year 1864, the lamented author made careful studies and sketches of the copious new materials as they came to his hands, with a view to a continuation. A portion of these was selected for the first Supplement, and the drawings and engravings of these eighty-three plates were completed before his death, in April, 1873. The drawings were made under his immediate superintendence, by the same meritorious draughtsman who executed those of the original volume, Mr. August Schrader, and they were engraved on copper by Mr. William Dougal. Some progress had been made in the preparation of the letter-press, but only a small portion of it was found to be in readiness for the printer. Its preparation and completion, as well as the oversight of the press, have devolved upon his friend and intimate companion in Bryological studies, Mr. Leo Lesquereux, to whom this has been a labor of love and the paying of a tribute of affection to an endeared memory. Inasmuch as he had to draw up a large proportion of the following descriptions from mere notes and remarks appended to the specimens in the herbarium, it would have been only just, no less to Mr. Sullivant than to Mr. Lesquereux, that the name of the latter should be placed upon the title-page as the editor of this posthumous work. But he has strenuously objected to this, and his decided wishes have been deferred to. Regarding the incomparable "Icones" and this Supplement as a fitting memorial of one who will rightly be remembered as the father of American bryology, he declines to have his own name inscribed upon the monument, however subordinately. Accordingly, it only remains for the writer of this preface to express—on the part of the botanists who are to be benefited, and of the Sullivant family, at whose expense this memorial is published—most grateful acknowledgements to Mr. Lesquereux for his valuable and essential services." A. G.

17. *Attar of Roses*, for European commerce, is almost exclusively supplied by a small tract of country in Rumelia, on the southern side of the Balkan Mountains. There has been some question as to what species of Rose was employed; but of late it has generally been thought to be the Damask Rose. Mr. Hanbury, having received a packet of specimens from the rose fields of the Balkan, submitted them to Mr. Baker of Kew, he being the most accomplished rosarian; and Mr. Baker has determined them to be for the most part *Rosa damascena.* This species is quite unknown in a wild state; and Mr. Baker regards it "as most likely a cultivated race of *R. Gallica*, which spreads in a wild state from France to Kurdistan." (See Jour. Bot. for Jan., 1875.) A. G.

18. *British Wild Flowers considered in relation to Insects;* by Sir John Lubbock, Bart, F.R.S., M.P., with numerous illustrations. London: Macmillan & Co. 1875. pp. 186, 12mo.—Although the revival of this fascinating and fruitful subject, and the first clear exposition of its importance in the vegetable economy, are due to an Englishman—it being Mr. Darwin's happiest piece of subsidiary work—there has been no British text-book or popular treatise* to impart the requisite knowledge of the facts, and to

* Except a little work by Mr. Bennett, entitled "How Flowers are Fertilized," which we have not seen.

excite and gratify the interest which these are sure to engender. There have been some excellent articles in the magazines; but Mr. Darwin's revelations seem not to have been followed up as they have been elsewhere, especially in Germany, where the literature of the subject is very considerable. In the United States it has become a part of popular botanical instruction,—not so generally, however, as it ought to be; for this, and other matters of plant-behavior, may be expected to double the charm of botanical study, by opening new fields of surpassing interest and almost endless variety. Nothing can be better adapted to sharpen the powers of observation in the young.

Sir John Lubbock's lecture before the British Association last August upon this topic attracted great attention, which his series of articles in *Nature* widened; and now these articles are collected to form this handy volume,—one of the *Nature Series*, to which the author had already contributed his more elaborate and thorough essay on "The Origin and Metamorphoses of Insects." As the author remarks, he "had made no serious study of Botany," at which we do not wonder. As it is few indeed can be expected to give their powers, with the success he has commanded, to so many engrossing subjects, financial, ethnological, zoological and other. But as an entomologist, "the intimate relations which exist between flowers and insects," as brought to light by recent researches, came directly in his way. His observations and notes originally prepared—and as we judge very recently—"with the view of encouraging in my children that love of natural history from which I myself have derived so much happiness" (and we may add science no little advantage), naturally suggested that a wider use might be made of them; and this attractive, but rather hastily prepared volume is the result. Not much in the way of original observations is here to be expected; but there are some, and good ones. There are seven chapters. The two introductory chapters are the most important and satisfactory. They give an admirably clear account of the general subject, succinct, but sufficiently full to convey a good idea of the various ways in which most flowers are adapted to be cross-fertilized by the visits of insects, and through which these visits are secured, while others are in their way as well served by the winds. And there is an especially instructive account of the modifications of the mouth-parts and legs of bees and butterflies, for their profit in their visits to flowers, while they profit them. This is condensed from Herman Müller and the illustrations are his.

In the remaining chapters the orders of the principal British flowers are taken up seriatim, and the fertilization of a good number of them explained and illustrated,—sufficiently so in many cases, at least in the earlier orders; but, on the whole, if so wide a range and systematic treatment were undertaken, it were better to carry it out more fully. The little cuts from Bentham's Handbook, not having been prepared in view of this subject, are here of small use. They are supplemented by larger and clear illustrations of separate flowers, from Müller, Axell, Hildebrand and Darwin.

Now that we fairly well understand the meaning of these various arrangements for the fertilization of flowers, perhaps we ought to give to the first discoverer of them, Christian Conrad Sprengel, rather more credit than the present author awards him. If he did not perceive "the real significance of the facts which he had discovered," it was not because he, like his contemporaries, was "led to assume that each flower was created as we now see it." The meaning of the arrangements comes out as clearly upon that supposition as upon any other. Mr. Darwin puts the case better, when with his characteristic exactness, he says that "Sprengel failed to understand the full meaning of the structure of the flowers which he has so well described, from not always having before his mind the key to the problem, viz: the good derived from the crossing of distinct individual plants." The law of nature that organic beings shall not fertilize themselves in perpetuity, is the key to the whole; and for this key we rightly acknowledge our indebtedness to Mr. Darwin, who first turned it to full account, in a masterly way. Yet the principle involved was enunciated by Andrew Knight, in the year 1799. But even this was anticipated by Sprengel, in 1793, in the declaration to which his observations had led him, that "Nature does not wish that any complete flower should be fertilized by its own pollen." Kœlruter's equivalent suggestion is still earlier, and much antedates that of Knight (instead of following it, as Mr. Knight implies), if really to be found in his book published in 1761, as is lately stated. Like most first discoveries, these were not followed up, nor half their importance foreseen. A. G.

19. *Amphipod Crustaceans of the family Gammaridæ in Lake Baikal.*—Dr. B. N. Dybowsky has described *ninty-seven* species of Gammarids from Lake Baikal. They include one Swedish species, *G.* (*Pallassa*) *cancelloides;* and also the *G. neglectus* of the lake is hardly distinct from *G. pulex.* The species occur at all depths, the greatest depth dredged, 1373 meters, affording them as abundantly as the littoral zone, though fewer in species. The species of small depths are mostly vividly colored; those at greater depths are less bright in color, and the kinds from depths greater than 700 meters are more or less whitish in tint.—*Ann. Mag. Nat. Hist.*, IV, xv, 230.

20. *Large Cephalopod.*—A cephalopod "of great bulk," 12 feet in length, has been captured on the coast of Japan.—*Japan Mail*, Jan. 23.

21. *The Doctrine of Descent and Darwinism;* by Oscar Schmidt, Prof. Univ. Strasburg. The International Scientific Series. 324 pp., 12mo, with 26 wood-cuts. New York, 1875. (D. Appleton & Co.)—This volume contains, in a brief dogmatic form, the views of Darwin on descent, combined with those of the more imaginative Hæckel. The author has nothing but matter in his philosophy, and is intolerant toward those who do not think with him.

III. Astronomy.

1. *Venus.*—The Italian observers at Maddapore in Bengal, to which party the eminent spectroscopist Tacchini belonged, besides observing all four contacts, ascertained an important fact respecting the atmosphere of Venus. The ring around the planet, which in the former transits, as in the present one, was visible around Venus both on and off the sun, indicates in the spectroscope that the atmosphere contains aqueous vapor.—*Nature*, Jan. 21.

2. *A Society for Spectroscopic observations on the Sun* has been formed in Calcutta.—*Nature*, Feb. 25.

3. *Astronomical and Meteorological Observations made during the year* 1872 *at the U. S. Naval Observatory.* Rear-Admiral B. F. Sands, U. S. N., Superintendent. Published by authority of the Hon. Secretary of the Navy. cvi, 372, 58 and 22 pp., 4to. Washington, 1874.—This new volume of the U. S. Naval Observatory opens with an account of the Observatory, the Transit Circle, with tables for correction and use, etc., and the Mural Circle, occupying over 100 pages. The following part of the volume contains the tables of the results of observations in 1872 with the Transit (160 pp.); with the Mural Circle (161–204 pp.); with the Equatorial (207–232 pp.); mean declination of stars, from individual observations with the Mural Circle (235–246 pp.); mean places of miscellaneous stars, from individual observations with the Transit Circle (249–268 pp.); Catalogue of stars observed with the Transit Circle (271–278 pp.); Right ascensions, N. Polar distances and semi-diameters of the Sun; Small Planets; Declinations of the Moon. It concludes with meteorological tables, and a report on the difference of longitude between Washington and Detroit, Michigan, Carlin, Nevada, and Austin, Nevada.

4. Professor Argelander.—Friederich Wilhelm August Argelander, born at Memel in East Prussia on the 22d of March, 1799, died at Bonn on the 17th of February. He was for a while assistant in the observatory at Königsberg, under Bessel, afterward, in 1823, Director of the Finland Observatory at Abo and Helsingfors, and in 1834, Director of the Prussian Observatory at Bonn, where he continued his assiduous labors until within a short time of his death.

Professor Argelander's astronomical labors were principally in the field of fixed-star observing. In this they may be described as Herculean; his survey of the northern heavens including the observation in zones of more than *three hundred thousand* stars, the charting of which has been of the greatest service in many astronomical inquiries. Nor did he fail to compare many of his observations, being thereby led to several remarkable discoveries of proper motion and variability of light of certain stars. While in Finland, he made a determination of the motion of the solar system in space, with results nearly the same as those of Sir William Herschel. His careful and comprehensive estimation, too, of the comparative magnitudes of all the stars visible to the naked eye should be mentioned (Uranometria Nova).

The Royal Astronomical Society of London marked their sense of the value of Professor Argelander's sidereal labors by the award of their gold medal in February, 1863. His last observations, so far as we are aware, were of the bright comet of Coggia, in the summer of last year.—*Athenæum*, Feb. 27.

IV. Miscellaneous Scientific Intelligence.

1. *Engineer Department U. S. Army. Progress-Report upon Geographical and Geological Explorations and Surveys west of the* 100*th Meridian in* 1872, under the direction of Brig. Gen. A. A. Humphreys, Chief of Engineers, U. S. A.; by First Lieut. George M. Wheeler, Corps of Engineers, in charge. 56 pp., 4to. Washington. 1874.—According to this report, the work performed by the expedition under Lieut. Wheeler in 1872 extended over the astronomical, topographical, meteorological, geological and natural history departments. For the determination of latitude and longitude three parties were engaged, and for topographical observations, five parties. The area covered topographically during the year exceeded 50,000 square miles, and included part of Western and Southwestern Utah, Eastern Nevada, and Northwestern Arizona. This "Progress-Report" contains historical and descriptive accounts of various mining districts and mines within the region examined, observations on irrigation for the country, and on its agricultural resources, timber lands, routes for communication, and other points of interest.

The geologist, Mr. G. K. Gilbert, states that about White's Peak, in the Schell Creek Range, Nevada, in latitute 39° 15′ north, there are the terminal moraines of five or six glaciers, 8,000 feet above the sea-level; on Wheeler's Peak, of the Snake Range, Nevada, latitude 39° north, several moraines and an alpine lake; and on Old Baldy Peak, near Beaver, Utah, in latitude 38° 18′ north, two terminal moraines. The ancient extent of the great Salt Lake,—when it stood 900 feet above its present level as proved by its elevated beach lines,—is made 18,000 square miles, which is a little less than the area of Lake Huron. Mr. Gilbert observes that, in the plateau region of the Upper Colorado, the rock-system, ranging from the Tertiary to the Devonian, is comparatively undisturbed, and denudation has left the harder beds projecting in a succession of steps. Across these steps there is a series of parallel faults which divides the steps into limited tables, that are drained by tributaries of the Colorado and Sevier Rivers.

According to the scheme for the publication of the results of the Wheeler Expeditions, the Report will include six quarto volumes, and also one topographical and one geological atlas, each 19 by 24 inches. Volume IV of the series is to contain the geology; volume V the paleontology, which is to be illustrated by numerous plates of vertebrate and invertebrate fossils; and volume VI, the natural history of the expeditions.

Numerous excellent photographs have been taken, which will be used for illustrating the geological and other volumes. They represent grandly the scenery of the Colorado and of other parts of the region under survey.

2. *Smithsonian Contributions to Knowledge*, 1874, 4to. *Miscellaneous Collections.* Vols. xi, xii, 8vo, 1874.—The very valuable series of Smithsonian publications was enlarged by the addition of three volumes during the year 1874. The volume of Contributions contains Problems of Rotary motion presented by the Gyroscope, the Precession of the Equinoxes and the Pendulum, by Brevet Maj. Gen. J. G. Barnard; a contribution to the History of the Fresh-water Algæ of N. America, by H. C. Wood, Jr., M.D., with 21 plates, many of them colored; an investigation of the Orbit of Uranus, with general tables of its motion, by Simon Newcomb.

Vol. xi, of the Miscellaneous Collections, contains memoirs on the Arrangements of Mammals and Fishes, by Dr. T. Gill (200 pp.); monographs of N. A. Diptera, by H. Lœw (376 pp.); on collecting and preserving Insects, by A. S. Packard, Jr. (60 pp.); New N. A. Coleoptera, and classification of the Coleoptera, by J. L. LeConte (146 pp.).—Vol. xii contains a Review of American Birds in the Smithsonian Museum, by S. F. Baird (484 pp.); the Constants of Nature, Part I: Specific gravities, Boiling and Melting Points and Chemical Formulæ, by F. W. Clarke (272 pp.); on Telegraphic Announcements of Astronomical discoveries, by Joseph Henry (4 pp.).

3. *Chemical Examination of Alcoholic Liquors;* by Professor A. B. PRESCOTT. 108 pp., 12mo. New York. 1875. (Van Nostrand.)—Professor Prescott has supplied a want long acknowledged in our chemical literature by this concise and well arranged little manual. The special acts of legislation on the subject of alcoholic liquors and wines, their adulteration and falsification, which now slumber in the statute books of this country, have been framed with so little skill or with such bigotry or partizanship as to be practically inoperative. The importance to society that all articles used as foods, medicines, or beverages should be held subject to strict scientific examination by authority of law, and that the frauds now practiced should be systematically exposed and suppressed, is such as to admit of no debate. These frauds, pernicious to health or life, are by no means confined to alcoholic beverages. And the analyist will find assistance in meeting them, not only in this Manual of Dr. Prescott, but also through the use of the Outlines of Proximate Organic Analysis, by the same author, already noticed. B. S.

4. *Appleton's Cyclopedia.*—The American Cyclopædia: a Popular Dictionary of General Knowledge. Edited by GEORGE RIPLEY and CHARLES A. DANA. Vols. I—X, 1873–1875. Royal 8vo. New York.—It is now twelve years since the first edition of Appleton's American Cyclopedia was finished. It was followed in the eleven succeeding years by as many "Annual Cyclopedias," uniform with the original work, in sixteen volumes. Although much the larger part of these volumes is properly given to historical, political, civil, military and social affairs, including biography,

statistics, commerce, finance, and literature—science has by no means been neglected, as we have in successive years pointed out in our bibliographical notices.

The new edition of this work, of which ten volumes are now ready, was undertaken in 1873. No decade of this century has been marked by more rapid advances in science than that covering the interval between these two editions; and equally remarkable have been the social and political changes. To fuse all the new material, thus rapidly accumulated, with the old, into a homogeneous and compact unity, has required the recasting of the whole work. Of course a large number of writers and revisers have been busy in preparing the eight or nine thousand closely printed pages in the ten volumes already published. Many of these articles are brought down to date, with a completeness not found in the first edition; while, as far as we have examined the several volumes, the matter of former scientific and technical articles has been extensively revised with care and good editorship. The geographical maps introduced add greatly to the value of the Cyclopedia, and the wood-cut illustrations are numerous and well selected. A considerable number of names of authors, not before contributors to the Cyclopedia, now appear in connection with articles on various scientific topics. The authorship of some of the physical, chemical, geological, and technical articles is as follows: Count L. F. de Pourtalès, of the U. S. Coast Survey, Prof. J. E. Hilgard, Dr. Thomas M. Drown, Prof. Cleveland Abbé, Dr. Rossiter W. Raymond, Dr. T. S. Hunt, Dr. A. M. Mayer, Dr. Joy, and Dr. Charles L. Hogeboom. Many of the astronomical articles are from the pen of Mr. Richard A. Proctor, of England.

The tenth volume ends with "Magnet," by Cleveland Abbe.

B. S.

5. *Transactions of the American Institute of Mining Engineers.* Vol. ii. May, 1873, to Feb., 1874. 331 pp. 8vo, with 3 plates. Easton, Pa. Published by the Institute, at the office of the Secretary, Lafayette College.—This vigorous young society is doing good service in its published contributions of original memoirs on subjects appropriate to its purposes, many of them of permanent value, recording the results of methods and investigations of great interest to all concerned in such matters. B. S.

6. *U. S. Northern Boundary Commission*, A. CAMPBELL, Commissioner. *Natural History*, No. 1. *On the Muridæ*, by Dr. E. COUES, U. S. A., Surgeon and Naturalist of the Commission. Reissued with additions from the Proc. Acad. N. Sci. Philad., 1874. 28 pp., 8vo, 1874. Contains many valuable notes on the species.

Birds of the Northwest: a Handbook of the Ornithology of the region drained by the Missouri River and its Tributaries; by ELLIOTT COUES, Capt. and Assist. Surgeon U. S. A.—Miscellaneous publications 3, of U. S. Geol. Survey of the Territories, F. V. HAYDEN, U. S. Geol. in Charge. 792 pp. 8vo. Washington, 1874.

Texas Geological Report.—Mr. Buckley, in a recent letter to the editors, states that the heading of Devonian in his Report over a section treating of the Trenton formation (see p. 224 of this volume) was a printer's error. There is nothing in the Report to suggest this.—EDS.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

Art. XXXIV.—*Notices of Recent Earthquakes*, No. 5; by Professor C. G. Rockwood, Jr., Rutgers College.

Jan. 6, 1874.—A shock was felt at Wolfboro, N. H.

Jan. 14, 1874.—The village of Saru-Kamush, thirty miles east of Harpoot, Turkey, "was entirely destroyed, and a good many houses in villages near by were thrown down."

Jan. 19, 1874.—A slight shock at San Francisco.

Jan. 26, 1874.—Two shocks at Manchester, N. H., at 2 and 5 A. M., the first light, the second heavy.

Feb. 10, 1874.—There began a series of disturbances in Bald and Stone Mountains, McDowell County, N. C., which continued at intervals for several months. The phenomena appear to have been occasional earthquake shocks, at no time violent, but accompanied by explosive and rumbling noises, and occurring, sometimes two or three in a day, and again with intervals of several days. These increased in frequency and intensity until the night of February 22, when the most severe shock was felt. About March 17 and 26, the shocks were again of some intensity, as also on April 14 and 17. A correspondent of the New York Evening Post, writing from Spartanburg, S. C., under date of March 23, and having just visited the affected region, reported experiencing a decided shock, with a deep rumbling noise, about sundown of March 18, and another on March 19, these being all that he felt during a five days' visit. Another observer says "the sounds resembled the report made by blasting in a deep quarry or well, at first explosive and then reverberating." The shocks were most sensibly felt near the tops of the mountains, but were sometimes perceptible at distances of ten or fifteen miles, or even farther.

A paper by Gen. T. L. Clingman of North Carolina, on the volcanic character of this region, was read before the Washington Philosophical Society, July, 1874, and is noticed in this Journal, III, vol. ix, p. 55.

Feb. 12, 1874.—A shock at 6^h 30^m A. M. at Saco, Me.

Feb. 12, 1874.—Two shocks felt in the evening at Hilo, and also at Hamakua, Hawaii.

Feb. 15, 1874.—A shock at Copiapo, Chili

Feb. 27, 1874.—A severe shock at 10^h 40^m P. M. at Bangor and Eastport, Me.

March 12, 1874.—A slight shock at Yarmouth, Nova Scotia.

March 12, 1874.—A slight shock at Sidney, N. S. W.

March 16, 1874. — An earthquake in Southern Mexico, stated to have been "very severe" in the province of Guerrero, but slight at the city of Mexico.

April 11, 1874.—The Japan Gazette of this date says "sharp shocks of earthquake had been felt at Hamaoa, causing great alarm."

April 18, 1874.—A shock at St. Thomas, W. I.

May 3, 1874.—Letters from the Harpoot Mission, Eastern Turkey, under date of May 8, say: "Last Sabbath morning (May 3), at seven o'clock, a severe shock of earthquake was felt here and in all the plain. Houses fell in several villages, but at Haboosi, in the eastern part of the plain, the effect was disastrous." Again, under date of May 16: "The village of Haboosi, twelve miles from here, with a population of 2,500, was reduced to a heap of ruins in one minute of time, and twenty persons were killed. Not more than three or four houses are left standing. The large flat earthen roofs were thrown upon adjoining buildings, and the ruins are so commingled that it is not easy for the inhabitants to tell where are the foundations of their own houses. In other villages the disaster has been very serious, and we fear the end is not yet. Shocks continue daily."

May 5, 1874.—A sharp shock about midnight at Callao, Peru.

May 14, 1874.—A series of severe shocks about 9 A. M. at Hilo, Hawaii, and the adjacent coast. "Simultaneously with this earthquake the crater of Kilauea became more brilliant and active."

May 24, 1874.—Two sharp shocks about 2 A. M. at San Francisco.

June 11, 1874.—Two sharp shocks at 8 P. M. at San Francisco. No damage done.

June 17, 1874.—A slight shock at 12 P. M. at Salt Lake City. "There were several vibrations, the shock continuing for about ten seconds. It was plainly felt at Alta and at Granite, where a rumbling noise was also heard."

June 18, 1874.—A shock at Guayaquil, Ecuador.

June 23, 1874.—A severe shock about 9^h 25^m A. M. at Hong Kong, China. "The rumbling and trembling of the earth lasted fully fifteen seconds." The harbor was much disturbed, bells were rung and two small houses were thrown down.

June 27, 1874.—"Strong shocks" at Constantinople, Turkey.

July 7, 1874.—A strong shock at 2^h 7^m A. M at Valparaiso, Chili.

July 9, 1874.—A slight shock about 4 P. M. at Cairo, Ill.

July 26, 1874.—A shock at Vienna, Austria.

Aug. 8, 1874.—A shock in the morning at Valparaiso.

Aug. 8, 1874.—A severe shock at noon at St. Thomas, St. Kitts and Antigua, W. I.

Aug. 17, 1874.—A slight shock at Demerara, Trinidad and Grenada.

Aug. 20, 1874.—A severe shock at Yokohama, Japan.

Aug. 26, 1874.—A severe shock in the morning at Puerto Rico. "Vibrations lasted two minutes; houses rocked."

Sept. 3, 1874.—A destructive earthquake occurred in Guatemala, centering near the Volcan del Fuego. Advices from Antigua state that, since the beginning of August, slight shocks had been felt, becoming more frequent toward the end of the month. From Aug. 27, the town of Duenos, and other places near the volcano named, felt shocks at short intervals, accompanied by subterranean noises. On the night of Sept. 3, about 9 P. M. (one account says 8^h 30^m, another 9^h 18^m), the most violent shock occurred. The movement was a series of vertical and horizontal impulses combined; the direction was west to east, as noted by a swinging lamp. The shock was stated by one observer as lasting twenty-five or thirty seconds; by another as continuing in its intensity during four seconds and then gradually diminishing. Sounds like thunder were heard from the earth. Many other less violent shocks were felt during the night, the principal one at 2 A. M. In Antigua the church bells were rung by the vibration, about two dozen inhabited houses were destroyed and thirty-two lives lost. The town of Duenos was entirely ruined, and some persons were killed there and in neighboring villages. An eruption of cold compact mud issued from the heights of Cerro del Tigre, a small mountain at the base of the Volcan del Fuego, and which appears to have been the center of disturbance.

Sept. 26, 1874.—In connection with the eruption of Mt. Etna, which began Aug. 29, an earthquake occurred extending to the village of Randozza, and destroying several houses.

Oct. 7 and 12, 1874.—Severe shocks and subterranean noises near Mazatlan, Mexico.

Oct. 26, 1874.—An "unusually heavy" shock in Chili about $0^h\ 12^m$ A. M. Its duration was about thirty seconds and direction east to west. The Director of the National Observatory reports that it was followed by a rise of 2°·2 of the thermometer.

Nov. 11, 1874.—Trembling and subterranean rumbling at Guanajuato, Mexico. Many houses injured.

Nov. 12, 1874.—A slight shock about 10 P. M. at Virginia City, Nev.

Nov. 13, 1874.—Two shocks, each lasting ten seconds, were felt at Vera Cruz, and along the Mexican coast. Several houses were destroyed. Shocks continued to be felt at intervals for at least ten days.

Nov. 13, 1874.—A slight shock at Guayaquil, Ecuador.

Nov. 24, 1874.—A slight shock at Salem, Newburyport and throughout Essex County, Mass. Direction west to east.

Nov. 29, 1874.—Two heavy shocks at Oreana, Nev.

Dec. 10, 1874.—A somewhat severe shock was felt throughout Westchester and Rockland Counties, N. Y., and Bergen County, N. J. It extended as far as Peekskill on the north and Norwalk, Conn., on the east. The time is stated generally as half-past ten P. M. (one observer giving $10^h\ 23^m$). The duration is variously estimated from three seconds to one minute, the majority, however, putting it at five or six seconds. The direction of the vibration appears to have been from northwest to southeast, the reports being about equally divided between west, northwest and north, only one observer giving northeast. The shock was most severe in the neighborhood of Tarrytown and Nyack, but did no damage anywhere. It was at all places accompanied by subterranean noises, which are described as a long rumble ending with a violent explosion.

Jan. 7, 1875.—A shock at Valparaiso, Chili.

Jan. 18, 1875.—A shock in Ecuador.

Feb. 7, 1875.—Three shocks at San Francisco, the first about 2 A. M., the second at $10^h\ 45^m$ A. M., lasting two seconds, with the motion vertical and vibrations north and south; the third at $11^h\ 45^m$ A. M., not so heavy as the preceding.

Feb. 9, 1875.—Three slight shocks at Preston, Conn., not felt across the river in Norwich.

Feb. 11, 1875.—An earthquake at Guadalajara, Mexico, extending to San Cristabal and destroying houses in both places.

March 10, 1875.—A shock at 12 M. in the vicinity of Issequena, Goochland County, Va.

My thanks are due to John M. Batchelder, Esq., of Boston, for information received.

New Brunswick, N. J., March 20, 1875.

ART. XXXV.—*On Dr. Koch's Evidence with regard to the Cotemporaneity of Man and the Mastodon in Missouri;* by JAMES D. DANA.

THE evidence of the cotemporaneity of Man and various extinct Quaternary Mammals in Europe and Great Britain is complete: that is, it is beyond reasonable doubt or question; for (1) it has been gathered with great care by the best of geological observers; (2) it has been verified through the re-examinations of reported cases by other able geologists; and (3) it has been further verified by the special investigations of committees of scientific societies.

The North American facts thus far announced have not, unfortunately, the same broad basis for confidence.

Among the earlier of the reported discoveries are the two in Missouri, brought out by Dr. Koch. The account of them has often been cited by writers on the subject; and Mr. J. W. Foster, in his "Pre-Historic Races of the United States of America," prefixes to the citation the remark that Dr. Koch, at an interview with him, during the last year of his life, assured him, "in the most solemn and emphatic manner, that his statement was true." Mr. Foster also observes that "to deny the accuracy of his statement is to accuse him of having attempted to perpetrate a scientific fraud,"—a decision not sustained by the ordinary rules or treatment of evidence; for Science has constantly to guard itself against the assertions of men who are honest, but are not experienced in scientific investigation, and, in all such cases, rightly asks for corroborating testimony. Moreover, Dr. Koch's statement of his facts may be true, and still his conclusion as to their proving the cotemporaneity of Man and the Mastodon in North America be wrong.

The question which American Science should carefully consider — as carefully and guardedly as has been done for similar cases in Europe — is, whether Dr. Koch was a competent observer, and whether his observations are a sufficient basis for the conclusion that has been drawn from them.

I have before me four pamphlets by Dr. Koch, dated, severally, 1841, 1843, 1845 and 1853. They relate to his discoveries in this country — the first two of them to his *Missourium*, and the others to his *Hydrarchos*, or, as these publications call it,—his *Hydrargos*, or species of *Hydrachen*. The following are copies of their title pages, commencing with the earliest:

Description of the MISSOURIUM, or MISSOURI LEVIATHAN, together with its supposed habits; Indian traditions concerning the location from whence it was exhumed; also, comparisons of the Whale, Crocodile, and Missourium with the Leviathian, as described in the 41st Chapter of the Book of Job; by Albert Koch. 16 pp. 8vo. St. Louis, 1841. [1840 on the cover, indicating that the copy is from a second edition.]

Description of the MISSOURIUM THERISTOCAULODON (Koch), or MISSOURI LEVIATHAN (Leviathan Missouriensis), together with its supposed habits and Indian traditions; also, comparisons of the Whale, Crocodile and Missourium with the Leviathan, as described in the 41st Chapter of the Book of Job; by Albert Koch. Fifth edition enlarged. 28 pp. 8vo. Dublin, 1843. [A "third edition" of 24 pages appeared in London in 1841.]

HYDRARGOS, or GREAT SEA SERPENT OF ALABAMA, 114 feet in length, 7,500 lbs. weight, now exhibiting at the Apollo Saloon, 410, Broadway. Admittance 25 cents.—Description of the HYDRARGOS SILLIMANII (Koch). A gigantic fossil Reptile, or SEA SERPENT: lately discovered by the author in the State of Alabama, March, 1845. Together with some geological observations made on different formations of the rocks during a geological tour through the Eastern, Western and Southern parts of the United States, in the years 1844–1845; by Doctor Albert C. Koch, Corresponding Member of the Societies of Halle, and of Dresden, &c. 16 pp. 8vo. New York, 1845. [Following this, Dr. Koch published at Berlin, in 1845, a book of 99 pages, with 8 plates, entitled "Die Riesenthiere d. Urwelt," giving an account of his Mastodontoid discoveries in America.]

Description of the family of Animals now extinct, but known to the scientific world under the appellation of HYDRACHEN:* these animals, when living, were the most gigantic, powerful and horrible beasts of prey that ever ruled over and spread terror through the primitive Oceans; also an account of the discovery of the ZEUGLODON MACROSPONDYLUS of Müller, and of the remains of Hydrachen in general; by Dr. Albert Koch, Corresponding Member of various Scientific societies. 12 pp. 8vo. New Orleans, 1853.

The *first* of these pamphlets was printed when the MISSOURIUM was on exhibition at St. Louis in 1840, 1841; the *second*, when the skeleton was in Ireland, it having been taken to London in 1841; the *third*, when Dr. Koch's first collection of ZEUGLODON remains was arranged and on exhibition as the "Hydrargos" in New York; the *fourth*, after this first Zeuglodon collection had been carried (in 1845) to Europe, and purchased (in 1847) for the Royal Anatomical Museum at Berlin

* In this change of name from *Hydarchos*, the *Water-Chief* (the suggestion, no doubt, of some friend, since he never wrote it right), to *Hydrachen*, a word that looks as if made up from the Greek word for *water* and the German for *dragon*, Dr. Koch evidently intended to adopt Müller's German term for the family, *Hydrarchen*.

(where it was studied by Müller); and after another "Hydrargos" had been obtained by Dr. Koch (in 1848), in the vicinity of "Washington Old Court House, Washington Co., Alabama," and had been transported (1) to Dresden (where, through "eight months' faithful labor," it was set up by the 6th of May, 1849), and also (2) to Breslau, (3) to Vienna (1850), and (4) to Prague, and at each place put on exhibition; but not to Munich, because "the only saloon disposable was too small for the exhibition;" and, finally, had come back to its native country, "after it had established its just fame in Europe" as one of the "Hydrachen," and been put on exhibition in New Orleans.*

Still other accounts of earlier date are at hand in this Journal, vols. xxxvi and xxxvii of 1839; the *first* (vol. xxxvi, p. 198) cited from a newspaper article of January, 1839, which was evidently written by Dr. Koch (then Mr., the title of Doctor appearing first in 1845); the *second* (vol. xxxvii, p. 191), signed "A. Koch, *Proprietor of the St. Louis Museum*," and credited to the "St. Louis Com. Bulletin of June 25," 1839.

Further, a note on the bones at St. Louis collected by Mr. Koch was presented to the American Philosophical Society, in October, 1840, by Dr. W. E. Horner, and an abstract from the Proceedings of that Society is cited in vol. xl, (1841) of this Journal.

It is evident from these documents that Dr. Koch was a man of enterprise, "an indefatigable collector." The credit is also due him of having performed a great service to science by his collections; for these included one of the best skeletons of the Mastodon that has been unearthed and two nearly complete skeletons of Zeuglodon, besides portions of other Mastodon and Zeuglodon individuals. Dr. Koch's "St. Louis Museum" contained, in 1840, according to Dr Horner, "200 or more teeth of the Mastodon and American Elephant, a dozen or more lower jaws of the Mastodon, with very numerous specimens of other parts of the head and skeleton generally, though no perfect head;" "the skeleton nearly complete of a Mastodon;" and, besides, "the head of an animal which Mr. Koch calls nondescript," which Dr. Horner thought to be that of a Mastodon, and another interesting Mastodon relic, "denominated by the proprietor (Dr. Koch) *Missourium Kochii*."

The two cases of the discovery of human remains along with those of the Mastodon, mentioned by Dr. Koch, are described in the pamphlets published in London and elsewhere abroad; in the Transactions of the St. Louis Academy, vol. i, p. 61, 1857;

* The skeleton was on exhibition in St. Louis as early as 1855 or 1856, as stated in this Journal, II, xxi, 146, 1856; was there, as I learn from Dr. Lapham, sold to the Museum (Curiosity shop); and thence, later, taken to Wood's Museum in Chicago, where it ended its remarkable career in the great fire of 1871.

and the *first* of the cases at an earlier date in a newspaper article of January, 1839, cited in vol. xxxvi of this Journal (1839). This earliest account was written by Dr. Koch himself, the discoverer, for it is all in the *first* person; and, as it appeared within a few months of the discovery, it best deserves citation. It is therefore here republished, and after it, that of the *second* case, from the pamphlet of 1843.

I. "It is with the greatest pleasure the writer of this article can state, from personal knowledge, that one of the largest of these animals has actually been stoned and buried by Indians, as appears from implements found among the ashes, cinders, and half burned wood and bones of the animal. The circumstances are as follows:

"A farmer in Gasconade County, Missouri, lat. 38°20′ N., lon. 92° W., wished to improve his spring, and in doing so, discovered, about five feet beneath the surface, a part of the back and hip bone. Of this I was informed by Mr. Wash [Walsh, in pamphlet of 1843], and not doubting but the whole, or nearly the whole skeleton might be discovered, I went there and found as had been stated, also a knife made of stone. I immediately commenced opening a much larger space; the first layer of earth was a vegetable mould, then a blue clay, then sand and blue clay. I found a large quantity of pieces of rocks, weighing from two to twenty-five pounds each, evidently thrown there with the intention of hitting some object. It is necessary to remark, that not the least sign of rocks or gravel is to be found nearer than from four to five hundred yards; and that these pieces were broken from larger rocks, and consequently carried here for some express purpose. After passing through these rocks, I came to a layer of vegetable mould; on the surface of this was found the first blue bone, with this a spear and axe; the spear corresponds precisely with our common Indian spear, the axe is different from any one I have seen. Also on this earth was ashes, nearly from six inches to one foot in depth, intermixed with burned wood, and burned bones, broken spears, axes, knives, &c. The fire appeared to have been the largest on the head and neck of the animal, as the ashes and coals were much deeper here than in the rest of the body; the skull was quite perfect, but so much burned, that it crumbled to dust on the least touch; two feet from this, was found two teeth broken off from the jaw, but mashed entirely to pieces. By putting them together, they showed the animal to have been much larger than any heretofore discovered.

"It appeared by the situation of the skeleton, that the animal had been sunk with its hind feet in the mud and water, and unable to extricate itself, had fallen on its right side, and in that situation was found and killed as above described, consequently the hind and fore foot on the right side, was sunk deeper in the mud, and thereby saved from the effects of the fire; therefore I was able to preserve the whole of the hind foot to the very last joint, and the fore foot all but some few small bones, that were too much decayed to be worth saving. Also between the rocks that had sunk through the ashes, was found large pieces of skin, that appeared like fresh tanned sole leather, strongly impregnated with the ley from the ashes, and a great many of the sinews and arteries were plain to be seen on the earth and rocks, but in such a state as not to be moved, excepting in small pieces, the size of a hand, which are now preserved in spirits.

"Should any doubts arise in the mind of the reader, of the correctness of the above statement, he can be referred to more than twenty witnesses, who were present at the time of digging."—*This Journal*, 1839, xxxvi, 198.

The statements respecting this discovery in the pamphlet of 1843 agree in the main with the above. There is the additional information that the excavation took place in October, 1838; and that the locality was within 300 yards of the Burbois (rightly Bourbeuse) River; but nothing is said of the "large pieces of skin that appeared like fresh tanned sole-leather strongly impregnated with the ley from the ashes," or of "the sinews and arteries" that "were plainly to be seen on the earth and rocks," portions of "which are now preserved in spirits."

II. "The second trace of human existence with these animals, I found during the excavation of the Missourium. There was embedded, immediately under the femur or hind leg bone of this animal, an arrow-head of rose-coloured flint, resembling those used by the American Indians, but of a larger size. This was the only arrow-head immediately with the skeleton: but in the same strata at a distance of five or six feet, in a horizontal direction, four more arrow-heads were found; three of these were of the same formation as the preceding; the fourth was of very rude workmanship. One of the last mentioned three was of agate, the others of blue flint. These arrow-heads are indisputably the work of human hands. I examined the deposit in which they were embedded, and raised them out of their embedment with my own hands.

"The original stratum on which this river flowed at the time it was inhabited by the Missourium Theristocaulodon (and up to the time of its destruction), was of the upper green sand. On the surface of this stratum, and partly mingled with it, was the deposit of the before-described skeleton. The next stratum is from three to four feet in thickness, and consisted of a brown alluvium of the *Eocene* region, and was composed of vegetable matters of a tropical production—it contained all the remainder of the skeleton.

"Most of these vegetables were in a great state of preservation, and consisted of a large quantity of cypress burs, wood and bark, tropical cane, ferns, palmetto leaves, several stumps of trees, and even the greater part of a flower of the strelitzia class, which, when destroyed, was not full blown. There was no sign or indication of any very large trees, the cypresses that were discovered being the largest that were growing here at the time. These various matters had been torn up by their roots and twisted and split into a thousand pieces, apparently by lightning, combined with a tremendous tempest or tornado; and all were involved in one common ruin. Several veins of iron pyrites ran through this stratum.

"The next over this formation was a layer of plastic clay of the Eocene region, also with iron pyrites—it was three feet in thickness. Over this was a layer of conglomerate, from nine to eighteen inches in thickness; over this a layer of marl of the Pliocene region, from three to four feet in thickness; next a second conglomerate, from nine to eighteen inches in thickness; this was succeeded by a layer of yellow clay of the Pliocene; over this a third layer of conglomerate, from nine to eighteen inches in thickness; and at last the present surface, consisting of a delta, or alluvial deposit, formed by the river, consisting of brownish clay, mingled with a few pebbles, and covered with large oak, maple and elm trees, which were, as near as I could ascertain, from 80 to 100 years old. In the center of the above-mentioned deposit was a large spring which appeared to rise from the very bowels of the earth, as it was never affected by the severest rain, nor did it become lower by the longest drought."—*Dr. Koch's Pamphlet of* 1843, pages 27, 13 and 14.

The first question before us is: Whether the observations and conclusions in the above statements may be accepted with confidence because made by a geologist, or a man of scientific training?

In the account of the second case above cited, Dr. Koch says that the Missourium was embedded in "a brown alluvium of the *Eocene* region" resting on the "upper green sand;" that next over it there was plastic clay of "the Eocene region" and beds of "the Pliocene region." He thus makes his Missourium to have come from the Lower Tertiary, and from a bed just above the upper green sand (Cretaceous), when actually from Quaternary beds; and he uses the terms *Eocene* and *Pliocene* as if he had no familiarity with geological facts or language. The earlier pamphlet of 1840 avoids this bad geology, the "upper green sand" in that being called simply quicksand, and the other beds merely beds of clay and conglomerate. All the pamphlets sustain the conclusion that Dr. Koch knew almost nothing of geology, and that what he gradually picked up from intercourse with geologists he generally made much of, but seldom was able to use rightly.

In zoölogical knowledge he was equally deficient. The account of the Missourium, in the pamphlet of 1841, recognizes a resemblance to the Mastodon and Elephant; but, notwithstanding this, it says that "his feet were webbed;" that he had "been without doubt an inhabitant of water courses such as large rivers and lakes," as his webbed feet, solid bones without marrow, short and thick legs, flat and broad tail, etc., proved; that his curving tusks, 10 feet in length, "were carried by him almost horizontally [as represented on the cover of the pamphlet of 1843], so that it would be impossible for him to exist in a timbered country;" that his food (the teeth having before been described rightly as eight in number, "four upper and four lower") "consisted as much of vegetables as flesh, although he undoubtedly consumed a great abundance of the latter;" that he "*was capable of feeding himself with his forefoot, after the manner of the beaver or otter*;" and that he "possessed, also, like the hippopotamus, the faculty of walking on the bottom of waters and rose occasionally to take air;" that "the singular position of the tusks* has been wisely adapted by the Creator for the protection of the body from the many injuries to which it would be exposed while swimming or walking under water; that it appears that the animal was covered with the same armor as the alligator, or perhaps the megatherium."

Later in the pamphlet, he goes on with his conclusions and says: "After having examined this subject in all its bearings, I have come to the conclusion that the *leviathan*—described in the 41st chapter of the book of Job—is none other than the Missourium here described, and from this time I shall call it the *Missouri Leviathan* (*Leviathan Missourii*)."

Next follows a comparison with the account of Job, taking up the several verses in order. On the first, "Canst thou draw out Leviathan with a hook?" he says: "The Missourium, as I have described, was a creature of enormous magnitude, ferocity, and strength, as well as fleetness in swimming; and by reason of his great weight and strength could attack the largest animals with impunity and overcome them with ease; nor is it probable that any combination of human force was able to draw him out of his native element." The sentence "Who can come to him with his double bridle?" has the following exposition: "The tusks coming out of the head until they arrive at a parallel with the nose, then turning suddenly back and forming a semicircle around the head (like a shield to prevent anything from approaching it), and measuring from point to point in a straight line over the head 15 feet; it can be seen at once how utterly futile would be any attempt to cast a bridle over him."

Dr. Koch closes this exposition and his pamphlet with a paragraph explaining how the "Leviathan, which is described as being an inhabitant of Asia, came to be found in the extreme west of the globe."

* The position which one chanced to be in when the Missourium was exhumed, In the newspaper article by Mr. Koch, cited in this Journal at p. 191 of vol. xxxvii, a *Mastodon* is reported as having been found with the tusk in this position, and "Koch's Missourium" is mentioned as a nondescript animal, the head of which he found near the same place.

The Dublin pamphlet of 1843 shows some gain in knowledge; but the author still holds that the Missourium was not solely herbivorous; that its tusks curved outward horizontally; that it "waded frequently at the bottoms of the former gigantic rivers and lakes of the west;" that "the ribs resembled more those of the Reptilia than those of the quadrupeds, being situated half reversed in the body [Dr. Koch's misplacement of them]; that is, the lower edge of the rib bends in toward the intestines, and the upper edge out toward the skin" (as stated *also* in the pamphlet of 1840); and he ends off with the same detailed "comparison of the Leviathan with the Missourium," and the same explanation of how such an Asiatic inhabitant came to be found "in the extreme west of the globe."

Now this web-footed aquatic animal, capable of feeding himself with his forefoot, was no other than the *American Mastodon*, whose forefeet were as good for putting food into its mouth, or picking its teeth, as any Elephant's. The specimen taken to England, in 1841, as the Missourium, and which Professor Owen says was "well-known to the public as the *Missouri Leviathan*, when exhibited with a most grotesquely distorted and exaggerated collection of the bones in 1842 and 1843 in the Egyptian Hall, Piccadilly," is now (1846), he adds,* an almost complete skeleton of "the *Mastodon giganteus*, mounted in strict accordance with its natural proportions in the British Museum;" and a representation of it, copied from Owen, is the figure of the Mastodon on page 566 of the writer's Manual of Geology.

It is pretty plain that Dr. Koch had not been trained to scientific investigation. This is equally obvious from his two pamphlets on the "Hydrargos."

(1) The skeleton exhibited in New York in 1845, and described in the pamphlet of that date, was 114 feet long, and this was at least 35 feet longer than nature—the vertebræ gathered by him in Alabama having been all strung together into one long "Hydrargos," though belonging really, as Dr. Jeffries Wyman announced, to individuals of different ages, and according to Müller, to at least two species (*Zeuglodon macrospondylus* and *Z. brachyspondylus* of Müller).

(2) The head was in part a piece of bad patchwork; Dr. Wyman stating in his notes, made after a careful examination,† that the cranium proper (the part over the brain) was made out of a single piece of bone without sutures, leading to the supposition that it was not the true cranium, an inference sustained, he says, by there being no foramen for the passage of the spinal

* History of British Fossil Mammals and Birds, by Richard Owen, F.R.S., etc., London, 1846, page 298.

† Proceedings Boston Nat. Hist. Soc., 1845, p. 65. In this Journal, II, ii, 129 (1846), where Dr. Wyman's article is noticed by B. Silliman, Jr., there is a figure of the remarkable head.

marrow, and no larger space for the brain than that for the spinal cord on the upper side of some of the vertebræ; and by the amount of cement, which left little or nothing of the under surface in sight.

(3) The extremities of the so-called paddles were formed, says Dr. Wyman, of *casts of* "*a species of Nautilus.*"

The Hydrargos or Hydrachen pamphlets hence do not require any modification of the opinion that Dr. Koch had not been trained to scientific investigation.

But on this point we have the opposing assertion of Dr. Koch. Being in a foreign country, where he had to make himself known, he opens his pamphlet of 1843 with the following introduction of himself to the public:

"Previous to my commencing this Treatise, I wish particularly to mention that I have not only devoted the greater part of my life to the theoretical study of Natural History, but have also made myself intimately acquainted with the practical part of it."

Still, we are unable to set aside the facts presented in the preceding pages and the opinion to which they have led, and therefore feel forced to take this introductory paragraph differently from what the author intended, and gather from it that Dr. Koch was a man of large pretensions. This same impression is conveyed by the account of his scientific travels in North America, which occupies the following six pages. I give an example. On the third of these pages he describes the era of the "mighty Missourium" and "ponderous Mastodon" as a time when, according to "every geological research," the earth's surface was "uninterrupted by any of the rough, broken, rugged deformities which now present themselves on every side," when "the climate was free from noxious vapors," and all was "delightful," etc.; and then dwells on the sudden dreadful change when "the ground was cursed for man's sake" and "all those gigantic creatures perished," and "the garden of delicious fruit trees and blooming flowers was converted into a gloomy forest of thorns and thistles." He also gives us his idea as to the nature of the great catastrophe, as follows: "The principal instrument used to cause this change, according to my views, was a certain Comet that came in contact with our globe, which caused not only a different position of our earth, but also the interior fire and water to come into an immediate violent collision, which created a revolution, that naturally sought for vent, and therefore burst through the crust of the quivering earth, tore up countries and sank them in the sea."

This is enough to prove that these pages do not sustain his large claim.

Holding, then, to the conclusion that Dr. Koch was quite ignorant of geology and without scientific training, we are forced to doubt, to doubt strongly, his direct and definite statement that he had devoted the greater part of his life to "the theoretical study of Natural History" and had made himself "intimately acquainted with the practical part of it." It is true that he knew about the earlier part of his own life better than any other person then living. Any way, he certainly overrated almost infinitely the results on himself of so prolonged study. This much we are disposed to allow in favor of his sagacity: that Dr. Koch appreciated the absurdity of the Leviathan story, and introduced it, after some thought about the people he was among, merely to get a full house for his Missourium; and that his attempted show of scientific knowledge had the same end in view. If this supposition is unjust to him, the other alternative explanation has to stand. In his New Orleans "Hydrachen" pamphlet (1853), the inside pages of the cover contain a long cited article* which makes the Zeuglodon the Leviathan of Job—thus showing apparently that his previous convictions were not too strong for a change of opinion, especially after the Missourium had turned into a Mastodon.

The special statements respecting the mode of occurrence of the human relics cited on pages 338 to 340 remain for consideration.

In the account of the deposits which afforded the Missourium, Dr. Koch speaks of "the present surface as consisting of a delta or alluvial deposit," which suggests a doubt as to whether the overlying beds of sand and pebbles may not have been of very recent formation through river action. It is not made certain that they were true Champlain deposits. He says that one arrow-head lay "immediately under the femur or thigh-bone," and he further states, in his later article of 1857, that he "carefully thought to investigate" the point as to its having "been brought thither after the deposit of the bone," and decided against it. The observation and conclusion would have been more satisfactory had the author of them been a better observer.

The description of the deposits in Gasconade County, containing the remains of an animal "the principal part of which had been consumed by fire," is a still more unsatisfactory basis for a safe conclusion as to age. But in the article of 1857 he says that "the layer of ashes, etc., was covered by strata of alluvial deposits consisting of clay, sand and soil from eight to nine feet thick *forming the bottom of the Bourbeuse* [*River*] *in*

* It is headed "From the New York Evangelist," and must have been written in 1845, when the skeleton was on exhibition in New York City. The author's name is not given.

general," which seems to make it almost certain that the beds were of quite recent origin. Neither in the account of 1839, nor of 1843, is the kind of animal mentioned, that of 1843 saying that "they were the remains of an animal which had clawed feet and was of the size of an elephant," and "that the construction of the foot [fore foot] shows that it possessed much power in grasping and holding objects;" but in that of 1857 he says "the bones were sufficiently well preserved to enable one to decide positively that they belong to the *Mastodon giganteus.*"

The tragic part of the story—about the elephantine beast having been burnt alive by the Indians after they had used their bows, and also thrown more than 150 great pieces of rocks "two to twenty-five pounds in weight" at him in vain,—is an hypothesis in keeping with the rest of his documents. A fire kindled about the shoulders of a mired Mastodon would have taken long to get through the hide and muscle so as to char the bones; and an Indian's appetite would have been pretty sure to have stopped the cooking short of this charring. The charring might have been done very long after the miring and death of the animal, and the facts be all as they are reported. The remark that "the greater portion of the bones had been more or less burned by fire" favors the idea that the fire was made about the bones at some time between the era of the Mastodon and the present time, and not about the living body.

The failure to repeat, in either of the later accounts, the early statements respecting the large pieces of skin that appeared like fresh tanned sole-leather," and the "sinews and arteries plain to be seen on the earth and rocks," shows that he afterward doubted and rejected this part of his observations; and this unavoidably suggests some doubt as to the other points; even to questioning whether the charring was not in fact only a blackening in color due to burial in the marsh—a very common effect from such a cause; whether the crumbling was not a result of that natural decay which so generally befalls old bones; and whether the stone implements found were not small oblong stones of nature's chipping or polishing.

Thus stands the evidence. If the statements respecting the deposits had been published by a good geologist with no more of detail, and without any special effort afterward to make all things positive, there would be some room for doubt, considering the many chances of error that exist. But in the present case they were not made by a good geologist; they were not made by one trained to investigation, or to habits of precise statement; nor by one who had a knowledge of any department of science; nor by one whose sound common sense was so obvious a characteristic as to demand consideration for his opinions and statements; nor by one wholly free from pretense and sham.

Taking all things that have been reviewed into consideration, I think there is sufficient reason for regarding Dr. Koch's evidence of the cotemporaneity of Man and the Mastodon *very doubtful.* It is to be hoped that the geologists of the Missouri Geological Survey now in progress will succeed in settling the question positively.

The cotemporaneity claimed will probably be shown to be true for North America by future discoveries if not already so established; for Man existed in Europe long before the extinction of the American Mastodon.

ART. XXXVI.—*Bentham, On the recent Progress and present State of Systematic Botany.*

[Continued from page 294.]

As to the necessity or advantage of artificial keys to species in systematic works, when the species of a genus are brought into an order which as much as possible exhibits their natural relationships, it is seldom difficult to divide and subdivide the groups by important characters, if pains enough be taken, so that the series of subordinated divisions shall completely and practically do the work of an artificial key. The advantages are that the student's attention is fixed from the first upon the more natural characters and their combinations; also, the more thorough the subdivision, the briefer and more diagnostic may be the description of the species, since the points mentioned in the sections need not be repeated.

In this connexion we can best bring in the few remarks we have to offer upon the present tendency, which Mr. Bentham favors, to merge specific character (or full diagnosis) and detailed description into one, making of that one the latter rather than the former, and drawing it up, when Latin is used, in the nominative rather than in the ablative case. Granted that "we cannot now restrict them to the twelve-word law of Linnæus," and that "a twelve-line ablative diagnosis is an absolute nuisance," our choice is not bound to either of these extremes, and the happy medium may generally be hit. The diagnostic form is a constant enjoinder of brevity and of utmost perspicuity. The protracted specific characters which Mr. Bentham rightly deprecates generally mean slovenly work. To keep them within bounds we have only to insist upon critical grouping, and subordinated sections and subsections, such as we have just recommended. In this way we adapt the Linnæan diagnosis to our present needs, retaining all its advantages. The other course we fear will tend to prolixity and looseness, however well it may work in such judicious and practised hands as those of Mr. Bentham. Finally, if we have no diagnosis, but only a description, then the nominative case is a matter of course. If we retain the Latin diagnosis, we may well retain the ablative case, as having some advantage in succinctness, and the *prestige* of long use. A reasonable punctuation ought, however, to be settled on,—the two prevalent extremes being about equally awkward and inconvenient. A *juste milieu* is not far to seek. Even in English there is still advantage in the diagnostic form, relegating details and subsidiary or explanatory matter to a separate sentence or paragraph.

Of Linnæus's two great gifts, the binomial nomenclature and the diagnosis, we are almost as reluctant to give up the one as the other.

Upon the languages actually in use in systematic botany, Mr. Bentham has some interesting remarks, which fill three or four pages. In the preparation of this and his previous somewhat similar addresses, he had to consult botanical publications in no less than fifteen languages. Surely no other living botanist is able to do so, and to read a majority of them with facility. It is conceded that, while works intended for the beginner or amateur, or for teaching the well-known botany of a particular country, should be in the familiar language of the country, yet "purely scientific treatises, and technically descriptive works, which all botanists may have to take cognizance of, and for which the commercial demand may be too limited to ensure their translation into various languages," should be written in the one most likely to be understood by the greater number of students of all countries,—that is, in Latin; which, moreover, is "best suited for technical diagnoses and descriptions, from its concise character and from its susceptibility of being subjected to technical forms, without jarring upon the conventionalities of living languages in familiar use." To which we may add, that a sufficient, long-tried, and well-settled vocabulary has been formed from it, which cannot be readily rendered into other tongues without danger of ambiguity, except by transferring the terms themselves, as we have done, into English, the genius of our language lending itself readily to the transference. Happily, botanical English and botanical Latin are very much alike.

Modern languages are, and must needs be, more and more used for general descriptions and scientific investigations and discussions; "and of these are three which at the present day every botanist ought to understand, and in one of which [besides his vernacular] he ought to be able to write,—all three having a rich literature in every branch to repay the labor of learning them, independently of science; these are French, English, and German."

"French has long been considered the one among modern languages forming the nearest approach to a common one; it is easy, comparatively simple in construction, not overburdened with redundant words, and, above all, is readily broken up into short phrases, an invaluable qualification for clearness of methodical exposition. It has long been the recognized diplomatic language, and the first foreign one taught in most European schools; and although within my own recollection national animosities may have from time to time thrown it into disfavour in Germany and Eastern Europe, yet it always appears to recover its *prestige* there in general society. At the meetings of the botanists of various nations congregated at Florence last May, it was the general medium of intercourse, although the Frenchmen present were in a very small minority. And in every branch of science or literature to which I have paid more or less attention, it possesses more instructive elementary works, more readily intelligible treatises and clearer expositions of abstruse subjects, than any other language I am acquainted with. For the botanist, therefore, as well as for all naturalists, its study is still, and I believe will long remain, of first-rate importance.

"The English language has of late years been recommended by more than one continental naturalist for general adoption as a vehicle for international scientific intercourse. It partakes of some of the advantages of both the French and the German. Though less brilliant, it offers more variety than the former, it is less involved than the latter, and it appears to be capable of giving more precision and force to argument than either. It is now the national language of the largest proportion of the civilized population of the globe, and its use continues steadily to spread out of Europe generally, and to a certain extent among European naturalists and other educated classes, especially in eastern and northern Europe. They begin to admit the necessity of consulting our untranslated treatises and memoirs, and our German and east European botanical correspondents, at least, accept English letters as readily as French. In southern Europe French is still much more generally understood; but even there the objections to the extended use of our language for botanical works have now, I believe, lost much of their force.

"The German is a more difficult language, much more difficult, indeed, for the Latin nations of southern and western Europe than for ourselves. Its construction is involved, its extraordinary copiousness occasions a strain upon the memory; but it affords great facilities for giving expression to minutely distinguished details, whether of fact or of thought. It may thus frequently give greater solidity to their theoretical expositions than the French, but is infinitely more difficult to translate; and to those who are not thoroughly used to its intricacies it seems to foster, if not to create, confusion of ideas. Germany has now, however, so long included so many publishing centres of scientific importance, and its language has been so generally used by Scandinavian and Sclavonian, as well as by their own naturalists, that a sufficient acquaintance with it, to study the very numerous works it produces, can no longer be dispensed with by the general botanist."

Mr. Bentham goes on to consider the principal classes of works in systematic botany, recently published or in progress, under the heads: 1. of *Ordines Plantarum*, or the like,—of which Lindley's Vegetable Kingdom (very great in its merits and its faults) was the most complete and elaborate, and Le Maout and Decaisne's *Traité de Botanique* (and especially Dr. Hooker's English edition) the only modern substitute, and indeed far better in the way of structural exposition. But it covers less ground. Mr. Bentham rightly enough deprecates the proposed reproduction of Lindley's great work, as "scarcely fair to the memory of the talented author." To the bizarre classification and many strange and fanciful views of affinity not even Lindley's talents and ardor could give vitality and currency during his life-time. But there is a part of this thesaurus which might be reproduced, with needful additions, to great advantage, namely that which relates to the properties and uses of plants. This, well edited, would form a good-sized and surely a most useful volume,—a companion and supplement to the French work just mentioned, which is weak in this department.

Under the second head, of *Genera Plantarum*, a good account is given of the scope and plan of the work upon which Mr. Bentham is now engaged, in conjunction with Dr. Hooker. This publication began in 1862, and is now, it may be said, half done. We may count upon having the second volume completed before the present year is out.

Under the third head, of *Species Plantarum*, after more remarks upon De Candolle's Prodomus, and its completion, or rather its close at the end of the Dicotyledons, Mr. Bentham raises the question whether it may not still be practicable to have a condensed Species or Synopsis Plantarum for all Phænogamous plants, within a single generation. Alphonse De Candolle's recent estimate and hopeless conclusion are familiar to us. Mr. Bentham's less discouraging view, the grounds of which are disclosed in the following extract, is largely based upon his own experience.

"Alphonse De Candolle, in the above quoted 'Reflexions,' has shown how little chance there is of a uniform 'Species Plantarum' being again undertaken with any prospect of its being brought to a successful conclusion. He calculates that it would require fifteen or sixteen years' labour of some five-and-twenty botanists, working under the direction of about eight to ten editors,—a combination which it is highly improbable will ever be practically brought to bear. His calculations may, however, be a little overcharged. He supposes that each botanist would not work up more than 300 species in a year: that may be the case in a monograph, when every detail is to be gone through from personal observation; but this would not now be necessary in a general 'Species Plantarum,' which would be most useful as a concise methodical compilation. Much of the labour expended on the 'Prodromus' and on detached monographs and floras need not be repeated. As pre-Linnæan synonyms, upon which so much time was formerly expended, have now been generally given up, so, for post-Linnæan synonyms, there would now be no use in repeating those given in the 'Prodromus' and other works compiled from, unless where errors have been detected; and this alone would save a great deal of time, labour and expense. And with regard to the greater number of the orders or genera contained in the recent volumes of the 'Prodromus' and the best modern monographs and floras, a careful and intelligent abridgment of the specific characters without reëxamination is all that would be necessary.

"It might be useful to consider what would be the requisites of any such abridged 'Species Plantarum' or 'Synopsis,' restricted within limits which should render it possible, at least as to phænogamous plants. We might expect it to follow the sequence of orders the most generally adopted, that of the 'Prodromus' and of our 'Genera Plantarum,' with such slight modifications only as the progress of science has rendered necessary, without attempting hypothetical improvements. To each order and to each genus should be given short diagnostic characters, abridged from the last 'Genera Plantarum' or other best sources, selecting chiefly those which are most essential and contrasted, but including also the most striking or the most general amongst the adaptive ones, and a general indication of geographical range, with careful reference to the works where more details are to be found. Where the orders or genera are large, a synopsis or conspectus of the principal divisions and subdivisions would be useful.

"To each species should be given:—

"(1) The name.

"(2) The diagnosis, specific character, or abridged description, which are but different names for the same thing, and which it appears to me would be always more satisfactory in the nominative than in the ablative case. After the example of Linnæus, and based upon the doctrine of the fixity of species, it has been almost universally the custom to distinguish the specific diagnosis and description, the former to contain the absolutely distinctive characters (any deviation from which would exclude a plant from the species), the latter to aid the student in identifying a plant by the enumeration of characters which, though general, might vary in the same species, or which it may possess in common with other species. In order to mark the more strongly this difference, the diagnosis, when in Latin, has been given in the form of the ablative absolute, the description in the ordinary nominative form. There is, however, nothing really absolute in nature. There is no class of characters which may not occasionally admit of exceptions: and although care should be taken to select the most important and constant ones, yet in some instances, those which are generally discarded as too variable for a diagnosis, such as dimensions, colour, &c., may yet be most useful, or even essential for the distinction of species, or even of genera. These diagnoses, moreover, to be useful should be short. We cannot now restrict them to the twelve-word law of Linnæus, but a twelve-line ablative diagnosis is an absolute nuisance.

"(3) Reference to the source whence the diagnosis is taken, to the work where a further description, the synonymy, and history of the species are to be found, and to any plates where it may be satisfactorily represented; and all further synonymy should be avoided, except where it may be necessary to refer to descriptions, names, or modifications published since the one specially abstracted from.

"(4) The habitat of the species.

"(5) Occasional notes on affinities or other points in the history of the species should be very sparingly indulged in, and only when they may assist essentially in the provisional determination and elucidation of a plant. All discussions on doubtful points and all details should be reserved for monographs or separate papers, where alone they can really tend to the advancement of the science.

"Each volume of the 'Synopsis' would of course be accompanied by a full index of genera, species, and such synonyms as it may have been found necessary to give.

"The whole work would be so indispensable to botanists of all nations, that, like the 'Genera Plantarum,' it should be entirely in botanical Latin, which, moreover, from the number of conventional expressions to which a technical meaning has been assigned, is specially suited for short diagnoses.

"No new species should be first published in this 'Synopsis.' Nothing has tended more to produce confusion in systematic botany than the publication of real or supposed new species, with short diagnoses, unattended by any full description or detailed indications of its affinities, &c. However carefully the diagnosis may be worded so as to distinguish the species from those previously published, it would be insufficient for its identification, and full descriptions would be inadmissible from the plan of the work. At the same time, it is to be expected that the author, in preparing the 'Synopsis,' should meet with new forms, which he may be desirous to make known, in order to render his work as complete as possible. But his course should be to give their full history in a separate monograph, to which, *when published*, he could refer in the 'Synopsis.' He should here not only thus avoid all addition to the numerous puzzles with which the science is overloaded from insufficient description, but strictly abstain from all mention of manuscript and other names which, according to the recognized rules of nomenclature, are not admitted as sufficiently published.

"The grade of plant-race to which the specific name and diagnosis should be attached would be the species, in the Linnæan sense, which, though not susceptible of a strict definition, is pretty generally understood amongst botanists, whether they may designate it as a true species, a Linnæan, or a compound species The 'Synopsis' might also distinguish marked varieties whose admission or rejection as species might be doubtful; but the innumerable forms variously termed varieties, subspecies, or critical species, should be passed over in silence, as their admission would simply render a general work impossible, and a more partial one comparatively useless. The enumeration and distinction of the various forms of *Brassica campestris* and *oleracea*, of *Pisum sativum*, *Viola tricolor*, &c., may be serviceable to the agriculturist or gardener, that of the forms of *Rubus fruticosus* may be interesting to the investigator of the flora of a limited district, but they are only useless encumbrances to the general systematist as well as to the naturalist in other branches who would have to make use of the 'Synopsis;' and the names and diagnoses of two hundred forms of *Draba verna* would be a simple nuisance, of no use whatever to any one.*

* "The mode of dealing with species which, in the present state of vegetation, pass into each other through a series of intermediate forms which cannot fairly be supposed to be hybrids, is well discussed by Nägeli in a series of papers in the "Sitzungsberichte" of the Munich Academy for 1866, the result of careful observation chiefly of the genus *Hieracium*. After admitting himself to have been originally a firm believer in the fixity of species and a strong advocate of the hybrid parentage of the large number of intermediate forms observed, he acknowledges his conversion to the doctrine of evolution. "In the present state of the science" he sees "no other possibility than the assumption that the species of *Hieracium* have

"Taking the species, therefore, in the Linnæan sense, we would, with Alph. de Candolle, estimate the number of Phænogams now published, or in the course of publication, from materials already in our herbaria, at between 110,000 and 120,000. A competent botanist would readily get through three or four thousand in a year. In the 'Flora Australiensis' I had no difficulty in preparing a thousand to twelve hundred in the year, and that was all original work, entailing the personal examination of every species often in numerous specimens, and a long and tedious investigation of synonyms. Such a compilation as I have above characterized would require, it is true, a competent knowledge of plants and occasional verifications; but still the labour would be reduced by at least two-thirds; and 300 species a month, with a month or six weeks' vacation, would be no great strain upon the mind. Thus three or four botanists might complete a synopsis of ten thousand species in the year; and the general synoptical enumeration of all known Phænogams would not be beyond the range of possibility, however little chance there may be of my living to see it commenced."

The doubt which rises is, whether several or indeed any botanists can be found in our day capable of turning off good work at anything like Mr. Bentham's rate, and so exceptionably well situated in respect to herbaria and libraries, and in the command of their time. Easy as the work may seem, the number of botanists who are able to elaborate a genus and draw up fairly good botanical descriptions is wonderfully small.

arisen by transmutation either from extinct or from still surviving forms, and that there are still persistent a great number of the intermediate stages (races) formed either by the original differentiation of the extinct species, or in the course of the transformation of one yet living species into the diverging forms."—*Sitzungsber.*, 1866, i, 330.

In a subsequent paper he shows that the genus *Hieracium* affords instances of great diversity in the degree to which differentiation has attained and in the definiteness of the species established by the extinction of intermediates. He instances, amongst those to which he would in their present state assign the rank of species:—

1. Aggregate forms, such as *H. Pilosella*, which cannot as yet be separated into distinct groups. *H. Hoppeanum*, Schult., *H. Pelleterianum*, Mérat, *H. Pseudo-pilosella*, Jen., are not yet sufficiently isolated by the disappearance of intermediate forms to be ranked as species.

2. Forms which, by the disappearance of closely allied ones, have attained sharper and more fixed limits, and yet between which isolated intermediates may still be found, are exemplified by *H. Auricula*, *H. aurantiacum* and *H. Pilosella*, or by *H. murorum*, *H. villosum* and *H. glaucum*. On the other hand, it is uncertain whether the relations of *H. Auricula* and *H. glaciale*, or of *H. murorum* and *H. vulgatum*, should be included in this stage, or are still in the first-mentioned category.

3. Species between which no constant intermediates survive, but which still are capable of producing intermediate hybrids, are represented by *H. alpinum* and *H. villosum*, by *H. alpinum* and *H. glaucum*, by *H. murorum* and *H. umbellatum*, &c.

4. Lastly, the three sections *Pilosella*, *Archieracium* and *Stenotheca* are races which become so far-distanced from each other that hybrid fertilization no longer takes place between them.—*Sitzungsb.*, 1866, i. 472.

The thing is quite possible if mere literary compilation is intended; but something more than this is needed.

While it would be best, and in case of a mere compilation even necessary, that new species should be first published elsewhere than in this desired "Synopsis," yet we cannot agree that, in any proper elaboration or digest of the species of a genus, "the diagnosis would be insufficient for its identification." It is just here, where the new species is brought into line with its relatives, that the diagnosis should suffice; and if a diagnosis does not serve for the new species, it may do no better for the old ones. Upon the form in which specific characters may best be cast, in a synoptical work—whether that of diagnoses, under sections and subdivisions, or of open descriptions, led to by an artificial key—we have already offered some remarks.

Mr. Bentham proceeds to discourse of monographs of orders and genera, of floras or histories of the plants of particular countries or districts (this division ending with a loud call for the North American Flora), and, finally, of specific descriptions, detached or miscellaneous. His remarks upon the latter are important and timely.

"Had I to report only on the progress, and not on the present state also, of systematic botany, I should here stop; for the great majority of recent detached and miscellaneous descriptions are almost as much impediments as aids to the progress of the science. I have too often in my Linnean Addresses, especially in those of 1862 and 1871, animadverted on the mischief they produce, to enter now into any details; I can only lament that the practice continues, and is even rendered necessary by considerations not wholly scientific. Horticulturists must have names for their new importations. It is due to travellers who, under great perils and fatigues, have contributed largely to supplying us with specimens of the vegetation of distant regions, that the results of their labour should be speedily made known; it is even important to science that any new form influencing materially methodical arrangements should be published as soon as ascertained. But all this is very different from the barren diagnoses of garden-catalogues, and the long, uncontrasted descriptions hastily got up for the futile purpose of securing priority of name. I own that I have myself erred in the want of sufficient consideration in the publication of some of the species of Plantæ Hartwegianæ; and some descriptive miscellanea, even by men who stand very high in the science (such as Miquel's 'Prolusiones,' above referred to, and Baron von Mueller's 'Fragmenta'), are rendered comparatively useless from their utter want of method. Whilst, therefore, discouraging as much as possible all such detached publications of new species, I would admit their occasional necessity, but suggest the following rules as the result of a long practical experience:—

"No detached description of a new species should be ventured upon unless the author has ample means of reviewing the group it belongs to; and if any doubts remain of its substantive validity, he should refrain from giving it a name till those doubts are cleared up.

"The description, when given, should be full, but contrasted and accompanied by a discussion of affinities with previously known species, and an indication of the place the new one should occupy in the several monographs and floras in which it would be included.

"An illustration of the new plant, with analytical details, should never be neglected where circumstances admit of it."

We would heartily second these recommendations. They are especially applicable in this country. Time is short and the work before us is heavy. One grievous impediment to its progress and trial to patience comes from the loose and rambling descriptions of species, or even genera, hastily put forth by those who have not the means of making the proper investigations and comparisons, and in some cases not the knowledge which enables them to hit the genus or even the family correctly. The best of us commit mistakes enough, but, it is to be hoped, clear up many more than we make. The road we have to traverse, and to make smooth for those who come after us, is difficult and rugged enough as it is. Shooting rubbish into it is a serious hindrance. Real aid, however, is joyfully welcomed, and no one in our day who is able, or desirous even to attempt to do systematic botanical work, has ever received aught but help and encouragement from those who have to bear the burden and heat of the day. A. GRAY.

ART. XXXVII.—*On the Influence of Color upon Reduction of Light*; by M. CAREY LEA.

IN this Journal for March of last year, I published a train of investigations which had for their object the study of the changes produced in the sensitiveness of certain substances to particular rays of light, as caused by the presence of various colored and uncolored bodies. These results were incompatible with a law shortly before announced by Dr. Hermann Vogel, as governing the action of colored bodies on the sensitiveness of silver bromide.

Dr. Vogel's law was, that to render AgBr sensitive to any ray, or to increase its sensitiveness, it is only necessary to place in contact with it a substance capable of promoting the decomposition of AgBr, and which substance must absorb the rays in question, and not other rays.*

My own conclusion was that the power of heightening sensitiveness to particular rays was one in no way connected with the color of the sensitizing body; indeed, that perfectly colorless bodies, or bodies having very pale neutral colors might also exercise the functions of heightening sensitiveness to particular colored rays.

Since the publication of my former paper, I have made further investigations, and Dr. Vogel has published a second paper. In this second paper Dr. Vogel, from whom I have regretted to differ, has to a considerable extent adopted my own views. He reaches the same conclusion, as to the power of substances destitute of color to exalt the sensitiveness of AgBr to particular rays. As this was the main result of a long investigation, and the demonstration of it the principal object of my paper (from which paper and its conclusions Dr. Vogel strongly dissented), it would have been more agreeable to me if Dr. Vogel had acknowledged it as originating with me. This, however, is a matter of small importance. Dr. Vogel does not seem to have adverted to the fact that this conclusion is scarcely compatible with his theory, formulated in the foot-note; with the alleged function of *color* as modifying sensitiveness to particular rays.

If this theory were true, it must be easy to find very numerous instances capable of supporting it, as the number of organic coloring matters capable of taking up bromine is very large. Nevertheless, three only have been brought forward by Dr. Vogel in the two papers referred to, out of which three, two at least certainly do not seem to afford the desired proof.

Coralline and naphthaline red are substances which transmit strong red light, and consequently the sum of their absorption spectra must in each case be green: to confirm Dr. Vogel's theory, they should enhance the sensitiveness of AgBr to green light. But Dr. Vogel finds an increased sensibility to *yellow* rays only. Obviously yellow cannot represent the absorption by a red color. If Dr. Vogel's law be true, a red substance *may* heighten sensitiveness to yellow, but it *must* heighten it to green.

Now with the substance principally experimented on by Dr. Vogel, coralline, I have lately made a number of trials, and have succeeded in definitely fixing its action with respect to AgBr.

* Wir im Stande sind Bromsilber für jede beliebige Farbe lichtempfindlich zu machen, respectiv die bereits vorhandene Empfindlichkeit für gewisse Farbe zu steigern; es ist nur nöthig einen die chemische Zersetzbarkeit des Bromsilbers befördernde Stoffe zuzusetzen, welcher die betreffenden Farbe absorbirt, die andern nicht.—*Ber. Deutsch. Chem. Ges.*, 1873, p. 1305.

To the red rays, including those whose wave-lengths are from $\lambda 605$ to the end of the visible spectrum, coralline very materially increases the sensitiveness of AgBr.

To the yellow rays, taking as representatives those whose wave-lengths vary only moderately from $\lambda 570$, coralline moderately increases the sensitiveness of AgBr.

To the green rays, taking principally those whose wave-lengths lie between 517 and 569, coralline gives *no increase whatever* of sensitiveness to AgBr.

So that coralline, far from being a support to the theory of Dr. Vogel, gives in fact a confirmation of my own view, viz: that substances heighten the sensitiveness of AgBr to particular rays, without the existence of any relation between the color of that ray and their own proper color.

It is a little curious that coralline acts very differently with AgI. So far from increasing the sensitiveness of that substance to red light, it actually diminishes it.

Rosaniline is another substance whose action conflicts with Dr. Vogel's law. I find that it quite destroys the sensitiveness of AgBr to yellow rays.

From all the foregoing I conclude, that there exists no relation whatever between the color of substances and the color of the ray to whose influence they modify the sensitiveness of silver bromide.

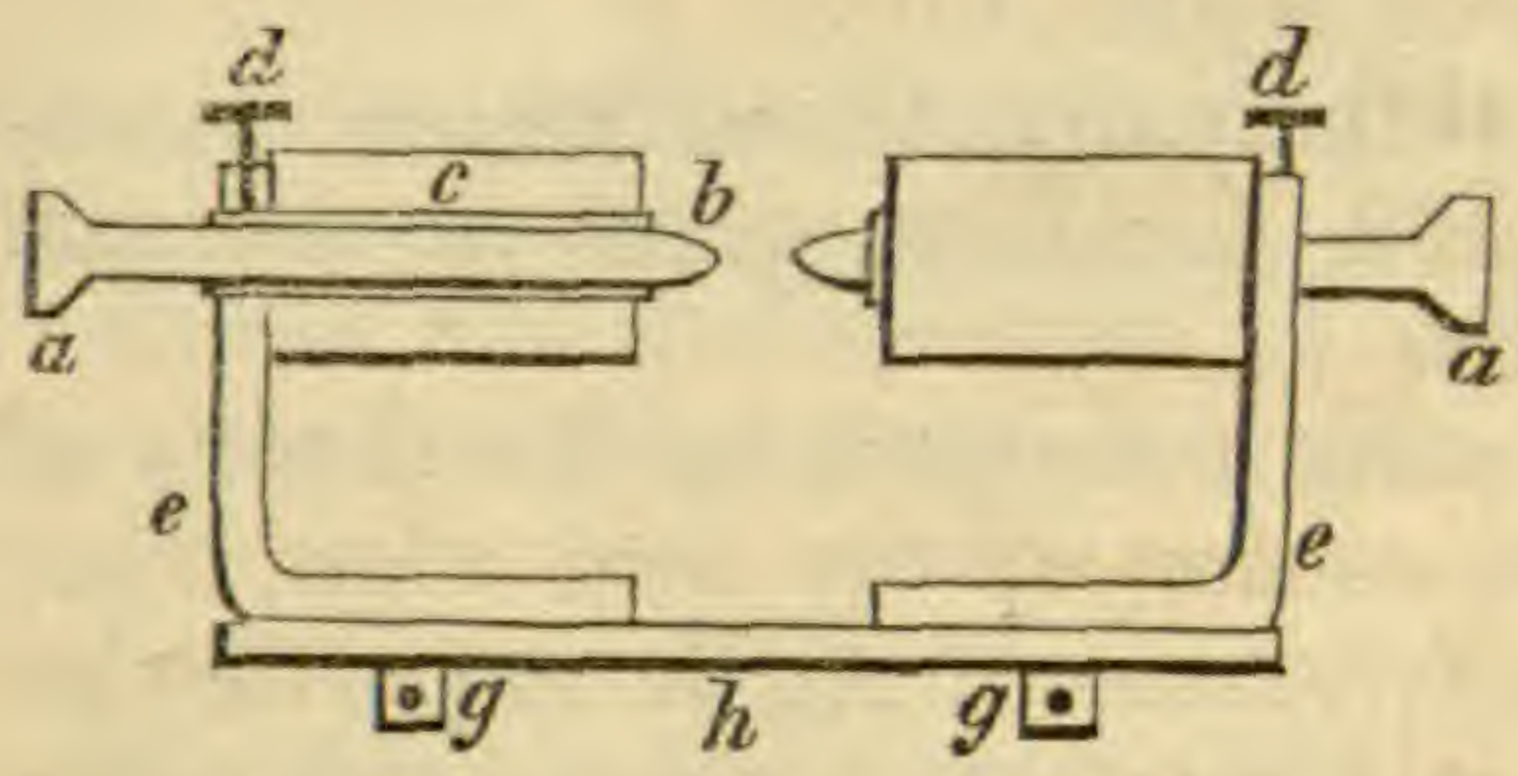
Philadelphia, March 20, 1875.

ART. XXXVIII.—*On a New Diamagnetic Attachment to the Lantern, with a Note on the Theory of the Oscillations of Inductively Magnetized Bodies;* by HENRY A. ROWLAND, Assistant Professor of Physics in the Rensselaer Polytechnic Institute.

1. *Description of Apparatus.*

SOME time ago, in thinking of the theory of diamagmetism, I came to the conclusion that apparatus of large size was by no means necessary in diamagnetic experiments, and on testing my conjectures experimentally, I was much pleased to find that they were true. So that for more than a year I have been in the habit of illustrating this subject to my classes by means of a small apparatus weighing only about a pound or two, which I place in my lantern and magnify to a large size on the screen.

The effects obtained in this way are very fine and are not surpassed by those with the largest magnets; and we are by no means confined to strongly diamagnetic substances, but, with proper care, can use anything, even the most feeble. The apparatus which I used consisted of a horseshoe electro-magnet, made of an iron bar half an inch in diameter and about ten inches long, bent into the proper form, and surrounded with four or five layers of No. 16 wire. But the following apparatus will, without doubt, be found much more convenient. It can be made of any size, though the dimensions given will probably be found convenient.



The apparatus is represented in fig. 1. To a straight bar of iron *h*, 7 in. long, $\frac{1}{4}$ in. thick, and $\frac{3}{4}$ in. wide, are attached two pieces *e e* of the same kind of iron by two set screws *g g*, which move in slots in the piece *h*. Into these pieces are screwed two tubes *c* made of iron and having an internal diameter of about $\frac{7}{16}$ in. and a thickness not to exceed $\frac{1}{16}$ in. Through these tubes the iron rods *a b* slide and are held at any point by the screws *d*. One end *b* of this rod is rounded off for diamagnetic experiments and the other enlarged and flattened at the end for magne-crystallic experiments. On the tube *c* a helix of No. 16 or No. 18 wire is wound so as to make up a thickness of .4 or .5 of an inch and having a length of $2\frac{1}{4}$ in. The object of the screws *g* is principally to allow the rods *a b* to be reversed quickly and to adjust the position of the helices. When the apparatus is to be used for only one kind of work it can be much simplified by doing away with many of the moving parts.

This instrument can be used either with the ordinary magic lantern, or better, with one having a vertical attachment. In the latter case the plane of the instrument is horizontal and the substances are suspended from a wire made quite small, so as not to cut off too much light.

The suspending thread in the case of bismuth can be quite large but for other bodies a single fiber of silk is best: these in the shape of bars half an inch long can be each attached to a fiber having a little wire hook at its upper end and hung in a cabinet until required.

The theory of feebly magnetic or diamagnetic bodies oscillating in a magnetic field is very simple and yet the results are of the greatest interest, especially the effect of the size of the apparatus, which is here given for the first time.

2. *Theory.*

Let a very small particle of a body whose coefficient of magnetization κ is very small, and either positive or negative, be placed in a magnetic field of intensity R; it will then have an induced magnetic moment of κvR, where v is the volume of the element. The force acting on this particle to cause it to go in any given direction will be equal to the product of the magnetic moment into the rate of variation of R in that direction,* and hence is $\kappa v \mathrm{R}\frac{d\mathrm{R}}{dx}$ in the direction of x. The total force acting on the body in the direction of x is therefore

$$\mathrm{X}=\tfrac{1}{2}\iiint \kappa \frac{d(\mathrm{R}^2)}{dx}\,dxdydz,$$

and the other components of the force are

$$\mathrm{Y}=\tfrac{1}{2}\iiint \kappa \frac{d(\mathrm{R}^2)}{dy}\,dxdydz$$

and

$$\mathrm{Z}=\tfrac{1}{2}\iiint \kappa \frac{d(\mathrm{R}^2)}{dz}\,dxdydz.$$

Let, now, the axis of z be vertical, the axis of x in the line of the magnetic poles of the magnet, and y at right angles to both. Then the moment of the forces acting on the body to turn it about the axis of z is

$$\mathrm{M}=\tfrac{1}{2}\iiint \left(\kappa \frac{d(\mathrm{R}^2)}{dx}\,y-\kappa \frac{d(\mathrm{R}^2)}{dy}\,x\right)dxdydz,$$

where the integration extends throughout the volume of the body.

If the body is suspended so as to turn freely about the axis of z it will vibrate about the position for which M is a minimum or else will remain at rest at that point. The number of single oscillations made when the angular elongation ϑ is very small, is

$$n=\frac{1}{\pi}\sqrt{\frac{\mathrm{M}}{\vartheta \mathrm{I}}},$$

in which M and ϑ must be measured simultaneously, and I is the moment of inertia of the body.

$$\therefore\quad n=\frac{1}{\pi\sqrt{2\vartheta \mathrm{I}}}\sqrt{\iiint \kappa\left(y\frac{d(\mathrm{R}^2)}{dx}-x\frac{d(\mathrm{R}^2)}{dy}\right)dxdydz.}$$

Now let us suppose that the whole apparatus changes size, the relation between the parts remaining constant, so that the apparatus becomes m times as great as before. Then x, y, dx, dy, and dz will increase m times and I, m^5 times. To determine the changes in $\frac{d(\mathrm{R}^2)}{dx}$ and $\frac{d(\mathrm{R}^2)}{dy}$ we make use of the theorem of Sir Wm. Thomson, that "*similar bars of different dimensions, similarly rolled, with lengths of wire proportional to the squares of their linear dimensions, and carrying equal currents, cause equal forces at points similarly situated with reference to them.*"

* Thomson, Reprint of Papers, Art. 679, Prob. vii.

But as the above only applies to equal currents, I have generalized it in the following. *In any two magnetic systems whatever, similar in all their parts and composed of any number of permanent or electro-magnets, wires carrying currents, or bodies under magnetic induction, the magnetic force at similar points of each will be the same when the following conditions are complied with; 1st. the magnetic materials at similar points in the two systems must be exactly the same in quality and temper; 2d, the permanent magnets must be magnetized to the same degree at similar points of the systems; 3d, the coils of the electro-magnets and other wires or bundles of wires carrying the current must have similar external dimensions in the two systems and must have the product of the current by the number of wires passing through similar sections of the two systems proportional to the linear dimensions of the systems.*

This will apply to the case we are considering when the product of the current by the number of turns of wire varies in direct proportion to the size of the apparatus. Hence in this case $\frac{d(R^2)}{dx}$ and $\frac{d(R^2)}{dy}$ will vary inversely as m. Hence we see that n will be inversely proportional to the size of the apparatus: and although we have only proved this for the case when κ is small, it is easy to see that it is perfectly general. The advantage of small diamagnetic apparatus is thus apparent, for the smaller we make it the more vibrations the bar will make in a given time and the more promptly will the results be shown.

It might be thought that by hanging a very small bar in the field of a large magnet, we might obtain just as many vibrations as by the use of a small apparatus: but this is not so, for Sir Wm. Thomson has shown* that the number of oscillations of a feebly magnetic or diamagnetic body of elongated form in a magnetic field is nearly independent of the length when that is short. So that the only way of increasing the number of vibrations is to decrease the size of the *whole* apparatus, or to increase the power of the magnets: the latter has a limit and hence we become dependent on the former.

The theory of the effect of the size of the body is very simple, and we may proceed as follows. Let the body be in the form of a small bar whose sectional area, a, is very small compared with its length, and let γ be the angle of the axis of the bar with the line joining the poles, and r the radius vector from the origin. Developing R^2 as a function of x and y by Taylor's theorem, and noting that as R is symmetrical with reference to the planes XZ and YZ, only the even powers of x and

* Reprint of Papers, Art. 670. Remarques sur les oscillations d'aiguilles non crystallisées.

y can enter into the development, we have, calling R_0 the value of R at the origin,

$$R^2=R_0{}^2+\frac{1}{2}\left(\frac{d^2(R_0{}^2)}{dx^2}x^2+\frac{d(R_0{}^2)}{dy^2}y^2\right)$$
$$+\frac{1}{2.3.4}\left(\frac{d^4(R_0{}^2)}{dx^2}x^4+6\frac{d^4(R_0{}^2)}{dx^2dy^2}x^2y^2+\frac{d^4(R_0{}^2)}{dy^4}y^4\right)+\&c.$$

When the vibrating body is very small the first two terms will suffice: hence we have

$$M=\frac{1}{2}a\varkappa\left(\frac{d^2(R_0{}^2)}{dx^2}-\frac{d^2(R_0{}^2)}{dy^2}\right)\sin\gamma\cos\gamma\int_{-\frac{1}{2}l}^{+\frac{1}{2}l}r^2dr,$$

in which l is the length of the bar. If S is the density of the body (weight of a unit of volume), $I=\frac{a\,l^3\,\delta}{12}$ and n becomes

$$n=\frac{1}{\pi}\sqrt{\frac{\varkappa}{2\gamma}\left(\frac{d^2(R_0{}^2)}{dx^2}-\frac{d^2(R_0{}^2)}{dy^2}\right)},$$

in which, however, it is to be noted that $\frac{d^2(R_0{}^2)}{dy^2}$ is essentially negative and so the sign of the term containing it will be positive in the actual development.

This equation is independent of the dimensions of the body, and hence we conclude that when the body is small and very long as compared with its other dimensions, the number of vibrations which it will make in a given field is dependent merely on its coefficent of magnetization and on its density; a result first given by Sir Wm. Thomson, in the paper referred to. I have given it once more and put it in its present form merely to call attention to the facility with which $\varkappa$ can be obtained from it when we have measured R in different parts of the field by known methods. This could be done by means of a rotating coil as used by Verdet, or my magnetic proof plane which I will soon describe, combined with my method of using the earth inductor. This will give the best method that I know of for obtaining $\varkappa$ for diamagnetic or weak paramagnetic substances.

Troy, Jan. 15, 1875.

ART. XXXIX.—*On the Primordial Strata of Virginia;* by WM. M. FONTAINE.

MY investigations in the strata of the Primordial period in Virginia were confined to the immediate vicinity of the Blue Ridge, near Harper's Ferry, Rockfish Gap, Balcony Falls, and the Peaks of Otter. They extended to the rocks of the Calciferous epoch. These strata are well exposed along the west base of the Blue Ridge throughout the State.

The careful and accurate studies of these and the overlying formations, made by Prof. Wm. B. Rogers, have thrown much light on the complicated stratigraphy of the region. He shows that in the northern portion of the State, extending from Harper's Ferry to the south end of Page County, the Primordial slates are inverted so as to overlie the later formations on the west, and to pass with a high southeast dip under the like dipping strata of the Blue Ridge. In the middle counties, especially near Balcony Falls, these strata lie with a gentle northwest dip on the west slopes of the Blue Ridge. In some of the more northerly portions of this district, they lie immediately on the edges of the southeast dipping older slates, while at Balcony Falls and its vicinity the two systems of strata are separated by a ridge of syenitic rocks. Farther to the southwest inversion again occurs. This inverted dip is found in all the strata of Silurian age and extends into those of the Devonian. The former occupy nearly all of the "Great Valley of Virginia," while the latter appear in the Great North Mountain, and its prolongations, which bound this valley on the west. The strata of the valley lie generally in a closed synclinal, producing a continued series of southeast dips. This compressed mass of rocks, on the west side of the valley, is thrust up against, and partly over, the Devonian strata, affecting them also with a southeast dip, producing a long line of fault, and bringing Hudson River shales up so as to overlie even strata of the Subcarboniferous period.

It will thus be seen that the amount of displacement produced is enormous. Owing to the contortions thus caused, and the possibility of repetitions from closed folds, all estimates of thickness, unless based upon long-continued examinations, must be received with caution.

I shall in this paper commence with the description of the section obtained at Balcony Falls. This I do because the strata there appear to present their normal development and dip; and also for the reason that here alone has Prof. Rogers given, in any detail, a description of the Primordial strata. It will be seen that my results do not agree entirely with his, and I must confess that I cannot reconcile them. In view of this difference, I should hesitate to maintain the correctness of my observations were it not that they are substantially verified by the section made at Rockfish Gap. This last was made along the cuttings for the railroad at that point, which were not in existence when Prof. Rogers made his examinations.

Before giving my own results at Balcony Falls, I will quote Prof. Rogers's description of the strata there found. He says:

"The formation (his No. I) here rests on igneous rocks, mostly syenitic in character, which form the main axis of the Blue Ridge. These are well seen along the pass. As we approach its termination, we mark the commencement of the rocks of No. I, which are seen on the side of the canal lying on the syenitic mass, with a northwest dip.

The lowest stratum next the syenite is a brownish, decomposing slate, evidently much altered by the syenite. Next is a grayish and reddish sandstone; then a slate similar to the former; then a repetition of the sandstone; again a slate, and, at the termination of the gap, heavy beds of massive white sandstone, the typical rock of this series. The average dip of the latter is, in the cliffs at the entrance of the pass, 55° northwest.

If we now return to the east, by the road leading over the mountain, we are accompanied for a long distance by these upper sandstones, and we then pass in succession over the underlying strata, which extend with a gentle dip almost to the summit of the mountain."

I now proceed to give the result of my own observations. Referring to a former article,* the reader will remember that the last rock described in the Balcony Falls section of the crystalline strata of the Blue Ridge, was a syenite of probably later age than the mass of the ridge. Next to this occurs the first of the rocks which I hold to be of Primordial age. We have: (1.) Unbedded quartzite, with crystals of feldspar. 120 feet. (2.) Brown, crumbling, argillaceous rocks or sandy shale, conglomeritic in its upper portion, 40 feet. (3.) Brown, decomposing, thinly laminated, and contorted shale, 10 feet (4.) Conglomerate, like the upper portion of (2), 20 feet. (5.) Shales, like (3), 12 feet. (6.) Conglomerate, like (4), 15 feet. (7.) Crumbling, brownish shales, passing in the upper portion into argillaceous sandstones of the same hue and texture, 200 feet. (8.) Massively bedded, coarse white quartzite (apparently Rogers's typical No. I), 500 feet. Up to this point the rocks are well exposed in the cliffs which closely border the canal. Hence there is no danger of overlooking reduplications.

The dip of (3) is confused by contortion; that of (4) is 70°. From this point the inclination gradually declines, until in (8) it is about 55°. Proceeding west across the strike, we next encounter a series (9) of thinly laminated shales, with some beds of red and gray sandstones. This series is much more disturbed than the preceding, and, owing to its having been long subjected to the action of the river, in its efforts to cut through the massive barrier interposed by (8), it presents

* This Journal, January and February, 1875.

to the canal, slopes covered with debris. Hence details of the succession and dip of the strata cannot be given with accuracy.

A better exposure is given on the road mentioned above in Rogers's description. Here, too, however, great confusion exists. By far the greater portion of the mass is composed of thinly laminated, gray and reddish shales. Some beds of brick-red and gray sandstones of coarse texture occur, much indurated, and sometimes impregnated with epidote, chlorite, etc. Also, one or two beds of diorite apparently. Probable thickness, 600 feet.

To the west this is overlaid by a great series (10) of alternating beds of quartzite and kaolin shales. These rocks, where they join (9), present the same contortions and confused stratification, but in passing farther west, the folds open out, and are finally seen well displayed in the high mountain through which the river cuts its way at the "Cement Mills."

This mountain is the most westerly of the parallel ranges which compose the Blue Ridge at this place. At its western base the James and North Rivers meet, and force a passage, exactly at the point of junction. We thus find here the same features as those presented by the Potomac and Shenandoah at Harper's Ferry.

Standing at the Cement Mills, just where the river issues from the gorge and in this first barrier, the perpendicular walls of the opposite bank are seen to be composed of beautifully regular arches of No. (10), piled one above another to a great height. Probable thickness, 700 feet.

Both (9) and (10) seem, by a mighty thrust from the west, to have been crowded high up against the firm barrier opposed by the syenitic mass. This accounts for the gentle northwest dip which, as Prof Rogers correctly states, is shown by these upper strata in passing over the mountain to the east. In taking the section along this road, I did not find this to be true of the lower strata up to No. (8). They, even near the top of the syenitic mountain, show the same high dip that is seen along the canal. The massive, unyielding plates of No. (8) seem to have protected them to a certain extent, but have themselves been extensively fractured. Hence, in passing along the mountain road from the mills to the east, we observe the following typographical features: Looking westward, we see the strata of (10) rising and falling in rapid symmetrical undulations and forming the lofty range which fronts the valley of the river. Proceeding eastward, up the western slopes of the syenitic range, we pass first over the broken fragments of (10) and then of (9). Both, by the flattening out of the undulations, have a gentle northwest dip, and are partly crowded over the fractured outcrop of (8). Next appear the lower strata in unchanged position.

Returning to the line of section, we find the western slopes of the mountain overlooking the valley of the James to be covered high up with boulders and alluvial matter, by which the junction of (10) with the next series (11), and some adjoining space, is concealed. The river has at some time flowed several hundred feet higher than its present level.

The series of strata which I have numbered (11) in this section occupies a narrow belt between the mountain last mentioned and James River. The dip is very regular, being about 55° to the northwest. The rocks, so far as seen, next to the mountain, are more or less ferruginous, and local pockets of iron ore occur in the sandstones of (10) forming the mountain, especially near the line of junction.

The first rock seen next to the mountain is thinly laminated, fragile shale, of yellowish and reddish hues, not fully exposed. Next, to the west, we have bluish calcareous slate, and slaty limestone, 50 feet. Then very thinly laminated, firm, deep red slates, 60 feet. Next a similar slate of blue color, 15 feet. Then a bed of dark blue, hard, and dense limestone, used for cement, 13 feet. Then thinly laminated red slates, 20 feet. Then coarser, and thicker bedded, blue slates, 40 feet. Lastly, a coarse, rough, massive, siliceous limestone, 40 feet.

These strata are all well exposed in the excavations made for gaining the cement stone. This group of impure limestones is the equivalent, in Virginia, of the "Calciferous sandrock," and is present at all the sections examined by me, holding a similar position with respect to the Potsdam strata. They present, also, remarkably constant features in composition, especially the last mentioned, which, both at Rockfish Gap and Harper's Ferry, may be recognized at a glance. The cement limestone, from its physical appearance, is the purest of the group. The following is its analysis, obtained from the owner of the mills: SiO_2 34·225; Al_2O_3 with a little Fe_2O_3 7·8; CO_2 30·4; CaO 17·380; MgO 9·513; KO ·12; water and organic matter, ·5; loss, ·062. The thickness of this group, up to the last mentioned limestone, is probably 600 feet, including the concealed ground. My section did not continue beyond this point.

On the west side of the river is a valley, from half to three-quarters of a mile wide, which is bounded on the west by a range of heights called "Salling's Mountain." I observed in the western banks of the stream about eighty feet of fine-grained kaolin shales and sandstone, like those of (10), but more shaly. These have the same northwest dip; how far they extend into the valley I do not know. Prof. Rogers says that Salling's Mountain is composed of brown shales, which he makes the upper member of his No. I, or Potsdam formation. He further says that in them the dip is inverted, or to the southeast, the limestones of the Great Valley, i. e., the Trenton, Chazy, &c. (his No. II), passing under them. My section not having extended into these strata, I can say nothing concerning their age, except that they would seem to overlie the Calciferous sandrock, as the continued section above given extends through the Potsdam strata to those of the Calciferous. From this change of dip it appears that in this region the break and overturn of strata, which elsewhere extends through all the Primordial rocks, is found only in the strata overlying the Calciferous.

Some of the strata given in the above section present features of special interest, which must now be noticed.

The quartzite, No. (1), which immediately joins the syenite, is noteworthy as being the most completely metamorphosed rock seen in the entire section. This is evidently due to its contact with the crystalline rock. It is without bedding, and is affected by the same system of northeast and southwest joints seen in the syenite, and apparently forms one mass with the latter, no distinct line of junction being visible. The texture is nearly compact, from the fusion of the quartz grains. Numerous brilliant, perfectly crystallized, particles of white feldspar of small size occur. A few small, imperfectly crystallized garnets are seen in it. The next rock, No. (2), next to the quartzite, is a brown, crumbling, shaly mass, without bedding, which at its western edge terminates in a bed of feldspathic conglomerate. This has a high inclination to the northwest. The appearance of the lower portion of No. (2), and the highly altered condition of (1), seem to show that the upheaval of the adjacent portion of the syenite took place after their deposition, while the succeeding conglomerates are evidently the products of this disturbance. These conglomerates all closely resemble each other, and present some interesting features. They are composed of water-worn particles of quartz and red feldspar, of all sizes, up to that of a buckshot. The feldspar largely predominates, and is remarkable for its freshness, showing even in very small particles brilliant cleavage surfaces. Both it and the quartz are plainly derived from the neighboring syenite. The deposition must have taken place rapidly. The coarser particles are cemented together by a dark gray, very fine-grained paste, having the appearance, texture, and hardness of talc slate. It is apparently formed of finely comminuted feldspar and argillaceous matter. The entire mass weathers by exfoliation of concentric crusts, producing rounded boulders most strikingly like an igneous rock. Indeed, I was induced by this peculiarity to study closely its composition, under the impression that such was its nature.

These conglomerates crop out on the top of the mountain, and are partially exposed in the road. Here I discovered that the upper part of No. (4) was composed of a mass of angular fragments of slate cemented together by conglomeritic matter. These fragments of slate, sometimes as large as the hand, are of precisely the same character as the argillites which make up so large a part of the Blue Ridge, especially to the north. Their existence here shows not only that these argillites are older than the lowest Primordial rocks, but that they were already in a metamorphosed condition prior to the Primordial Period. The shales lying between the beds of conglomerate are very much contorted, and they, with the succeeding strata up to (8), seem to be mainly composed of finely comminuted feldspathic and argillaceous material, which had not been long exposed to decomposing and dissolving agencies.

The massive beds numbered (8) in the section differ strikingly from the underlying rocks in every respect. The material composing them is almost entirely quartz and of a white color, the grains being more or less rounded and cemented together. A few specks of yellow earthy matter occur, marking the position of decomposed particles of feldspar. With this exception, the rock is remarkably free from all minerals except quartz. If I mistake not, this is the rock mentioned by Prof. Rogers as typical No. 1, or Potsdam. But from his descriptions, given elsewhere in his reports, the strata which I have numbered (10) coincide more nearly with his sandstone, No. I. This also agrees best with the relative positions of No. (10), and of the Calciferous sandrock, which forms the upper part of No. (11).

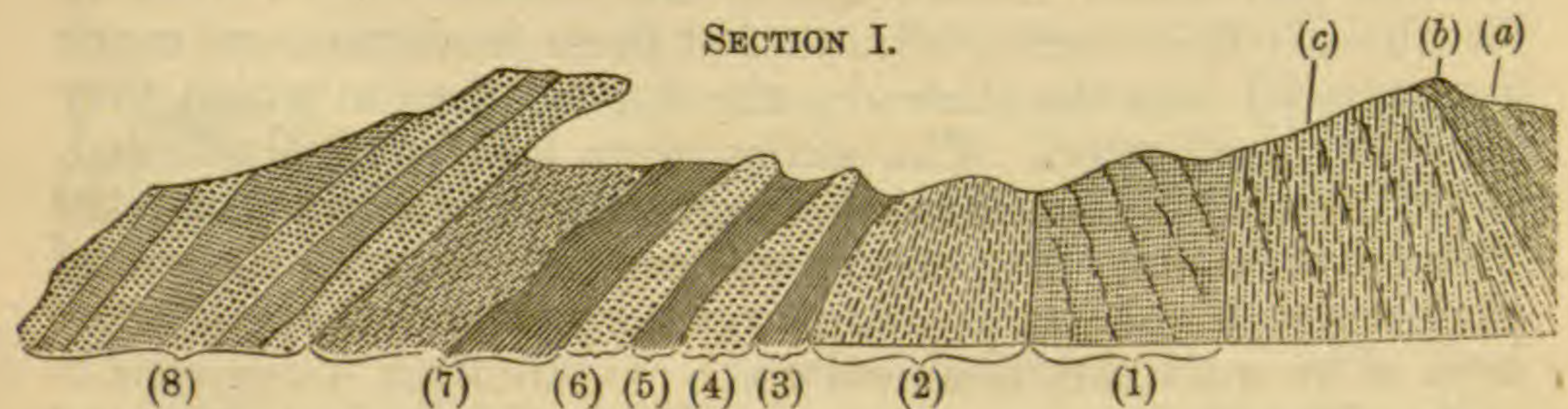
We may pass over the strata forming (9) in the section, as they lie in such confusion that it would be unsafe to attempt to give details. I may state, however, that the sandstones which occur in the shales of this series are quite thin. The coarsest and most massive layers are not more than 8 or 10 feet thick. It is worthy of note that these sandstones are much more altered than the shales by the disturbances to which they have been subjected. The shales seem hardly at all affected, while the sandstones are much indurated and often impregnated with epidotic and other metamorphic products. The material composing the shales is gray, argillaceous matter, with some beds of brown and reddish colors.

No. (10). This series, which is probably the equivalent of the Potsdam sandstone of New York, is composed of alternating strata of quartzite and kaolin shales. The quartzite layers vary in thickness from 20 feet to 3 or 4 feet. Many are quite compact, and some resemble vein quartz in fracture and other features.

The quartzites predominate in the lower beds. The kaolin shales often pass into a fine-grained sandstone, in which the grains of sand and kaolin of uniform size are equally and uniformly mixed. This latter rock, which is very common in the Potsdam of the northern part of the State, appears in great force at Rockfish Gap, and will be described in the section there more fully. The strata of (10) are remarkable for their freedom from coloring matters, and for the thorough decomposition of the feldspathic matter present. The kaolin shales and shaly sandstones occur in plates of a few inches to a foot or more in thickness. They are much fractured by the extraordinary disturbance to which they have been subjected. Notwithstanding the great amount of motion which has taken place in these strata, the shales do not seem to be metamorphosed beyond perhaps a partial loss of plasticity. Here again the sandstones show greater alteration. It is generally true, I think, that beds of pure argillaceous matter undergo far less metamorphosis in composition and texture than the siliceous layers which are interstratified with them. This at least is very generally true of the disturbed rocks of the Silurian and Devonian areas in Virginia and elsewhere, where I have observed them. The usual effect on these shales of the compression, &c., produced by disturbances is to cause them to assume more or less of the slaty cleavage, but I have never seen any approach to general crystallization of the constituents, even in the most profoundly convulsed districts. Again, the change in the beds of sandstone is usually the consolidation of the individual grains of sand. When foreign material is introduced, it is always in the form of local impregnations, plainly caused by circulating heated waters. I will return to this subject later. The strata of No. (11) do not require a further description.

The following section, No. I, represents the strata from (1) to (8) inclusive. No. (8) rises in a cliff 200–300 feet high, leaning over in an arch toward the syenite.

SECTION I.

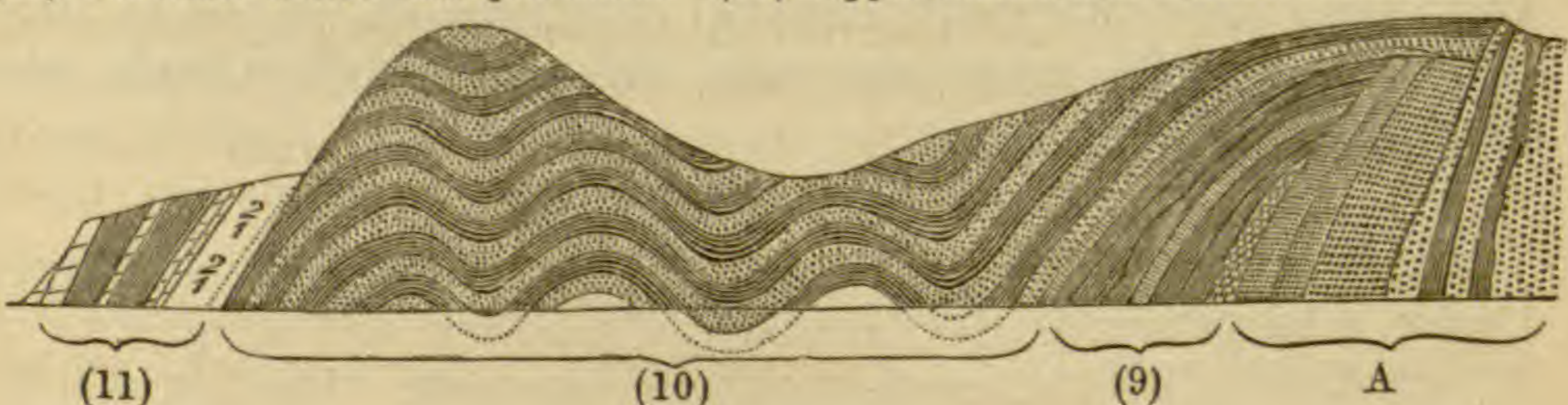


In this section, (*a*) represents the bed of quartzite mentioned in a former paper, as occurring on the east side of the syenitic mountain, while (*b*) denotes a portion of the mica slates which lean against this range on the east, with a southeast dip. The strata numbered from (1) to (8) denote those thus numbered in the descriptions, while (*c*) represents the syenites against which these lean with a high northwest dip. This section represents the stratification on the canal, but on the slopes of the mountain ascending from the west (8) and the overlying strata are crowded over to some extent on the outcrop of the subjacent rocks.

From the occurrence of the quartzite stratum at (*a*), and the fact that the Primordial strata ascend to the summit of the syenitic mountain, it might, at the first glance, be supposed that the slates at (*b*) are merely the extension of the strata on the west in a more highly altered condition. But this idea is forbidden by the great difference in the thickness of the western and eastern quartzites, and by the total change in the character of the beds, those on the east being a great mass of mica slates, quite regularly bedded, and showing none of the alternations of strata seen but a little distance away on the west. This relative position of the two systems of bedded rocks explains the fact mentioned by Prof. Rogers as occurring in the more northerly portion of the State, where Primordial strata with northwest dip lie upon the edges of the slates of the ridges which dip to the southeast. This would occur here were the syenitic mass absent, and, as we shall see, it does not form a dividing ridge farther north. The following section, No. II, gives a representation of the stratification of series (9), (10) and (11). As far as (9) and (10) are concerned, it is in part ideal, and I do not insist upon the correctness of my estimate of their thickness.

Section II.

A. No. (8) with subjacent strata. (9) Gray and reddish shales and sandstones. (10) Potsdam shales and quartzites. (11) Upper shales and Calciferous strata.



Peaks of Otter.

No detailed examination was made at this point of the Primordial rocks. At the west base of the syenitic range, gray shales and kaolin shales, very imperfectly exposed, were seen to pass a little distance up the mountain. They have a high southeast dip, showing the inversion of the lowest portion of the Primordial strata in this region. It is probable that some of the lower strata have been ingulfed in the overturn. Prof. Rogers states that from this point to the southwest the inversion generally prevails.

[To be continued.]

ART. XL.—*On the Silurian age of the Southern Appalachians;* by FRANK H. BRADLEY.

[Continued from page 288.]

[SINCE the previous part of this article was in type, another trip has been made from Athens to Murphy, by a road a short distance farther north than the one previously used. The section is essentially the same as that already reported, except that, after passing the soft schists of the Ducktown anticlinal, at the Hanging Dog Iron Works, the Ocoee and Chilhowee rocks, intervening between this anticlinal and the Valley River marble, have been forced past the vertical, and are exposed in inverted order, with northwesterly dips, until we have almost reached the valley at Tomotla, where southeast dips appear.

On page 284, line 13 from top, for "At Athens," read "Just south of Athens," for, about the railroad station, the Knox dolomyte shows an abundance of its characteristic chert, and the creek banks near the court-house have exposures of the shaly limestone of the Chazy epoch. The section was commenced perhaps a half mile south of the court-house.

Through inexcusable oversight, two errors have remained on page 286, after revision. As Safford's report and map both plainly show, the Knoxville fault passes a little north of the railroad at Athens, instead of two miles south of that place. The fault noticed at the latter point passes about nine miles south of Knoxville, where, though not mentioned in the section given, it separates the Cincinnati "iron-limestones" from the Knox dolomyte, both of which beds have there, locally, southeast dips. The Maryville outcrop of Knox dolomyte is thus shown to be the same one met with at Middle Creek and vicinity.]

5. *The Marble Belt.*

Three or four miles to the southwest of Dehart's, on Silver Creek, a tributary of the Nantahala, a heavy bed of marble is reported, which is supposed to carry silver ores. Farther southwest, perhaps ten miles from the Little Tennessee, its outcrop strikes the main valley of the lower Nantahala, not far below the Blowing Spring, and follows it, perhaps four miles, to Red Marble Creek, which it ascends to its head at Red Marble Gap, and thence descends Valley River. From the Blowing Spring to the Red Marble Gap the bed shows considerable quantities of a bright pink or flesh-colored marble, more or less variegated, in a patchy way, with various light shades of green and greenish-white, due mainly to the presence of more or less talc, which is sometimes in pieces large enough to make considerable flaws, or "dries," as the marble-workers call them. The value of the material as an ornamental stone is still further diminished by the frequent dissemination of small grains of quartz through the mass, which prevent a perfect polish. At some points along Red Marble Creek, especially near its mouth, we find large portions of the marble even shaly, with talc or chlorite, or both, and very much disturbed and intermingled with chlorite schists. Some of these impure portions are of a rich chocolate brown. On the mountain-side, northwest of the creek, ascending the road leading from its mouth across to the head of Tallula Fork of Cheowa, we find a second outcrop of the marble, mainly blue and bluish-white and partly chloritic, held in the trough of a small subordinate fold, as was suggested with respect to the disturbed strata between Valley River and Cheowa. Higher up, the underlying chlorite slates are so much distorted that, at one point, dips of S. 60° E. and S. 55° W. were noticed within ten feet of each other, in the solid strata.

The local fold just mentioned seems to be converted into a fault, as we pass southwestward, toward Valleytown. The main line of marble-outcrop, passing through Red Marble Gap, runs by Swepson's and Ingraham's localities, making deep and long hollows as it crosses the mountain-spurs, crosses Junaluska Creek, near Valleytown, and apparently continues nearly to Paint Creek, where the overlying pyritous and micaceous limestone outcrops, just southeast of the fault. Higher up, as on Junaluska Creek, the marble is underlaid by siliceous, chloritic and hydromica schists, of the age of the Knox shale, followed below by gneisses, partly schistose, partly quartzytic, representing the Knox and Chilhowee sandstones, which latter form a high ridge, for several miles, between this lead of marble and the upper part of the Valley River valley. On the northwest side of the fault, the marble makes its appearance about a mile above Valleytown, outcrops at several points near Whittaker's house, where a little quarrying has been done, and continues, apparently without interruption, down the valley to Murphy, where it crosses the Hiwassee. Thence, crossing the lower course of Notla River, it crosses the lower part of Hemptown Creek, then crosses the Ocoee River and continues to the White Path gold mines and Ellijoy, in Gilmer County, Ga., where we shall meet it again. The line thus traced is, in direct course, over sixty miles in length. Without more detailed surveys along the whole line, we cannot be sure that there are no other breaks in its continuity; but, as thus far known, the Valleytown fault appears to be the only very important one. Just opposite Valleytown, a partial break exposes another outcrop of the underlying gneiss, between Whittaker's and Collett's; but the two strips of the marble are united, as they pass southwestward, at perhaps ten miles below Valleytown. In this neighborhood, there are also local foldings of the overlying strata, but not such as to interfere greatly with the general regularity of the bedding.

Though the materials of the several outcrops are quite variable, yet the variation is of so constant a character in all, that one would have little hesitation in recognizing them as parts of one bed, even without the stratigraphical reasons for the conclusion. Along Valley River, and southwestward, the rock is mainly a bluish or grayish-white, fine-grained marble, the pink tinge of the Nantahala outcrops being rarely seen and then in very pale tints. One layer, from eight to twelve feet thick, is nearly black, or black-and-white striped, compact, and capable of taking a fine polish, thus forming a very beautiful ornamental stone, but still showing, under the glass, an oölitic structure like that of many of the lower layers of the unaltered Knox limestone. This was particularly noticed on J. T. Young's land, about a mile northeast of Valleytown, and at the mouth of Lenoir's shaft on lot "No. 6," near Murphy. The full thickness of the marble, near Murphy, is estimated at about four hundred feet.

Aside from disseminated grains of sand, which are sometimes very abundant, though at others entirely absent, the principal impurity of the marble is tremolite, which is sometimes present in quantity, either in separate, long, bladed crystals, or in finely radiated clusters, or in large, almost granular masses. It is said to form, at some points, considerable layers, consisting solely of it, which is certainly true at outcrops further south, near Gainesville, Hall County, Ga. As this mineral is essentially a silicate of lime and magnesia, it is natural to refer its origin to the abundant chert of the unaltered Knox dolomyte, which carries so much dolomyte in its intimate structure that it very readily disintegrates when exposed for some time to the action of percolating rain-water. At some points, as near Collett's, the marble is coarse-grained, and filled with small crystals of pyrite. At "No. 6," there is a thin layer of cellular quartz, possibly a true vein, filled with crystals of calcite, disseminated grains and masses of argentiferous galenite and some free gold.* The gravel along the outcrop, for several miles,

* The deep weathering away of the marble has caused the accumulation, upon the outcrop, of the gold originally disseminated through a large amount of rock; and surface-washings have therefore paid enormously.

The vein-stuff, at "No. 6," as exposed by shaft and drift, about fifty feet below the outcrop, shows the following section:—

White, fine-grained marble, with galenite, calcite and thin quartz veins,	5 to 6 feet.
Coarse-granular tremolyte,	2 to 6 inches.
Flinty quartz, with little calcite,	15 inches.
Yellowish-brown and greenish slaty limestone,	1 foot.
Green and brown, compact, knotty, hydromica slate, with disseminated pyrite, including streaks and thin layers of coarse-granular marble,	4 feet.

pays well for washing; and it is therefore inferred that this vein, or others like it, must be, so far, constantly present in the marble; indeed, similar vein-stuff has been seen in the outcrop, several miles up Valley River. I have not learned of the presence of sphalerite in the marble at any point.

One of the most common accompaniments of the marble, in this neighborhood, from the Blowing Spring to the Ocoee, and perhaps farther, is a bed of very pure steatite, or "cotton-rock," as it is locally called. This has been quarried, in small quantities, at several points, partly for the lining of furnaces at the Ducktown Copper Works, partly for the making of the so-called "lava" tips for gas-burners. Mr. A. A. Campbell of Tomotla, who has quarried much of it, tells me that he has sometimes found it filling small basins in the surface of the marble; but, as I understand his statement, this may have resulted from local sharp folds of the strata, and the steatite may still be a regular overlying layer conformable with the marble, as I believe to be generally the case. The outcrops, however, are not favorable to a decision on this point. At Tomotla P. O., the steatite lies in a bed, 8 or 9 feet thick, *below* the marble, and separated from it by a bed of granular quartzyte. Below the limit of precolation and consequent decomposition, the steatite is of a rich green tint, translucent, and endures sudden heating; when partially altered, it is opaque, of a rusty yellow color, and, by reason of absorbed water, splinters when quickly heated, but gradually hardens like the unaltered rock. At one pit, on Notla River, the surface is covered with a dense blue mud, which appear to be the ultimate result of underground decomposition. The rock sometimes contains tremolite crystals.

The marble is also pretty constantly accompanied, hereabout, by thin beds of cellular chert and itacolumyte (flexible sandstone), sometimes separate, sometimes running into each other. These, I believe, mainly overlie the marble. A good point for examining them is the neighborhood of Red Marble Gap.

Heavy beds of limonite, compact, cellular and ochreous, partly pure, partly cherty, also follow the outcrops of the marble, and have been mined, or rather quarried, at several points, for the supply of small furnaces and forges. These are of essentially the same character as the limonites which are so abundant along the outcrops of the unaltered or slightly-altered Knox dolomyte throughout East Tennessee, Georgia and Alabama, and extend northeastward to New England and Canada; but some of them are considered to be exceptionally pure. They are said to carry, at most points, small amounts of gold and silver, though rarely enough to make them worth working for those metals. These ores occur at four well-marked horizons, one immediately beneath the marble, the others above it, as shown in the accompanying section of the rocks at and near Murphy:

1. Hydromica schists, smooth and wrinkled, ferruginous, with garnets, staurolites, titanic iron and gold—some quartz veins.		
2. Fine-grained chloritic gneiss.		
3. Talcoid schists, with mica crystals.		
4. Dark greenish-black hornblende rock, with garnets.		
5. Micaceous limestone, with pyrite, weathering to *limonite*	500 +	feet.
6. Hydromica schists	150	"
7. *Limonites* (rarely mined)	50 to 70	"
8. Hydromica schists	100	"
9. Knotty quartzytes	65	"
10. Hydromica schists	25	"
11. Slaty steatyte,	30	"
12. Soft schists and gneisses, with streaks of speckled mica slates,	250	"
13. Hydromica schists, with *limonites*,	150 to 200	"
14. Marble	400	"
15. Limonites	100 to 200	"
16. Quartzyte.		
17. Heavy-bedded gneiss.		

No. 5 of this is the evident source of one of these limonite belts: and the others may very probably have similar origin; but I have not seen any exposure of the strata beneath them. This pyritous limestone was seen in the ridge between Professor Olmsted's house and Lenoir's shaft, near Murphy; also at the Parker gold mine, 11 miles northeast; also near Whittaker's (now Ross's) Mill, 14 miles northeast; also on Paint Creek, near Valleytown. The heaviest outcrop seen is at the Parker Mine. As the section shows, this bed, near Murphy, lies about 900 feet above the marble, which we suppose to represent the Knox dolomyte, though much thinner than that group is in its Tennessee exposures. This distance would not vary much from the space separating the Knox from the iron-limestone of the Cincinnati group near Knoxville, and I am strongly impressed with the belief that the pyritous and micaceous limestone is the equivalent of this latter bed, because of both its chemical composition and its position. The hornblende rock of No. 4 of the section may perhaps be included, since the dark-colored hornblendes are essentially silicates of lime, magnesia and iron; but, if so, we must also include all the overlying beds of the section, since rock of precisely the same characters occurs, in thin layers, at intervals, throughout the schists of No. 1, on the ridge back of the Parker Mine. I am at present inclined to thus include these schists, and so to refer the whole upper part of the section to the Cincinnati group.

About four miles above Murphy, on Peachtree Creek, another outcrop of marble occurs, which *appears* to be the equivalent of that already discussed, which requires the existence of a considerable fault somewhere between the two outcrops. I am not entirely certain as to the location of this fault, since the strata vary locally to such an extent, hereabout. I believe, however, that it is very close to the Peachtree outcrop. Accordingly, I would refer all the intervening strata to either the upper part of the Cincinnati group or the overlying beds of the Silurian. Ascending the Hiwassee, after leaving the auriferous hydromica schists of No. 1 of the foregoing section, which underlie most of the town of Murphy and extend nearly a half mile up the river, we find, first, a fine-grained, ferruginous micaceous, quartzytic sandstone; then, a thin bed of chlorite slate; then, a thousand feet or more of fine-grained gray sandstones, with quartz veins; then, white, gray and ferruginous quartzytes, partly heavy-bedded, with pyritiferous quartz veins, interlaminated with siliceous mica slate and hydromica schists, at least three thousand feet in all; then, several hundred feet of mottled hydromica slates, with mica crystals, a few staurolites, and some gold. This brings us to the mouth of Peachtree, on the line of strike of this marble outcrop: though the marble does not appear near and south of the crossing of the Hiwassee, yet the accompanying limonites, which are abundant on Peachtree, are also largely developed beyond the river, and a low valley, evidently eroded in soft strata, runs on for some miles toward the upper course of the Notla River. On Peachtree Creek, near M. L. Brittain's, the marble shows white, blue, gray and reddish-brown layers, the darker varieties being often quite impure with streaks of schist, partly siliceous. Beneath them, a pyritous steatite occurs at one point, which must be the equivalent of the "cotton-rock" above described; but the exposed outcrop is much more impure than that on Valley River and Notla. Above the marble, there is here a garnetiferous schistose brown limestone, which graduates into a calcareous mica schist. These beds, over 2,000 feet thick, form a high ridge, which, in its more eastern portion, between the two forks of Peachtree, is known as Breeding Mountain: an isolated portion lies between lower Peachtree and the Mission farm on Hiwassee River; and, south of the river, the line continues on between this belt of marble and Little Brasstown Creek. Just beyond this, another fault again brings up the marble, which outcrops at several points on Little Brasstown and on and near the Mission farm, being accompanied as usual by heavy beds of limonites. These limonites, both here and on Peachtree, are largely ochres, and are said to contain considerble amounts of silver, copper and lead. Above the Mission farm, the overlying calcareous mica schist forms another high ridge, which comes sharply to the river bank on both sides. Those two belts of marble are apparently broken off toward the northeast, though each has been traced some distance into the mountains, by lines of sink-holes. They probably reach the more southern branches of Vengeance's Creek, but do not appear on its more northern ones. Their southwestern continuations have not been traced continuously; but outcrops of marble, representing one at least and probably both, occur on Notla River, about at the State line. The marble of Jasper, Pickens County, Ga., is probably on the continuation of one of these belts.

In passing on up Brasstown Creek, we find principally mica and hydromica slates and schists, with many staurolites and small garnets, and increasingly numerous quartz veins which, as we approach the Georgia line, become pyritous and frequently auriferous. On both sides of the line, veins rich in gold have been opened, though none has yet been extensively worked. Two small stamp-mills are now running, in this neighborhood. In some of these veins, argentiferous galenite occurs in considerable quantities.

Somewhere near this point, both Emmons and Kerr indicate a great fault, separating the so-called "Taconic" or "Huronian," on the northwest, from the "Azoic" or "Laurentian," on the southeast. I cannot certify to the non-existence of such a fault; but I have crossed its supposed line and the succeeding belt of country for several miles, on three distinct routes, without having found any appearance of unconformability or any very marked change in rock characters, except that hornblendic strata become more numerous at some points. In ascending the Little Tennessee, from where we have supposed the main belt of marble to cross it, we find schists and gneisses dipping southeasterly, until within nine miles of Franklin, where northwesterly dips set in, continuing about five miles, until we meet with decayed, auriferous, hydromica schists dipping 45° to 60°, to N. 10°–15° E. As this has been the eastern limit of my explorations, I am not *sure* that this may not mark an approach to another series of rocks; but the character of the material does not indicate this, and I am inclined to believe that the *northeasterly* dips are only local, and that the limestone reported by Dr. Curtis as existing in considerable quantity on the western slope of the Cowee Mountains, about eight miles east of Franklin, is really the southeastern edge of the synclinal of which the Nantahala and Valley River outcrop is the northwestern. At least, I have found no definite boundary to the Silurian in this direction.

If there are *any* non-Silurian beds in this region, they are those which form the higher portions of the Valley River

Mountains and Nantahala Mountains. On the lower Nantahala, opposite the mouth of Red Marble Creek, an extensive outcrop of chloritic gneisses, dipping 55°, S. 65°–70° E., commences about two hundred yards southeast of the marble, which here dips 57°, S. 57° E. The intervening space is covered, but there is no indication of the presence of the pyritous, micaceous limestone which, farther southwest, occupies nearly the place of these gneisses. In this region of great disturbance, neither the variation in dip nor that in lithological character is sufficient to justify the inference of unconformability; yet there *may* be a fault here and displacement either up or down on its southeast side. Leaving the marble at Valleytown, and following the direct road to Franklin, we first cross a wide outcrop of hydromica schists; then, a thin bed of laminated quartzyte; then, chloritic and mica schists, gradually becoming more compact and siliceous and including some quartzytes. Until we pass the summit of the Valley River Mountains, at Morgan's Gap, the dips vary from 35° to 60°, and from S. 20° E. to S. 45° E., apparently in consequence of warpings of the strata rather than of any true unconformability; but, upon the eastern slope these are replaced by dips varying from S. 20° E. to S. 60° W., as if in the greatly disturbed strata about the axis of a very irregular synclinal. Both gneisses and schists here show more mica than chlorite. The irregularity of the dips continues until we pass the summit of the Nantahala Mountains, where the synclinal character of the region appears to be more strongly marked in sharp northwesterly dips, which continue down the southeastern slope. The rocks have become less schistose and more gneissoid, and include much hornblende. After reaching the valley, we encounter the auriferous hydromica schists, dipping N. 15° E. as before stated, which continue to Franklin. While I have not made sufficiently detailed examinations to be *certain* that these disturbed strata of the upper Nantahala are not of greater age, yet what I have seen of them has given me a very strong impression that they are *newer* than the Valley River marbles. This impression has only been strengthened by a trip from Parker's Mine to the head of Vengeance's Creek. Along this line, chloritic schists, which *must* be above the marble, gradually pass into others a little more compact and siliceous, (the precise equivalents of those first encountered on the Valleytown-Franklin road,) with laminated quartzytes. Near the summit, these include a considerable thickness of fine-grained nearly black mica slates, becoming siliceous above and striped with quartzytes.

In passing southeastward from Brasstown Creek toward the head of Hiwassee River, we find southeast dips at first; but these soon begin to alternate with northwesterly ones, showing such small local wrinkles as we should naturally expect along the somewhat irregular axis of a sharp anticlinal. Hornblendic layers here become rather more abundant, though there are still several belts of soft hydromica schists, with thin quartz bands, some of which are rich in gold. One of these latter, continued westerly, passes Blairsville, Union County, Ga., where rich ore has been found, though no systematic mining has been attempted. About two miles south of Hiwassee, Towns County, at Ivy Mount Mine, some of the hornblendic layers include copper ores, similar to those of Ducktown, though not yet fairly developed. Old works, followed on a small scale before the war, have recently been re-opened, and show very promising bodies of ore.*

Passing on southward, on the Unaka Road, we find the dividing ridge, or Blue Ridge proper, consisting of mostly heavy-bedded gneisses, partly hornblendic, with some schistose portions, all dipping northwesterly in a regular monoclinal. Descending the southern slopes of this last prominent range of the Appalachian chain, the foot slopes show a broad outcrop of the soft auriferous mica schists, with thin irregular quartz veins and occasional layers of gneiss, quartzyte and itacolumyte. These appear to be the opposing edges of the set of beds passing Hiwassee and Blairsville.† The recognized "gold belt" extends to beyond the Chattahoochee, and mining has been carried on, in the small way, at a great many points. Near Cleveland (formerly called Mount Yonah), we reach the axis of an anticlinal, along which appear heavy-bedded gneisses, which form an interrupted line of high knobs, running parallel with the main mountain. Of these, Yonah Mountain, in White County, and Walker's Mountain, in Lumpkin County, are the more prominent. These beds yield no gold; but the auriferous schists immediately recur and show almost continuously for at least sixteen miles south of Clarksville, Habersham Co. Southeasterly dips continue from the Yonah anticlinal to about ten miles south of C., where the synclinal of the Chattahoochee Ridge gives us northwesterly ones, which continue about five miles, to near Hollingsworth, where we pass another anticlinal and again find southeast dips. Besides the hydromica schists, with quartz veins and bands, which constitute the mass of the strata, we find some chlorite slates, and a few beds of gneiss, the latter partly granitoid, partly porphyritic. A few miles east of Clarksville, considerable quantities of marble have been

* The inclosing wallings are of very compact gneiss, partly hornblendic. The ore is pyritous, and carries large amounts of zinc-blende (sphalenite). The quartz gangue is at some points full of apatite, from whose alteration we have, in the crevices about the lower limit of decomposition, considerable surfaces of vivianite, in pale blue crystals.

† In mining reports upon this region, prepared in 1861, W. P. Blake described these strata as being metamorphosed Paleozoic.

quarried and burned into lime. The position of this outcrop indicates that the bed probably has a southeasterly dip, passes very near Clarksville (possibly along the depression of the valley of Soquee Creek), and is continuous with the outcrop at Limestone Spring, about two miles east of Gainesville. This bed must also occur on the north side of the anticlinal, along the foot of the mountain, but is not yet reported. In passing from the Yonah anticlinal direct to Gainesville, Hall Co., a second anticlinal axis is passed, near the crossing of the Chattahoochee, which is apparently not developed much farther east, as it was not seen on the Clarksville road. Near this river crossing, at the Glade Mines, a prominent bed of itacolumyte is reported; and several diamonds have been found in the gold washings. The marble, near the Limestone Spring, is essentially the same as that of the Valley River belt, but contains, perhaps, rather more impurities, heavy layers being here solid masses of tremolite. So far as seen, the immediately overlying beds were so covered with debris as to prevent comparison with those seen about Murphy. The Glade mines being very near this belt, one naturally connects the heavy limonite beds of that place with the similar ones of Murphy and vicinity. Silver ore is also reported from this vicinity.

Passing westward and northwestward from Gainesville, we reach the second anticlinal, just mentioned, about a mile from town, with dips at first about S. 75°–80° W., which are the first indications of approach to the irregularities which mark the *southwestern extremity of the Blue Ridge proper*. The local facts to be stated will perhaps be best understood if the general features of this southern part of the range are first briefly set forth. The Blue Ridge, which is a single range in northern Virginia, forks a few miles southwest of Lynchburg; and the two ranges thus formed gradually separate, to the southwestward, until, in middle and southern North Carolina, they are from sixty to seventy miles apart. The main strikes are S. 45°–65° W.; and, in the eastern range, which is the main watershed, these continue through Georgia into Alabama; but the western range, almost from the very point where it enters Georgia, bears more to the southward, the strikes being mostly about S. 5°–15° W., and rapidly approaches the eastern. This western range, as such, terminates before reaching the Etowah River; but the disturbances consequent upon the crowding of folds have been felt far to the southward and eastward, as we have seen.

After crossing the Shallow Ford of the Chattahoochee, we find more nearly the normal dips of this side of the anticlinal, in a heavy outcrop of thin-bedded gneisses, which dip 30°, N. 62° W., and in the overlying auriferous hydromica schists, banded with thin layers of quartz and hornblendic gneiss. As we approach the synclinal, disturbed dips again appear. We here reach nearly the horizon of the marble, but pass the synclinal axis without its appearance, about a mile west of the Chestatee River, which we cross near Robbins's mill. Dips of S. 25°–40° E., in gneisses and schists, continue until we have passed Crossville, Smithville and Barretsville, and have crossed the Etowah at Leadbetter's Ford. Somewhere in this space the marble must occur; but it was not seen in passing along the road. About twelve miles south of Jasper, we reach the line of probably the greatest crowding of folds and disturbance of dips. For the next four miles northward, the rocks are mainly hydromica schists and gneisses, with quartz and granite veins. Within this space, the following succession of dips was noted: N. 35°–70° E.; N. 20°–30° W.; S. 20°–70° E.; S. 35° W.; S. 60° E. From this latter point we find more regular southeast dips (S. 50°–85° E.) to beyond Jasper, Pickens County. As we approach the crossing of Long Swamp, at Tate's, about five miles south of Jasper, we see by the roadside a cliff of white and gray granular marble, partly quite pure, partly quartzose, dipping 32°, S. 62° E. Considerable quantities of the purer beds have been quarried near here, and at other points along the Swamp to above Jasper. From quarries now worked about a mile east of the town, I have seen specimens as pure and fine-grained as the best statuary marble, but am not informed as to the amount of such rock. This is probably the direct southern continuation of one of the Knox marble outcrops, which pass south of Murphy. The Knox shale appears to have been locally wanting, since heavy-bedded gneisses, which we must refer to the underlying sandstones, show considerable thickness along the western border of the Swamp; but fine-grained mica slates occur near this horizon, from two to four miles north of Jasper. Hence to Duckstown, we follow nearly the general line of strike, and pass over pretty continuous lines of gneisses and schists, with variable southeasterly and northeasterly dips. The marble outcrops are known, at short intervals, along to the right of the road and at gradually increasing distances from it. At Tolono Creek we cross what may be the continuation of the Valley River belt. The copper is on the left of the road, but has not been exploited, I believe, at any point south of the Mobile Mine, in Fannin County, five miles from Ducktown, where there were extensive works before the war, which are now in ruins.

To the southwestward, the copper-bearing strata appear, in Harraldson, Paulding and Carroll Counties, with nearly the regular northeast strike, but apparently broken up by faults, so as to show three approximately parallel lines of outcrop, without intervening folds. These have not been traced so closely through the intervening country that I can feel certain which, if either, is the exact equivalent of the Ducktown line. The more northern line passes through the Waldrope Mine, in lot 932 of the third district of Harraldston County, where a good ore-body, from eight to fourteen feet thick, has been exposed in a shaft about sixty feet deep. The dip is here about 45°, S. 55° E. Near the Gamble shaft, on lot 851, a heavy bed of compact red hematite runs parallel with the copper, and but a few rods from it. The second belt passes close to Draketown, Paulding County, where the McClarty shaft, 105 feet deep, showed from twelve to eighteen feet of not very rich ore. The dip is here about 80°, S. 47° E. The third belt passes about a mile north of Villa Rica, Carroll County, where several small shafts have been sunk, along the outcrop, and have shown, according to reports, from three to thirteen feet of ore, partly poor, partly rich. Near the eastern termination of the recognized outcrop of "copper gossan," large numbers of polarized fragments of magnetite are scattered over the surface; and these increase in size and number as we pass eastward; but the bed has not been traced far beyond the point where signs of copper disappear. This deposit is an interesting one as a continuation in oxyds of a belt of sulphides farther west. The iron looks rather like a titaniferous ore, but has not been analyzed. While these three belts show but slight lithological variations, the strata being mainly hydromica and talcose schists, with occasional belts of hornblendic gneiss, and are therefore probably referable to one series broken by two faults, they *may* represent two or even three horizons.

At Villa Rica, we reach a synclinal fold; and the copper-gossan appears on its southeastern side, with northwestern dip, a short distance to the southeast in Douglass County. This is probably the belt on which a little work has recently been done at several points near Carrollton, while, still farther west, Wood's Mine, in the edge of Alabama, has, for about a year, been yielding large amounts of rich ore. Along the axis of this synclinal, for a width of between one and two miles, we find a belt of hydromica schists, with several quartz bands, both thick and thin, carrying considerable gold. This has been mined at several points; and several millions are known to have been coined from this immediate neighborhood, mostly washed from the stream rubbish and decayed outcrops, but partly obtained by stamping the vein-stuff. Gold-bearing strata have been recognized near each of the two more northern belts of copper; but little work has been done upon them. The gold-bearing schists of Bonner's Mine, eight miles southeast of Carrollton, have more of the appearance of the higher strata of the upper Chattahoochee waters, and probably are their continuation, though the marble belt, which is the only horizon thus far certainly recognizable, has not yet been reported from this region, nor, indeed, from any point west of Atlanta. Dr. Stephenson reports that it passes about ten miles north of that city.

The evidence is certainly very strong that *all the strata of the region thus reconnoitred are of Silurian age.* The only exception thus far suggested is that of an area east of Marietta, Cobb County, Ga., where Dr. Little reports the surface covered with masses of partly decomposed massive granite, over an area two or three miles in diameter. This *may* be Archæan; and there may be other similar islands within the area indicated but I have not yet seen or heard of any. Tuomey's reports upon Alabama indicate that the metamorphic strata of that State are of the same character and age as their continuations in Georgia.

To the northeastward of the region visited, we have as yet nothing definite. Emmons says, however (l. c. p. 31), that "the prevailing dip of the rocks of the Blue Ridge is southeast. When, however, we have passed from the pyrocrystalline rocks to the Taconic system, the dips are changed, first to southeast and finally to northwest, which is the prevailing dip." In view of the facts observed upon the same belts in Georgia, and herein recorded, it seems fair to suggest that, in North Carolina also, the Blue Ridge is probably simply a synclinal, with local irregularities of dip along the axis; and that the "pyrocrystalline rocks," as well as the "Taconic," are *probably all Silurian*, instead of being "Azoic" or "Laurentian."

The question naturally presents itself: *When occurred the uplift and metamorphism of all this region?* We have as yet no *direct* evidence—as that of newer horizontal beds lying unconformably upon the edges of these strata—but the indirect evidence is strong. Aside from the beds recognized as genuine Archæan, none give signs of any disturbance prior to the date of the general upheaval which affected the entire series, to the top of the Coal-measures. Both the disturbances and the metamorphism, from the Cumberland Mountains to the eastern range of the Blue Ridge, at least in this lower portion of their extent, appear to belong solely to one system and time. Further, so far southeast as the foot of Chilhowee Mountain, we find Subcarboniferous strata, in regular position, involved in the disturbance; and there seems to me to be every reason for believing that the Coal-measures also once covered the entire region. The entire disturbance must then be considered *post-Carboniferous*, and is doubtless referable to the close of the Paleozoic.

Although the Smoky Mountains are as high as the Blue Ridge proper, and yet give passage to streams from the latter range, it is not necessary to infer the earlier elevation of the Blue Ridge, as Willcox has recently done (Proc. Philad. Acad., 1874, p. 165), for the more thorough metamorphism of the eastern range is sufficient to account for its greater resistance to erosion during the earlier ages. On this subject of erosion, I hope to speak further, at another time.

I must here express my acknowledgments for local information furnished me by Prof. E. B. Olmsted, of Murphy, Mr. J. Mack Whittaker, of Valleytown, Dr. Josiah Curtis, now of Washington, D. C., Messrs. J. R. Dean and R. R. Asbury, of White County, Ga., Dr. M. F. Stephenson, of Gainesville, R. J. Gaines, of Carrollton, Dr. George Little, State Geologist of Georgia, and Mr. W. L. Nicholson, Topographer of the Post Office Department, Washington, D. C.

Knoxville, Tenn., March 27th, 1875.

ART. XLI.—*Brief Contributions from the Physical Laboratory of Harvard College.* No. 15.—*On the construction of Gaugain's Galvanometer*; by JOHN TROWBRIDGE.

IN this instrument the law of the proportionality of the strengths of the electric currents, circulating through the coil of the galvanometer, to the tangents of the deviations of the needle, is exact when the distance of the center of the needle from the center of the coil is equal to one-half the radius of the coil. The theoretical demonstration by Bravais of the truth of this law of the galvanometer leads to the expression

$$\text{Eq. (1.)} \quad i=\frac{T\rho^3}{2\pi R^2}\left[1-\frac{3l^2}{2\rho^2}+\frac{15l^2D^2}{\rho^4}+\frac{15l^2}{4\rho^4}(R^2-4D^2)\cos\delta^2\right]^{-1}\tan\delta$$

in which i=strength of current.
T=horizontal intensity of the earth's magnetism.
R=radius of coil or circular wire.
l=length of needle.
D=distance from center of needle to center of coil.
$\rho^2=l^2+D^2+R^2$.
δ=deviation of needle.

We see from eq. (1) that when $(R^2-4D^2)=0$, or $D=\frac{R}{2}$, that the terms in the parenthesis are of the order $\left(\frac{l}{\rho}\right)^4$ and when $\frac{l}{\rho}$ is small these can be neglected.

In constructing the galvanometer the serious question arises: how much will a small error in the measurement of D and of R affect the law? and which will have the greater effect, an error in the measurement of R or in that of D?

Let us suppose at first that R and D have been measured correctly. We shall then have

$$i=\frac{T}{2\pi R^2}(l^2+R^2+D^2)^3 \tan\delta, \text{ in which } D=\frac{R}{2}.$$

Suppose now that, while R remains constant D differs from its true value by αD, in which α is a very small quantity. We shall then have, neglecting small quantities in Eq. 1:

$$i=\frac{T}{2\pi R^2}(l^2+R^2+(D+\alpha D)^2)^3\tan(\delta-m)$$

in denoting the decrement of the angle of the needle. The difference in value of these two expressions for the strength of a current is

$$i-i_1=\frac{T}{2\pi R^2}\Big((l^2+R^2+D^2)^3\tan\delta-(l^2+R^2+(D+\alpha D)^2)^3\tan(\delta-m.\Big)$$

Suppose now that D remains constant or R varies from its true value by the small quantity βD, in order to produce the same decrement as in the angle; we shall have

$$i_2=\frac{T\,(l^2+D^2+(R+\beta R)^2)^3\ \tan(\delta-m.)}{2\pi\,(R+\beta R)^2}$$

$$i-i_2=\frac{T}{2\pi}\left[\frac{(l^2+R^2+D^2)^3\tan\delta}{R^2}-\frac{(l^2+D^2+(R+\beta R)^2)^3\tan(\delta-m)}{(R+\beta R)^2}\right.$$

The difference in the values of the strengths of the currents are indicated by the final terms in the values of $i-i_1$ and $i-i_2$ which are

$$\frac{(l^2+R^2+D^2\,(1+\alpha)^2)^3\tan(\delta-m)}{R^2}$$

$$\text{and}\ \frac{(l^2+D^2+R^2\,(1+\beta)^2)^3\tan(\delta-m)}{R^2(1+\beta)^2}$$

Since $D=\frac{R}{2}$ we have by developing and neglecting the squares of α and β,

$$\frac{\left(l^2+\frac{5}{4}R^2+\frac{R^2\alpha}{2}\right)^3}{R^2}\quad\text{and}\quad\frac{\left(l^2+\frac{5}{4}R^2+2\beta R^2\right)^3}{R^2(1+\beta)^2}$$

Neglecting α and β when they are additive to a large whole number, the differences in the strengths of the currents will be expressed by the terms $\frac{\alpha R^2}{2R^{\frac{2}{3}}}$ and by $\frac{2\beta R^2}{R^{\frac{2}{3}}}$, α is smaller from the nature of the case than β. Hence

$$\frac{\alpha R^{\frac{4}{3}}}{2}<2\beta R^{\frac{4}{3}}.$$

Therefore an error in the measurement of R will not affect the law of the galvanometer so much as one in the measurement of D.

In order to obtain an idea of the magnitude of errors resulting from changes in the value of D, I arranged a galvanometer so that the coil, consisting in this case of a circle of thick brass wire, the resistance of which could be neglected, could be moved away from its true position, after the manner of Wiedeman's galvanometer. The value of R was 12 cm. and that of D 6 cm.

Value of D+X	Value of δ.
6	20°
7	19
8	18
8·5	17·5
9	16·5

A variation of 1 cm. produced a change in the deviation of the magnetic needle of 1°. (The galvanometer needle was 25 mm. long and was suspended by a single fiber of silk.)

The apparatus was also so arranged that the radius of the circle of brass could be changed, while D remained constant. It was found that the changes in the indications of the needle were inappreciable until the increase of the radius was 5 mm. when the increase amounted to 1 cm.,—a variation of half a degree was produced in the indication of the needle. The increase in resistance of the circuit was inappreciable. An error, therefore, of five millimeters in the determination of the radius of the coil was inappreciable, while the same error in the measurement of the distance of the needle from the center of the coil resulted in, comparatively, a larger error. In approaching the subject from another point of view, it can be proved* that the expression for the attraction of a single circular current on a point situated on the line passing through the center of the coil and perpendicular to its plane is

$$X=2\pi k\left\{\frac{a^2}{r^3}-\frac{3a^4}{2r^5}+\frac{15}{8}\frac{a^6}{r^7}-\ldots\ldots\right\}$$

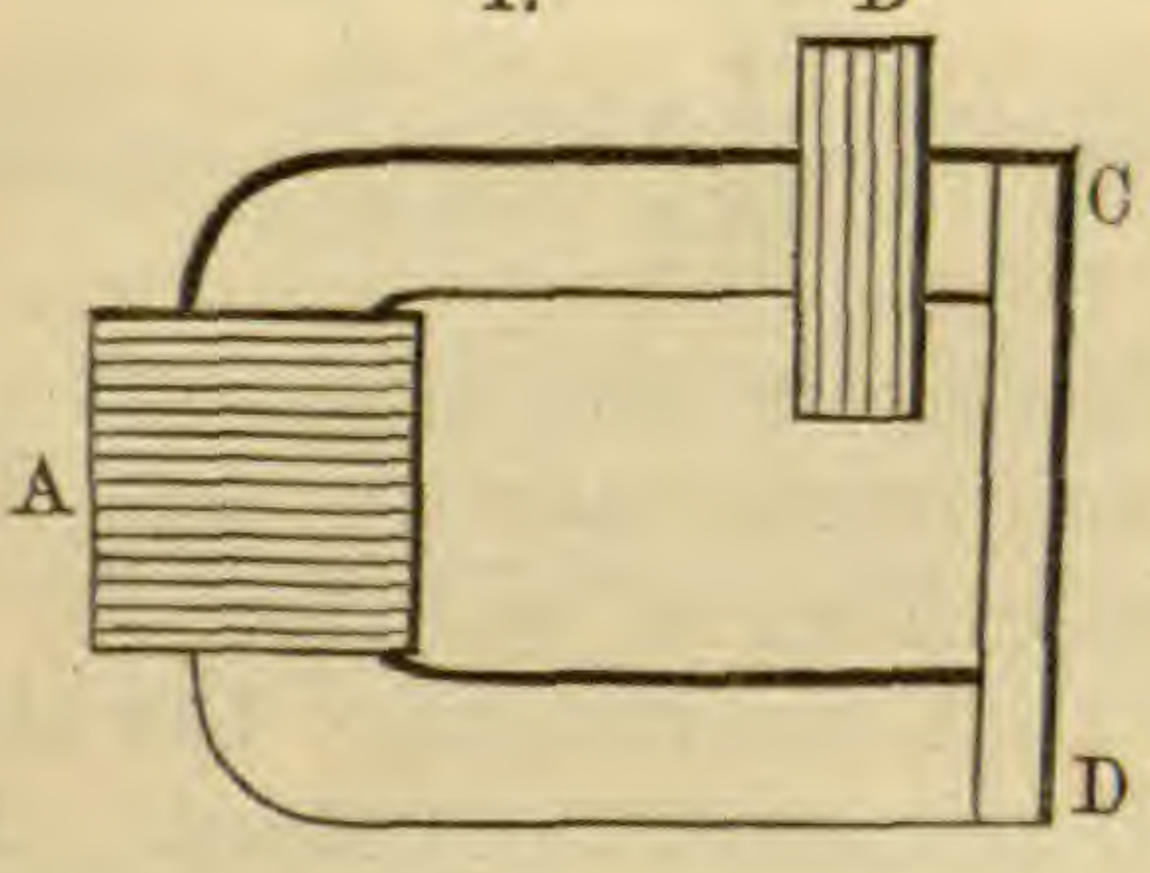
in which k is a constant depending on the strength of the current, a is distance of point from center of coil, and r is the radius of the coil. By inspection it will be perceived that a small variation in the value of a will affect the value of X more than a similar slight variation in the value of r.

* James Stuart, M. A., Phil. Mag., 46, 1873, p. 231.

No. 16.—*Upon the induced currents produced by the application of armatures to Horseshoe magnets and a new form of Magneto-electric Engine;* by W. R. Morse.

The apparatus consisted of cylindrical horseshoe electro-magnets, the wires of which were wound about the iron cores at the bend of the iron, so as to form practically straight electro-magnets with cores horseshoe in form. Upon one of the limbs of the horseshoe core a coil of fine wire was slipped so that the plane of its coils was at right angles to those of the electro-magnet. In fig. 1, A represents the coil of the electro-magnet; B that of the induction coil. Upon exciting the electro-magnet induction currents arose in the coil of fine wire B both at making and breaking the circuit. These currents were measured by a reflecting galvanometer placed in the circuit of the coil B; and were compared with those obtained from the same electro-magnet by placing a straight armature C D upon its poles and then exciting the electro-magnet. The following table shows the results obtained. Only the currents resulting from making the circuit are recorded, those proceeding from the breaking of the circuit being the same in value. The readings are expressed in the divisions of the scale of the reflecting galvanometer.

1.



Without armature.	With armature.	After removal of the armature. 1st deflection.	After removal of the armature. 2d deflection.
170	210	210	170
170	209	209	170
175	209	209	170
170	210	210	175

These results show that a marked increase (in these experiments, nearly twenty-five per cent) in the strength of the induction currents results from the application of an armature to the poles of the electro-magnet. The third and fourth columns of the table show that after the removal of the armature, the first induced current which results from again making the current in the electro-magnet shows the same increased effect; but that the following current resulting from breaking the circuit of the electro-magnet falls to its normal amount. This result is noteworthy, for it shows a certain molecular change in the iron which results from the application of the armature.

Although we can thus increase the strength of the induction currents produced in coils slipped upon the limbs of an electro-magnet, we diminish the lifting power of these individual limits by the employment of an armature, as the following results show:

Weight lifted without armature.	Weight lifted with armature on.
249	160
300	180

In the preceding experiments the straight iron bars forming the armatures were carefully deprived of whatever residual magnetism they might possess.

Experiments were next tried upon the effect of horseshoe electro-magnets used as armatures to electro-magnets of the same character as those employed in the preceding experiments. When two north or two south poles were opposed to each other, and the magnetic circuit, so to speak, of the two horseshoe-shaped cores was closed, very feeble indications were shown by the galvanometer. When, however, a north and a south pole were opposed, and the magnetic circuit closed, the strength of the currents obtained both on the application and the removal of the armature were very marked, as the following results show:

At contact of N. and S. poles.	On removal of N. and S. poles.
+360	−359
+362	−360
+361	−361

When the horseshoe magnet forming the armature was not used, and one of the limbs of the stationary electro-magnet was quickly slipped in and out of the induction coil, induction currents were obtained, the values of which are shown below:

Placed in.	Withdrawn.
+40	−40
+40	−40
+40	−40

In these experiments the stationary electro-magnet and the electro-magnetic armature were of the same size and the same magnetic strength.

Experiments were next made upon the influence of the mass of the iron forming the armature. This was found not to have so much influence as the residual magnetism of the iron. The results were very contradictory, as the following table shows:

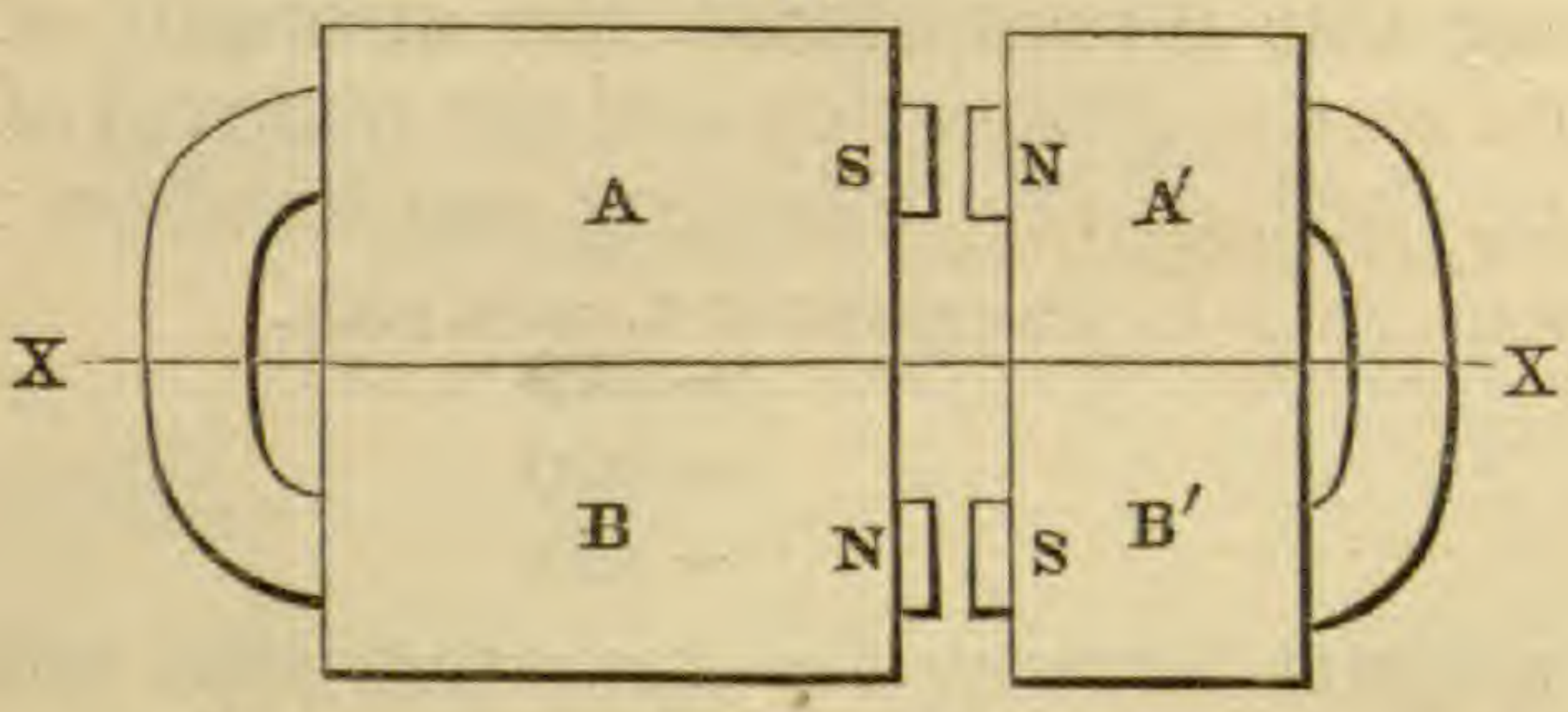
Weight of armature.	Deflection produced.
364 grams.	280
341	330
222	290
137	280
132	290
67	310

We are led to believe that the mass of the iron does not affect the results when it exceeds that of the stationary electro-magnet.

The induction currents resulting even from the employment of straight soft iron armatures which had been carefully deprived of residual magnetism are thus seen to be more than four times as strong as those obtained by merely slipping the induction coil on and off the limits of the electro-magnet; which is, practically, the method adopted in many later forms of the magneto-electric engine, particularly in that of the Gramm machine, in which different portions of a ring-shaped electro-magnet revolve toward and away from the poles of a horseshoe magnet. When electro-magnetic armatures are used the effects far surpass those obtained by non-magnetic soft iron straight armatures, as the preceding results show.

Professor Trowbridge suggests a magneto-electric engine of the following construction. The horseshoe armature is made to revolve about the line XX as an axis. By the preceding experiments it has been found that when a north and a south pole are opposed the induction currents flowing through B and A′ are in the same direction and those through B′ and A are also in one direction. By a suitable commutator the currents circulating through the coils on the stationary magnet can be sent through those on the armature, and vice versa. The residual magnetism in soft iron is sufficient to start the induced currents. Instead of one stationary electro-magnet it would probably be better to employ a number arranged about the axis XX. With projecting pieces of soft iron arranged upon the poles of the stationary magnets, the size of the horseshoe armature could be regulated to suit the varying conditions of speed.

2.



Experiments are now being made on this form of engine.

Art. XLII.—*Remarks on the Observations of the late Transit of Venus*; by Simon Newcomb.

Reports more or less detailed having been received from all the parties engaged in observing the late Transit of Venus, we are in a position to form at least a rough estimate of the measure of success which has been attained. This estimate can, however, at present, only be preliminary, because the accuracy of the individual observations and methods cannot be assured except by a critical examination, discussion, and comparison of the observations, a work which will necessarily require much time for its accomplishment.

Among the causes which affected the prosecution of the observations, the weather occupies the most prominent place. The most striking feature of the weather at the late transit, so far as concerns the American stations, is the impartiality with which clouds have been distributed among the several stations. Notwithstanding that the utmost pains were taken to choose positions where the weather record for November and December was good, the prosecution of the observations was more or less interfered with by clouds at every one of the eight stations. On the other hand, there was not a station at which the operations totally failed. At the most unfortunate one, Chatham Island, six or eight photographs of the sun with Venus on its disc were secured. At two stations, Hobarttown and Chatham Island, no contacts at all were observed. The number of good photographs of the sun with Venus completely entered upon its disc is approximately as follows:

Northern Stations.

Wladivostok, Siberia,	13
Pekin, China,	90
Nagasaki, Japan,	60
Total,	163

Southern Stations.

Kerguelen Island,	26
Hobarttown, Tasmania,	39
Campbelltown, Tasmania,	55
Queenstown, New Zealand,	59
Chatham Island,	8
Total,	187

While the small number of these photographs is extremely disappointing, their distribution among so many stations is a great advantage, through the facilities thus afforded for detecting and eliminating any constant error peculiar to any particular station.

Besides the photographs here enumerated, a number of photographs of the indentation made by the planet while entering upon the limb of the sun were obtained at some stations.

Contact observations were obtained at the American stations as follows:

First External Contact.

Northern stations: Wladivostok, Pekin, Nagasaki. ?

Southern stations: Kerguelen, Queenstown.

The difference of time between the mean of the northern stations and Kerguelen, due to parallax, is thirteen minutes.

Compared with Queenstown, the difference is only four minutes. Allowing a probable error of eight seconds in the comparison of these observations, they would alone give a value of the solar parallax with the probable error 0″·090.

First Internal Contact.

This was observed at the three northern stations, but only at Queenstown in the south. The American observations alone will therefore give us no result entitled to weight. The southern region for the observation of this contact is that extending from Kerguelen Land to Mauritius and Rodriguez, and here very little success was met with by the parties of any nation in the observation in question. It may, however, have been successfully observed by the English at Rodriguez, and by the Germans at Kerguelen, from neither of whom the writer has seen definite statements on this point. On the other hand, it was successfully observed by the English parties at the Sandwich Islands, whose observations will be available for combination with those of Dr. Peters at Queenstown, and of other observers in Australia, even if no observations were made at Kerguelen and Rodriguez.

Second Internal Contact.

This was also observed at all three northern American stations, but at only a single southern one, namely, Campbelltown. The mean difference of time due to parallax is fifteen minutes. The favorable southern region for the observation of this contact was Australia, and the islands east and south of it, and the weather was exceptionally unfavorable in most of this region. Some success was obtained at and near Melbourne, and the German expedition in the Auckland Islands was also successful, but the English and French expeditions nearly all failed in this important observation.

Second External Contact.

This was observed at only a single one of the eight American stations, Pekin. It is, however, the least fitted of the four contacts to be accurately observed, and the failure to secure it is therefore the less to be regretted.

It is my opinion that the optical observations of contacts made by the observers of all nations will, by their combination, give a value of the solar parallax of which the probable error will lie between 0″·02 and 0″·03. I also think that the American photographs alone will give a result at least as accurate as this, and probably more so. A large remaining mass of material will be the heliometer measures made by the Germans and Russians as well as Lord Lindsay, various optical measurements made near the moments of internal contacts, and photographs in which Venus was partly on the sun. The combination of all these may be expected to give a result of equal weight with either of those already mentioned. I think, therefore, that we may look forward with considerable certainty to seeing the probable error from the combination of all the observations less than $0''\cdot02$, and, perhaps, not much more than $0''\cdot01$. At the same time, it is not to be disguised that there is a possibility of unforeseen perturbing causes being brought to light by a comparison of all the observations, which will upset all our *a priori* estimates of probable error.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Occurrence of Diphenyl in Coal Tar.*—Fittig communicates the results of an investigation made in the Tübingen laboratory by Buchner, upon a liquid hydrocarbon oil obtained as a by-product in the manufacture of anthracene. The portions of this especially examined were the less thoroughly known fractions boiling between 170° and 200°—i. e., between trimethylbenzol and naphthalin—and between 220° and 270°—or between naphthalin and acenaphtene. The first fraction by repeated distillation was almost entirely resolved into products boiling below 170° and others boiling above 200°; whence the conclusion that coal tar contains no considerable quantity of a hydrocarbon boiling between these limits. The second fraction gave a more satisfactory result. After several fractionings of five degrees, the portions distilling over between 242° and 263° solidified on cooling. By cooling these fractions considerably and subjecting them to pressure, a white crystalline mass was obtained, which remained solid at ordinary temperatures, and distilled completely between 245° and 250°. After two recrystallizations from alcohol, the hydrocarbon melted at 70°–71°, and exhibited all the properties of diphenyl.—*Ber. Berl. Chem. Ges.*, viii, 22, January, 1875.

G. F. B.

2. *Explosiveness of methyl nitrate.*—Methyl nitrate was discovered by Dumas and Peligot in 1835. In 1862, Carey Lea* showed that it could advantageously replace methyl iodide in most chemical reactions, especially in the preparation of the methyl bases. In 1864, as a consequence of this observation, Hugo Löwenstein applied it in the manufacture of the violets derived from rosaniline by substitution; and it has since come so extensively into use as almost to displace methyl iodide from the market. The most serious objection to its use is its explosiveness; a fact first pointed out by its discoverers, and since, unfortunately, realized on a large scale in the case of the death of the talented young chemist, E. T.

* This Journal, II, xxxiii, 86, 227, 1862.

Chapman, and in the more recent disastrous explosions both in Germany and France. GIRARD, employing it largely for the production of colors, has made some experiments with it, with a view to obviate this difficulty. He finds, for example, that methyl nitrate, like nitro-glycerin, detonates by a blow; a drop on blotting paper producing, when placed on an anvil and struck with a hammer, an explosion quite as violent as nitro-glycerin. When mixed with pulverulent or porous substances, such as precipitated silica or infusorial earth, it yields dynamites fully as effective as those made with nitro-glycerin. By admixture with other liquids, however, such as methyl, ethyl, or amyl alcohol, acetone, benzol or toluol, Girard finds that it is no longer explosive. One part of methyl nitrate diluted with two or three parts of either of the liquids above named, does not explode either on heating its vapor, or by a blow. In such solutions, therefore, it is best kept for use. —*Bull. Soc. Ch.*, II, xxiii, 63, Jan., 1875. G. F. B.

3. *On Pure Dextrin, prepared from Malt.*—BONDONNEAU describes the properties of dextrin prepared by the action of diastase on starch. A kilogram of dry starch, diffused in two liters of water, was treated in the cold with an extract of 250 grams of bruised malt in 500 grams of water; the whole being heated on the water bath to 75° until the starch had disappeared. The liquid was then carried to boiling to destroy the diastase, filtered through animal charcoal, and concentrated to 32°–33° Baumé. To free the dextrin in this solution from the glucose (dextrose) present, it was first reprecipitated five or six times with alcohol, then treated with a copper test made with cupric chloride and sodium hydrate; this latter treatment destroying the dextrose. As thus obtained, the dextrin showed no coloration with iodine, gave only feeble indications with the copper test (equivalent to 1·85 per cent dextrose) reduced gold chloride and ammonio-silver nitrate, gave an abundant precipitate with a solution of barium hydrate and with ammoniacal lead acetate, but none with lead sub-acetate. The dextrose present, the author believes to be produced by small quantities of non-coagulable albuminoids present, acting as ferments. By care and rapidity in operating, dextrin may be obtained devoid of reducing power. The rotatory power of the dextrin thus obtained is $\alpha j = 176°$ to the right; that produced by torrefaction being $\alpha j = 183°$.—*Bull. Soc. Ch.*, II, xxiii, 98, Feb., 1875. G. F. B.

4. *On the Identity of Liebermann's Cœrulignone with Reichenbach's Cedriret.*—HOFMANN has continued his investigations upon the less volatile constituents of beech-wood tar. In a previous paper he had shown that from these could be isolated a liquid boiling at 270°, possessing a phenol-like character, and yielding, when treated with potassium dichromate, the beautifully crystallized substance described by Liebermann under the name of coerulignone, and also a magnificently crystallized compound in long yellow needles, dissolving in sulphuric acid with a carmine-red color. He has now been able by repeated fractioning and recrystalliza-

tion of the sodium salt, to isolate an oil boiling at 285°, which on oxidation is entirely converted into the yellow body, and which has the formula $C_{11}H_{16}O_3$, its bromine derivative being $C_{11}H_{14}Br_2O_3$. The yellow compound is a quinone-like body, having the composition $C_8H_8O_4$ and giving on reduction a hydro-compound $C_8H_{10}O_4$, crystallizing in white needles. Bromine gives a substitution derivative of the composition $C_8H_6Br_2O_4$. In regard to the body first named, to which Liebermann has given the name coerulignone, Hofmann concludes that it is identical with the substance long ago described by Reichenbach* under the name cedriret. The description originally given of it is quoted, and is full and complete. That a body possessed of properties so striking should have remained forgotten for thirty years, is exceedingly remarkable. In a note immediately following, Liebermann himself acknowledges the identity; though he was at first inclined to doubt it, owing to Reichenbach's having described it as a precipitate of fine *red* needles, and having obtained it from wood tar; whereas, his product was obtained from wood-vinegar and crystallized in dark steel-blue or violet needles. The production of this body by Hofmann from an oil derived from wood tar and evidently identical with Reichenbach's product, leaves no doubt of the identity.—*Ber. Berl. Chem. Ges.*, viii, 66, 69, January, 1875.

G. F. B.

5. *On a new Coloring matter, Eosin.*—A new coloring substance, introduced into commerce during the last summer under the name of Eosin, has been examined by HOFMANN. It has a beautiful red color, recalling that of rosaniline, but inclining more to garnet-red. The name eosin, by which it is known to the trade, unlike most similar names, is rational, being derived from Ἕως, the red of the morning dawn. It appears as a brownish-red powder, showing here and there facets with metallic luster. It is soluble in water and in alcohol, and its solutions are strongly fluorescent. Upon examination, it was found to contain no nitrogen, and to evolve hydrogen bromide on heating, leaving a carbonaceous residue containing potassium bromide. Distilled with zinc dust it afforded benzol. Its aqueous solution treated with an acid, threw down a brick-red powder, which, recrystallized from glacial acetic acid, appeared as yellow prisms having the composition $C_{20}H_8Br_4O_5$; a formula confirmed by the analysis of the barium salt, $C_{20}H_6Br_4BaO_5$. From these data Hofmann concluded that eosin must belong to that most remarkable group of bodies with which Baeyer has enriched chemistry, being a tetrabrominated fluorescin; a derivative of a body which he obtained by fusing resorcin with phthalic oxide. To test this hypothesis, Hofmann treated the potassium compound with potassium hydrate, heated, decomposed by an acid, treated the filtrate with ether, and from the etherial solution obtained dibrom-resorcin in beautiful white needles. Eosin is therefore the phthalëin of dibrom-resorcin. Its synthesis was very easily accomplished by acting on an acetic solution of

* Berzelius Jahresbericht, xv, 408.

fluorescin—prepared from resorcin and phthalic acid by Baeyer's method—by bromine, and then diluting with water. The red precipitate thus obtained dissolved in alkaline solutions with the characteristic color of eosin, and when crystallized from glacial acetic acid, afforded the same product as that met with in commerce.

In a paper published subsequently, BAEYER states that eosin was first produced commercially at the Baden Aniline Works by Caro, and by him introduced to the trade under that name. He suggests the following experiment to show the relations of eosin: A portion of the coloring matter is agitated with water and sodium amalgam at a gentle heat. The solution is soon decolorized, the bromine being removed and colorless fluorescin produced. If now, water be added and a few drops of potassium permanganate solution, the fluorescin changes to fluorescëin and the liquid becomes bright green and almost opake, in reflected light.—*Ber. Berl. Chem. Ges.*, viii, 62, 146, Jan., Feb., 1875. G. F. B.

6. *On the Structural Formula of Hydroxylamine.*—The body NH_3O, discovered originally by LOSSEN, and to which he gave the name hydroxylamine, possesses great theoretic interest. It may be regarded as ammonia in which hydroxyl replaces an atom of hydrogen; as a direct compound of the radicals amidogen and hydroxyl; or as a compound in which an atom of nitrogen has two of its units of attraction saturated by two hydrogen atoms while the third is united to one of the bonds of an oxygen atom, the other being saturated by hydrogen; thus $H - \overset{\overset{\textstyle H}{|}}{N} - O - H$. It would seem as if there could be little question upon the rational constitution of so simple a body. The above rational formula rests, first, upon the method of its preparation and second upon its ammonia-like properties. It is prepared by the reduction of nitric acid, precisely as nitro-methane is reduced to methylamine or nitrobenzoic acid to amidobenzoic acid; the radical NO_2 in all these cases being changed to NH_2. Hence from $NO_2.OH$ comes very readily $NH_2.OH$. Again, the ammonia-like structure of hydroxylamine is shown by the fact that it unites with acids to form salts without the formation of water. The structure above given, however, involves the assumption that two of the three hydrogen atoms, being similarly situated and combined, should exhibit the same behavior; while the third, being differently united, should behave differently. LOSSEN has undertaken to test this assumption experimentally. By an easy replacement of the hydrogen atoms in hydroxylamine by benzoyl, benzhydroxamic and di-benzhydroxamic acids, and tribenzhydroxylamine, are successively produced. Entirely analogous compounds are produced by anisyl. Calling the hydrogen atoms one, two, three, in this order $N\overset{1}{H}\overset{2}{H}O\overset{3}{H}$, we have, when both radicals replace hydrogen, benzanishydroxamic acid $N(C_7\overset{1}{H}_5O)(C_8\overset{2}{H}_7O_2)O\overset{3}{H}$ and anisbenz-

hydroxamic acid $N(C_8\overset{1}{H}_7O_2)(C_7\overset{2}{H}_5O)O\overset{3}{H}$, with two replacements; and dibenzanishydroxylamine $N(C_7\overset{1}{H}_5O)(C_7\overset{2}{H}_5O)O(C_8\overset{3}{H}_7O_2)$, benzanisbenzhydroxylamine $N(C_7\overset{1}{H}_5C)(C_8\overset{2}{H}_7O_2)O(C_7\overset{3}{H}_5O)$, and anisdibenzhydroxylamine $N(C_8\overset{1}{H}_7O_2)(C_7\overset{2}{H}_5O)O(C_7\overset{3}{H}_5O)$, when three atoms are thus exchanged. Now if hydrogen atoms 1 and 2 in hydroxylamine are precise equivalents, the first two of the above named five compounds are identical; if not, they are only isomeric. If hydrogen atoms 2 and 3 are equivalents, then the third and fourth of the above compounds are identical; but they are only isomers, if they are not. Lastly, if hydrogen atoms 1 and 3 are equivalent to each other, the third and fifth of these compounds must be the same; but if these atoms are not precisely identical in function, the compounds must be isomers. The author has proved the most important point, that benzanishydroxamic and anisbenzhydroxamic acids are not identical, but are isomeric. The former fuses at 133° to 134°, the latter at 147° to 148°, and their chemical reactions as given are quite different. It seems clear therefore that hydrogen atoms 1 and 2 are not the precise equivalents of each other, and that there are at least two kinds of such atoms in hydroxylamine. Lossen assigns therefore to dibenzhydroxamic acid the formula $C_7H_5O-\overset{\overset{H}{|}}{N}-O-C_7H_5O$ and to dianishydroxamic acid that of $C_8H_7O_2-\overset{\overset{H}{|}}{N}-O-C_8H_7O_2$. The author promises further researches to fix the position of the replacing radical in the monohydroxamic acids.—*Liebig's Ann.*, clxxv, 271, Jan., 1875. G. F. B.

7. *Influence of Pressure on Combustion.*—M. L. CAILLETET has studied the effect of a pressure of 30 to 35 atmospheres on the luminous, calorific and chemical rays, emitted by a burning body. The air was compressed by pumps in which the pistons were fixed and the cylinders movable, a layer of water or glycerine at the same time cooling the gases so as to protect the packing from the heat, and preventing leakage. The reservoir consisted of a hollow cylinder with four apertures; the first admitted the gas, the second allowed it to escape, the third admitted the manometer-tube, and the fourth was closed by a thick glass plate to allow of observation of the interior. The latter had a diameter of 10 cms. and a capacity of about 4 liters. Placing a lamp in this space, the brightness increased with the pressure of the air. The base of the flame, which under the ordinary pressure is blue and transparent, became white and very bright; but soon the appearance changed and thick clouds of smoke circulated through the apparatus and escaped by the stopcock closing the outlet. The flame seen through this smoke is reddish and the wick is found to be charred and much soot deposited, doubtless owing to the dissociation of

the gases containing carbon. The heat increases but not enough to burn an iron wire heated to redness in the common flame.

The brightness of the flame of burning phosphorus does not seem to increase, but that of sulphur is brighter and yellowish-red on the borders.

Potassium burns with a very bright violet flame. The combustion in a charcoal furnace did not seem more rapid under 25 atmospheres than at the usual pressure. An alcohol lamp with a wick formed of a single thread, and giving in the open air a scarcely visible flame, rapidly increased in brightness with the pressure. At 20 atmospheres, the flame is white and bright as that of an oil-lamp. Its spectrum is continuous and more extended than at ordinary pressures; the ray *D* is alone visible, apparently enlarged. Bisulphide of carbon also burns more brightly than usual. Neither it nor sulphur gives a perceptible quantity of sulphuric acid.

The chemical rays, as well as those of light and heat, seem to have an increased activity. A number of flattened tubes containing phosphorescent substances were exposed to the rays of these flames and shone with a much brighter light with the increased pressure.—*Comptes Rendus*, lxxx, 487. E. C. P.

8. *Magnetism.*—M. Bouty has studied the laws of magnetic action by means of a new and simple device for measuring magnetic moments. A small magnet attached to a mirror is fastened to the lower end of a rod of sealing wax and suspended by a filament of silk. In the upper part of the rod a small glass tube is inserted at right angles to the magnet. If now a magnet is inserted in the tube, the system will assume a position of equilibrium under the action of the two magnets, from which their relative magnetic moment is readily determined. The angular deflection is measured by means of a telescope and scale. The lower magnet has a length of 6 cms. and a diameter of ·2 mms; the tube a length of 2 cms. and a diameter of ·2 mms. By this arrangement the moment of magnets could be determined whose length was but 2 mms. and their diameter ·2 mms. With this apparatus the magnetization of a bar was measured when it was inserted a number of times into a helix, and was found to be well represented by the empirical formula $Y=A-\frac{B}{X}$, in which Y is the moment and X the number of insertions.

The effect of breaking a needle was next studied. The needle was heated to redness and plunged instantly into water, and the middle portion, about 150 mms. in length, alone employed. Green has deduced a formula for the magnetic moment of saturated bars of various lengths. But the primitive needle possesses in every point a higher degree of magnetization than corresponds to the saturation of the fragment which belongs to it after breaking. Two instruments are employed, one of great delicacy, for the short fragments, a second less sensitive for the longer pieces. The agreement of observation with theory is all that could be desired until the length becomes small compared with the diameter. The law for changes in the diameter and the effect of a fracture parallel to the axis were also studied. Finally, on the ground of the peculiar facts examined in this memoir, as well as the whole of the known facts, he concludes that the present theories of magnetism are insufficient to explain the peculiarities of the temporary magnetization of steel, and suggests that in regard to the magnetic properties of its elements this substance must be considered a heterogeneous mass.—*Phil. Mag.*, xlix, 81, 186. E. C. P.

9. *Frictional Electricity.*—M. ROSSETTI has made a careful study of the current developed by a Holtz machine and shown that it follows the laws of a galvanic battery. The machine was turned by a weight, and the work done measured when charged and discharged. The current was determined by a galvanometer and the resistance by four long fine tubes filled with distilled water. The current is nearly proportional to the speed, but increases a little more rapidly than the latter. The ratio of the two alters with the amount of moisture in the air, so that to produce a given current the machine must be driven faster in wet weather, although the work required is less than when the air is dry. The economy, therefore, is greater on wet than on dry days. A Holtz machine resembles a galvanic battery, having an electromotive force and interior resistance which are constant as long as the velocity and moisture are constant. The electromotive force is invariable for a given degree of moisture whatever the velocity, while with a given velocity it diminishes as the moisture increases. The interior resistance on the other hand is independent of the moisture and diminishes more rapidly than the velocity increases. In the actual instrument employed, when the moisture was ·69 the electromotive force equalled 41,000 volts, while with the moisture ·35 it equaled 57,000 volts. The resistance with a velocity of eight turns per second was 540,000,000 ohms, and with a velocity of two turns 2,680,000,000 ohms. The current follows the law of Ohm, consequently if very large exterior resistances are employed, the strength of the current gives the mechanical equivalent of heat. The mean of seventeen experiments gave as a result the number 428, which agrees very closely with the commonly received value.—*Ann. de Chim. et Phys.*, iv, 214. E. C. P.

10. *Chemical Sub-section in the American Association for the Advancement of Science.*—This sub-section of the American Association was organized at the Hartford meeting in August last. It is called the "Sub-section of Chemistry, Chemical Physics, Chemical Technology, Mineralogy and Metallurgy," and all persons interested in applied as well as in pure chemistry will be welcome at Detroit, where the next session is to be held, in August of this year. We make this statement very willingly at the request of Prof. F. W. Clarke, of Cincinnati University, who is the secretary of this section, and who is making active exertions to secure a large gathering of chemists on that occasion. Prof. S. W. Johnson, of Yale College, is chairman-elect of this section.

II. Geology and Natural History.

1. *Supplement to the Article on Dr. Koch's evidence with regard to the cotemporaneity of Man and the Mastodon; by the Author.*—Since the article on pages 335 to 346 was printed, I have come across another of Dr. Koch's pamphlets. It is a "second edition" of the New York pamphlet of 1845. In the main it is the same with the earlier one of that year. The most important difference is in the first half of the title page, which reads as follows:

"Description of the Hydrarchos Harlani (Koch). (The name Sillimanii is changed to Harlani, by the particular desire of Professor Silliman.) A gigantic Fossil Reptile, lately discovered by the author, in the State of Alabama, March, 1845."

A *second* difference is in the appended matter of nearly 10 pages, which extends the pamphlet to 24 pages. This matter consists of (1) an extravagant article from "The New York Dissector;" (2) the article from the "New York Evangelist" about the Hydrarchos and Leviathan, alluded to on page 344, as occupying the inside pages of the pamphlet of 1853; and (3) a puff from the "New York Morning News."

A *third* novelty is a large wood-cut of the "*Hydrarchos Harlani*," covering the last page of the cover. The body of the pamphlet contains only some verbal changes.

These New York pamphlets of 1845 contain one significant discovery of Dr. Koch's, made during his "geological tour," which is worth citing. He says: When at Golconda, Illinois, "I discovered a large deposit of old red Sandstone or Devonian system, in which I found a great variety of non-described fossil fish of most wonderful forms, the spiral columns of many of them bearing a striking resemblance to a screw, so that they are called by the inhabitants of the country *petrified screws*."

The Doctor's "spiral columns" of "fossil fish" are the common Bryozoan corals of the genus *Archimedipora*, found there, and elsewhere, only in Subcarboniferous rocks.

2. *Cold of the Glacial and other Geological epochs.*—The idea that a high-latitude elevation making a partial barrier across the shallower part of the Atlantic Ocean from Scandinavia to Greenland, would produce a change of temperature in the North Atlantic, is brought out by Mr. Prestwitch in his Presidential Address before the Geological Society of London, in 1871, to account for changes in the life of the ocean, during the latter part and close of the Cretaceous period; and the principle is recognized by Dr. W. B. Carpenter in his elaborate paper on Ocean Currents in connection with his Researches on board the "Shearwater" in 1871, read before the Royal Society in June, 1872, and published in No. 138 of the Society's Proceedings, xx, 535–644. J. D. D.

3. *Geological Survey of Wisconsin.*—The present geological survey of Wisconsin was organized in the spring of 1873, with Dr. I. A. Lapham as chief geologist, and Professor R. D. Irving,

of the State University, Professor T. C. Chamberlin of Beloit College, and Mr. Moses Strong, Mining Engineer, as assistant geolgists; and Professor W. W. Daniels, of the State University, as chemist. The appropriation was $13,000 annually for four years.

The name of the Chief Geologist was a guarantee that the work would be faithful and exact.

Two seasons have been occupied in office and field work. During the first season there were three parties in the field, and during the second. four, a special contract having been made for a survey, during the latter season, of the Menominee River Huronian region, with Major T. B. Brooks, of the Michigan Survey, the work being really but an extension across the State line of his previous labors in Michigan. By the close of the last season one-third of the State had been examined in detail, and very many interesting facts developed. Reports have been made sufficient to fill a large quarto volume, accompanied by hundreds of illustrations and over a hundred detailed maps. These maps embrace all the results possible to place upon them; it having been the aim of the corps to put as much of the work as possible in this permanent form. They are complete for all portions of the State examined, and include geological, topographical, agricultural and other maps, accompanied by large general sections, all drawn on a scale of two inches to the mile.

The entire lead region has been topograpically surveyed and mapped with contour lines at a distance of fifty feet vertical, as recommended by Whitney in his report on the same region. Careful determinations of dips were made at the same time, so that the exact position of the mining ground—confined to certain strata—is made known at each locality.

Northern Wisconsin, bordering on Lake Superior, has been examined in detail, and some interesting facts bearing on the ages of the Lake Superior sandstone and of the copper rocks ascertained. The main work in northern Wisconsin consisted in an investigation of the Huronian rocks and ores of the Penokie Iron Range of Ashland County. The range is thirty miles in length in Wisconsin and about a mile in width at base. Several streams break through it from the southward, affording magnificent sections of its rocks, and on its flanks the siliceous ores that form its mass everywhere outcrop in precipitous exposures. These outcrops have been measured and the ore sampled and analyzed. The report on this range alone would form a volume of considerable size, with some scores of illustrations.

Eastern Wisconsin has been nearly or entirely surveyed by P of. Chamberlin's party. He has been able to divide the Nia ara limestone into several subordinate formations. He has also obtained many new and interesting facts bearing on the drift phenomena of a region most remarkable for its glaciated surfaces, giant kettles, boulder clays and moraine heaps. He has also prepared a series of soil and timber maps of this region, and has collected no less than 14,000 fossils, many of them new forms.

Central Wisconsin has been examined in detail by Professor Irving, where he has made observations on the Lower Silurian of the Four Lake country; the Archæan quartzyte range of Sauk and Columbia Counties; the extensive Potsdam sandstone region of the center of the State, with its remarkable castellated outliers of sandstone, and numerous Archæan islands; the boundary between the Archæan and Potsdam; the rocks of the main Archæan body along the valleys of the Wisconsin, Yellow, and Black Rivers; and on the drift phenomena of the entire region, which are especially interesting because the area is just on the edge of the driftless region of the western half of the State.

While the members of the corps were just now expecting authority from the legislature for the printing of these reports, they were greeted, we learn, by the announcement that the governor had appointed a new chief geologist, and one whose sole recommendation for the position was political services, no one having ever heard of him before as acquainted with geology or any other science. It appeared that Dr. Lapham had been appointed under the law subject to the confirmation of the senate at its next session. At that time a new administration had come in and Dr. Lapham's name was never sent in, though he continued to perform his duties, and to be recognized by the State officials. This fact was taken advantage of to oust him, the appointment being defended in the senate by parties from the northern portion of the State, who had got the idea that the reports on the mineral regions of that section were not as favorable as interested parties desired. The whole thing was a total surprise to Dr. Lapham and other members of the corps, so that there was no time for any opposition on their part, or that of other friends of the survey and of good honest scientific work.

A great wrong has been done to Dr. Lapham, and a greater to the State. But we cannot believe that the State of Wisconsin will be satisfied to thus stultify itself before the world by sustaining the appointment to a scientific position of one who confessedly knows nothing of its duties.

4. *Geological Survey of Alabama. Report of Progress for* 1874; by Eugene A. Smith, Ph.D., State Geologist. 140 pp. 8vo. Montgomery, Alabama, 1875.—Prof. Smith, after a history of the Geological Survey of the State hitherto undertaken, gives in a brief and systematic form the results of his geological work carried on during the past year. His labors were confined mainly to the portions of the State occupied by crystalline rocks, and especially to Chilton, Talladega, Cleburne, Randolph, Clay, Coosa, Tallapoosa, Chambers, Lee, and Elmore Counties. The rocks, and the mines or valuable minerals they contain, are described with care. The crystalline rocks include granites, gneiss, hornblendic rocks, mica schist, hydromica slate, chlorite slate; and also hypersthenyte or noryte, which occurs near Columbus; with crystalline limestones, which are partly dolomitic. Among the materials of economical importance occurring in these counties

are included marbles; soapstone at many localities in Clay, Tallapoosa, Chambers and other counties; white porcelain clay; asbestus; mica; corundum, in Tallapoosa County; graphite; gold; copper, in Wood's Mine in Cleburne County; iron ores, which are associated usually with the hornblendic rocks. The Report closes with chemical analyses of various iron ores, coals and limestones.

5. *Geological Survey of New Jersey. Annual Report of the State Geologist*, Prof. GEORGE H. COOK, for the year 1874. 116 pp. 8vo. Trenton, N. J., 1874.—Prof. Cook gives, in his Report for 1874, new information on the remarkable series of Archæan iron mines in New Jersey, and also facts respecting mines of limonite, copper, zinc, and the quarryings of pottery clay, etc. He states that 700 to 1000 tons of metallic zinc are now made annually from New Jersey ores, 850 tons from Pennsylvania ores, and more than 3000 tons from Western ores. With regard to the white clays of New Jersey, he remarks that 265,000 tons of fire clay are annually dug in Middlesex County, about Woodbridge, Perth Amboy and South Amboy, and sold at an average price of $3.50 per ton. Besides, there are 20,000 tons of stoneware clay dug at South Amboy, which averages $4 per ton, and is shipped to all parts of the United States.

Prof. Cook states that the *geological position of the clay deposits is in the Cretaceous formation*, and that the stratum constitutes its lowest member. They occur in a belt of country stretching across the State from the northeast, on Staten Island Sound and Raritan Bay, to the southwest, ending on the Delaware in Gloucester County. Its northwest edge adjoins the Triassic red sandstone from Woodbridge to near Trenton, where for five or six miles it borders on the gneiss; thence to the southwest end, it follows along or near the Delaware River.

6. *Preliminary Report of the State Geologist of Oregon;* Rev. THOMAS CONDON. 22 pp. 8vo. Salem, Oregon. 1874.—Mr. Condon, who has in past years done much in the collection of the mammalian and other fossils of the interior of Oregon, was appointed State Geologist in October, 1872, but upon a salary of only $1000 per annum, and under the idea of his devoting but part of his time to the object. This preliminary report gives an interesting review of the topography of the State, with important facts respecting the great lake basins of the Tertiary, and the relations of the Tertiary sandstones containing silicified and coaly trunks of trees, to the overlying igneous rocks in the line of the Cascade Range. He speaks of the latter rocks as having a thickness exceeding 4000 feet, and as consisting of porphyry below, trachyte over the porphyry, and heavy dark basalt above.

7. *Prof. O. Heer's Arctic Flora.*—The first two volumes of Prof. Heer's Arctic Flora are as widely known as the name of the celebrated author. A third volume has been published recently*

* By Wurtzer & Co., of Zurich.

from materials collected by the Swedish Polar expeditions under the direction of Prof. Nordenskiöld. This volume admirably completes the work, by the superior character of its execution and by the interesting facts which it exposes in regard to the geological floras of the Arctic and Polar regions. It contains, 1st, a paper on the Carboniferous flora of the Arctic zone (eleven pages and six plates); 2d, the Cretaceous flora of the Arctic zone (one hundred and forty pages with thirty-eight plates); 3d, an appendix to the Miocene flora of Greenland (three pages and five plates); and 4th, a general revision of the Miocene flora of the arctic zone (twenty-four pages).

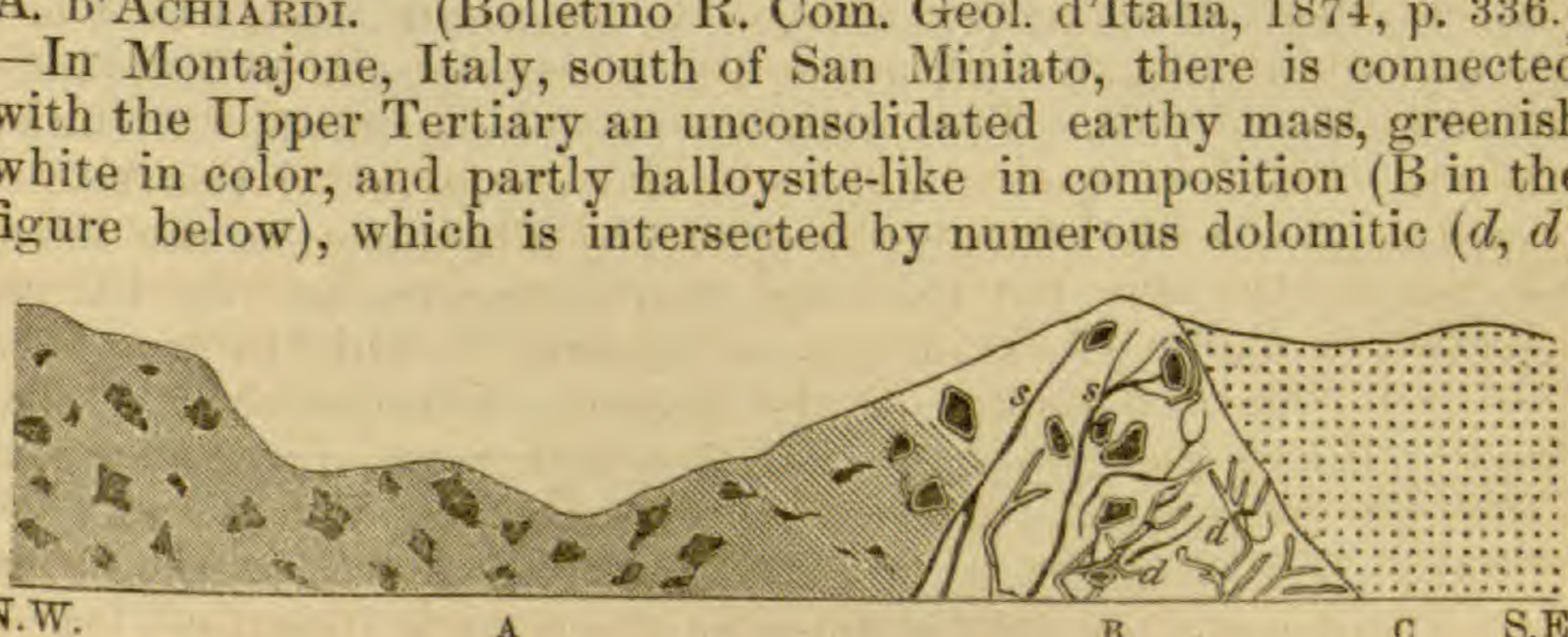
The most important part of this publication is that on the Cretaceous floras, not merely for the reason that the vegetation of the Cretaceous land was till now scarcely known, but because its exposition brings out documents related to a number of interesting problems which are masterly presented and discussed by the author. This part has a peculiar interest for the naturalists of this country, on account of the discovery in Nebraska and Kansas of a terrestrial formation closely related in time to that of the Upper Cretaceous of Greenland, in which a large number of fossil plants have been discovered and recently described by Lesquereux in a volume published by the Department of the Interior, as noticed on page 227. The fossil plants of Greenland are from two divisions of the Cretaceous; the lower one, which, from the character of its flora, is intimately allied to the Upper Jurassic, the flora being mostly composed of Ferns, Conifers, Cycadeæ, with a few monocotyledonous and a single dicotyledonous species, representing apparently a kind of *Populus*. The Upper Cretaceous division has in its flora, with a large proportion of Ferns and Conifers, two species of Cycas only, and thirty-four dicotyledonous species out of sixty-two which compose the whole flora. Among these there are species of the Genera *Myrica*, *Ficus*, *Sassafras* (one species), *Andromeda*, *Diospyros*, *Magnolia*, etc., which are also represented in the Cretaceous of Nebraska, either by identical or related forms. This indicates an evident relation, which, however, is far less marked than would be expected between two groups of plants from formations where synchronism is probable. For among the one hundred and thirty species described from the Dakota group of Nebraska, one hundred and thirteen are dicotyledonous and many of the genera, *Liquidambar*, *Salix*, *Betula*, *Alnus*, *Quercus*, *Fagus*, *Platanus*, *Laurus*, *Liriodendron*, *Menispermum*, are not represented in the flora of Greenland. In Nebraska also there is a preponderance of species referable to *Sassafras*, while from Greenland one leaf only is described as of this genus. As all these genera are now widely distributed in the North American flora, this preponderance of American types leads us to refer the origin of our present flora to the American Cretaceous.

An intermediate division, that of the Middle Cretaceous, is represented in the volume of Heer by a small number of plants from Spitzbergen, in all sixteen species of Ferns and Conifers with only one *Equisetum*.

8. *On Serpentine Pseudomorphs after Monticellite, a Lime-magnesia Chrysolite;* by G. vom Rath. (Monatsb. k. Akad. d. Wiss., Berlin, Nov. 19, 1874.)—The pseudomorphs described by Vom Rath are from the Pesmeda Alp, on Mt. Monzoni in the Tyrol. The syenyte, dioryte and "augitic greenstone," which constitute the Monzoni peak, come up through limestone [of the Triassic formation] which is in part crystalline; and this limestone contains many crystallized silicates near its junction with the other rocks, viz., fassaite, vesuvianite, gehlenite, garnet, spinel, etc. In a high ridge adjoining the Pesmeda Alp, at a height of about 2500 yards, the limestone, near its contact with "augitic greenstone," affords crystals of the form of monticellite, along with others of anorthite, garnet and spinel. The monticellite crystals, some of which are two inches long, are all changed to serpentine. They occur mixed with fassaite, and with a blackish green spinel which is also in part serpentine. The color of the pseudomorphs is light brown, yellowish and occasionally white. The crystals within are irregular in texture and color, as is well represented on a plate showing magnified sections. Vom Rath gives several excellent figures of the crystals. Unaltered monticellite has not been found at the locality, but it occurs massive (Breithaupt's batrachite) to the west of Pesmeda and to the southeast of Mt. Monzoni, near the junction of the limestone and syenyte. This massive kind is externally altered.

Vom Rath also states that the locality of serpentine-pseudomorphs affords others of *monticellite altered to fassaite.* The crystals are an inch and less in size. They have sometimes a nucleus of serpentine or calcite. The fassaite pseudomorphism in all cases preceded the serpentine.

9. *On the conversion of an argillaceous rock to Serpentine;* by A. d'Achiardi. (Bolletino R. Com. Geol. d'Italia, 1874, p. 336.) —In Montajone, Italy, south of San Miniato, there is connected with the Upper Tertiary an unconsolidated earthy mass, greenish white in color, and partly halloysite-like in composition (B in the figure below), which is intersected by numerous dolomitic (*d*, *d*)



A, clayey deposit containing nodules or fragments of indurated clay; B, the part of same deposit that has become halloysitic and in which the nodules consist of serpentine surrounded by dolomite; C, Upper Tertiary; *s, s*, steatitic veins; *d, d*, dolomitic veins.

and steatitic (*s*, *s*) veins, and contains besides isolated nodules of a fine green, compact serpentine, more or less translucent, which are often coated with dolomite. The bed or mass followed to the northwest loses its steatitic and dolomitic veins, and graduates into a rough, dark clay bed (A), containing nodules that are like the serpentine nodules in form, size and position, but which consist of indurated clay, reddish gray or grayish yellow in color. From the unaltered clayey nodules there is a gradual passage, through others partly altered, to those consisting wholly of serpentine. D'Achiardi concludes that the serpentine nodules were produced through the alterations of the clay nodules. He refers their formation to the action of hot magnesian waters on a hydrated aluminous silicate, and the replacement thereby of the alumina by magnesia. The halloysite-like material he regards as containing the alumina which was removed from the nodules in the process of alteration.

10. *On the formation of Mountains and the hypothesis of a liquid substratum beneath the Earth's crust;* by Rev. O. FISHER, (Proc. Cambridge Phil. Soc., Feb. 22.)—This paper was a sequel to one read in Dec., 1873, in which it had been shown that, upon the supposition that the inequalities of the earth's surface have been formed by contraction of its volume through cooling, they are too great to be so accounted for if the earth has cooled as a *solid* body. In the present communication it was therefore assumed that there is a *liquid* layer beneath the cooled crust; and an approximate calculation was made of the form which the corrugations of a flexible crust would take if so supported. It was shown that their lower surface would consist of a series of equal circular arcs arranged in a festoon-like manner, and having a radius $2\frac{\rho}{\sigma}c$, where ρ, σ are the densities of the crust and liquid respectively, and c the thickness of the crust. It was argued that the consequences of this form of corrugation agree fairly well with some of the phenomena of mountain elevation, but that it does not suffice to explain the ocean-basins and the continental plateaux.—*Nature*, March 18.

11. *Botany of the Island of Amsterdam.*—It is a curious fact that the little island of Amsterdam, in the South Indian Ocean, is known to be covered with trees, whilst the island of St. Paul's, only fifty miles to the south, is destitute of even a shrub. Botanists have long been anxious to determine the character of the Amsterdam forest, but the difficulty of effecting a landing on the island has generally prevented the collection of specimens. In the last part of the *Journal of the Linnean Society*, Dr. Hooker announces that at length he has received the desired specimens, these having been collected by Commodore Goodenough, who states that they represent the only species of tree growing on the island. Dr. Hooker identifies this with the *Phylica arborea* of Thouars, a tree which, strangely enough, is found in the remote Island of Tristan d'Acunha. It is a curious problem for those who study insular Floras to suggest how the same plant can have established itself on these two little specks of land, separated from each other by about five thousand miles of ocean.—*Athenæum*, March 6.

12. *Amphioxus lanceolatus.*—Prof. Huxley has shown, in a paper read before the Royal Society (Ann. Mag. Nat. Hist., IV, xv, 225),

that the anomalous *Amphioxus*, which Hæckel refused to admit into the class of Fishes, is closely related in some important characters to the Marsipobranch fishes. In the mouth with its tentacles, and in some other respects, *Amphioxus* is much like *Ammocœtes* (the young of *Petromyzon*). "The several pairs of nerves in *Amphioxus* which leave the cerebro-spinal axis between those which answer to the *portio dura*, and the optic nerve are represented by the third, fourth, fifth and sixth pairs of cranial nerves of the higher Vertebrates. The cranium of the latter is represented by those segments of the body of *Amphioxus* which lie in front of the fifteenth, counting from before backward, and their cranial nerves by the corresponding anterior pairs of nerves. No auditory apparatus was distinguished; but "in all other respects *Amphioxus* conforms to the Vertebrate type;" and, considering its resemblance to the early stages of Petromyzon (described by Schultze), there is no reason for removing it from the class *Pisces*. On account of its permanently segmented skull and its many other peculiarities, Prof. Huxley regards it as the type of a primary division which he names *Entomocrania*, other fishes being *Holocrania*.

13. *Zoological Station at Naples.*—Dr. Anton Dohrn has issued a Catalogue* of the Library of the Zoological station at Naples. Nearly one half of the volumes belong to Dr. Dohrn, and formed his private library at the time he established the zoological station; the other half consists of works presented either by the publishers or by the authors to the station. As a library of embryological and anatomical works on marine animals, it forms an admirable nucleus for the building up of a great zoological library. It only needs the continued interest which has been shown by all working naturalists to supply the station with everything published needed to carry on investigations in every department of zoology. Dr. Dohrn is anxious to secure the co-operation of American naturalists and hopes that they will remember the zoological station in the distribution of their papers. A. A.

14. *Birds of the Northwest:* a hand-book of the Ornithology of the Region drained by the Missouri River and its tributaries; by Elliott Coues. 8vo, 791 pages.—This volume forms part of the miscellaneous publications of the United States Geological survey of the Territories, under Dr. Hayden. It includes quite full synonyms of all the species and varieties belonging to the region, with many valuable descriptions of the habits, geographical distribution and variations of the species. The families *Laridæ*, *Colymbidæ*, and *Podicipidæ* are treated monographically, all the North American species being fully described. V.

15. *Geographical Distribution of Animals.*—Mr. A. R. Wallace has in the press a work on this subject, which is to be illustrated with elaborate maps, and woodcuts of animals. It will be published by Messrs. Macmillan.—*Athenæum*, Feb. 27.

* Die Bibliothek der zoologischen Station zu Neapel, Verzeichniss der daselbst bis zum Ende des Jahres 1873 vorhandenen Bücher. Leipzig. 8vo., pp. iv, 791. 1874. Wilhelm Engelmann.

III. Astronomy.

1. *On the Total Eclipse of the Sun of April 16th, as observed by Mr. Stone at Klipfontein in Namaqualand, South Africa*, 55 miles from the sea and 20 miles from the central line of shadow.—The general results which Mr. Stone considers he has obtained from the observations are summarized as follow: "1. A confirmation of Young's observations of the general, or nearly general, reversion of Fraunhofer's lines in the spectrum of the corona near the photosphere. 2. A spectroscopic examination of the outer corona, in contra-distinction to the inner corona, carried to the extent of rather more than a degree from the sun's center, which has proved that the spectrum of the outer corona consists of a linear spectrum of one bright line, either exclusively or sensibly, whose wave-length is 5,312, and of an ordinary sunlight spectrum with absorption lines. The spectrum of the outer corona has been shown to fade gradually away as the extreme visible limit of the corona is approached, and not to disappear sharply as if the extreme limit of the corona had been reached. 3. This spectroscopic examination of the outer corona, combined with the unchanged character of its principal features as seen at Namaqualand, Griqualand, and Basutoland, at intervals of absolute time extending to 10^m, and at distances of more than 500 miles, proves, I venture to think, the solar origin and cosmical character of the outer corona. The want of coincidence in the positions of the general extensions of the inner corona with the main branches of the outer corona is an additional argument against the atmospheric origin of the outer corona. 4. A comparison of the drawing by Mr. Hall, made at Namaqualand, and the photographs obtained in 1869 and 1871 shows the permanent character of the contraction of the inner corona in a direction parallel to, or nearly parallel to, the sun's axis of rotation. The strongly marked character of the contraction of the outer corona in the same direction, as seen in the eclipse of 1874, may not improbably ultimately lead to a similar inference in the case of the outer corona also."—*Monthly Notices*, February, 1875.

2. *Schiaparelli's Observations of Comet III* 1862.—The careful observations made by Professor Schiaparelli of Comet III 1862, which, among the large comets, possesses a peculiar interest from its connection with the August meteors (the *Perseids*), have been lately published, the delay having been occasioned by the difficulty of reproducing faithfully the original drawings, which have now been drawn on stone by Signor Tempel of the Milan Observatory. Prof. Schiaparelli, in his *Memoir*, first gives the original observations, and then discusses them under various heads. The apparent brightness of the coma increased from 6 mag. on July 24, to 1·7 mag. on August 31, and the intrinsic brightness, calculated by the usual formula, $\frac{1}{r^2\Delta^2}$, also increased from 0·210 to 1·017 within the

same period, but not uniformly; increasing for ten days, then remaining stationary for a like period, after which there was again an increase for ten days, followed by a second stationary period; these changes being unaccompanied by any marked variation in the size of the head. Corresponding to the increase in brightness of the head, there was a marked decrease in brightness of the nucleus, which could not, Signor Schiaparelli considers, have exceeded 350 miles in diameter when nearest to us, from which he concludes that its density must then have been considerable, as it alone contained the materials for the coma and tail in all succeeding apparitions of this comet. The appearance of the luminous jets is then discussed, and is connected with a general want of symmetry in the head of the comet, the left side of which (supposing the tail to be below the head) was more developed, so that the comet resembled a stick with a knob on one side. The most remarkable feature in this comet was the large inclination of the tails (of which there were three on August 21) to the plane of the orbit, a fact which was established by the circumstance that the apparent angle between the tail and the prolongation of the radius vector did not change sensibly on the passage of the earth through the plane of the orbit on August 10. The lateral deviation of the tail, which was very considerable, Prof. Schiaparelli refers to an explosive force from the left of the nucleus, from the effect of which the particles projected from the head would, under the action of a repulsive force from the sun, describe parabolas, having the head as vertex and the radius vector as axis, the tail being curved back till, near its extremity, it became parallel to the radius vector. This would require the nucleus (which was apparently unsymmetrical) to preserve a nearly constant direction in space, which the author considers might result either from a polar force residing in the sun, or from the absence of rotation of the nucleus. Another imporant conclusion drawn by Signor Schiaparelli is that the particles of the tail exercise a mutual repulsion on each other, causing the anterior boundary to curve forward till it cuts the prolongation of the radius vector, the axis of the parabolas which would be described by the particles of the tail if only under the sun's repulsive force.—*Monthly Notices*, February, 1875.

3. *The Gold Medal of the Astronomical Society.*—The Council have awarded the gold medal to Prof. D'Arrest, for his work entitled "Siderum Nebulosorum Observationes Havnienses institutæ in Specula Universitatis per Tubum Sedecimpedalem Merzianum ab Anno 1861 ad Annum 1867," and his other astronomical works. The President will explain to the meeting the grounds of this award after the Annual Report.—*Monthly Notices*, February, 1875.

4. *Fall of a meteor in Iowa.*—A meteor fell in Iowa on the night of Feb. 12th with loud detonations. The principal portion of the fragments from the stone have been secured for the Iowa State University by Prof. Leonard.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Anderson School of Natural History.*—The experience of the past two years has shown that it will be impossible to carry on the School of Natural History at Penikese on the same terms as formerly. At the close of the last session the Trustees had exhausted their resources. They propose to charge a fee of fifty dollars for the season of 1875, and to carry on the school during the coming summer if a sufficient number of applications are received in time to make the necessary arrangements. Even with the full complement of students, there will be a considerable deficit (as was the case last year) to be met by the friends of the school; the position of Penikese necessitating many expenses which need not be incurred in a more favored locality. Applications should be sent at once to the Director at Cambridge, Mass.; preference will be given to teachers and to those who intend becoming teachers. ALEXANDER AGASSIZ, *Director.*

2. *Note on a supposed change in the Climate of Scotland;* by A. BUCHAN. — Mr. Buchan concludes a paper in *Nature* of February 25, as follows: "The general result of the inquiry then is, that though large annual fluctuations of temperature have occurred, yet the warm and the old cycles, extending over longer or shorter periods, are so distributed over these long intervals as to give no indication that there has been any tendency toward a steady increase or decrease in the temperature, or that any permanent change has taken place in the climate of Scotland. And since the same remark applies with equal force to the observations of the separate months, it follows that meteorological records give no countenance to the idea of a permanent change having occurred in the climate of Scotland either as regards summer heat or winter cold. It may be added that during the past seven years the temperature of July has been above its average respectively 2·8,° 1·7,° 2·0,° 0·2,° 1·7,° 1·0,° and 1·8,° and that of December, as compared with its average +1·5,° −4·2,° −5·6,° −1·1,° −0·8,° +3.4,° and −7 4;° results quite in the opposite direction of the popularly entertained belief that the summers are colder and the winters milder than formerly."

3. *On the Periodicity of Thunder-storms* (*Ueber gesetzmässige Schwankungen in der Häufigkeit der Gewitter während langjähriger Zeiträume*)*;* by W. v. BEZOLD.—Von Bezold, in his study of the periodicity of thunder-storms, made use of a series of observations that extended over a period of 105 years (1764–1869) at one locality (Kremsmünster, Bavaria) almost without a break, and of others less complete at other places.

His conclusions he expresses as follows. In years when the temperature is high and the sun's surface relatively free from spots, thunder-storms are abundant. Since, moreover, the maxima of the sun-spots coincide with the greatest intensity of auroral displays, it follows that both groups of phenomena, thunder-storms and auroras, to a certain extent supplement each other so that years of frequent storms correspond to those auroras, and *vice versa.* He observes that such a connection between sun-spots and storms does not by any means sanction the supposition of a direct electrical interaction between the earth and sun, but may be simply a consequence of a degree of insolation dependent upon the sun-spots.

These changes in the insolation, according to Köppen, manifest themselves in different latitudes not cotemporaneously but successively. The phenomena of thunder-storms, on the other hand, do not depend alone upon the condition at the place in question with respect to temperature, but also on the condition of the atmosphere at points far distant and belonging to another zone. This appears most distinctly in the storms which accompany electrical displays. The peculiar intermediate position which the weather curve takes between the curves of sun-spots and temperature may possibly find its explanation in this fact.

Von Bezold closes with showing that observations recently published in Saxony confirm in a striking manner the conclusions he had reached.—*Ber. Ak. München*, Nov. 7, 1874. E. S. D.

4. *The Blind Fish and some of the associated species of the Mammoth Cave, Kentucky, probably of Marine origin.*—Mr. F. W. PUTNAM, in an artical published in the Bulletin of the Essex Institute, vol. vi, No. 12, 1874, remarks as follows on the origin of some of the present inhabitants.

That many, or, with two or three exceptions, nearly all of the thirty or forty species of vertebrates, articulates, mollusks and still lower forms, including a few plants, now discovered in the caves of Kentucky, are of comparatively late introduction, is probable from the fact that they are so closely allied to forms living in the vicinity of the caves. But that the blind fishes, the Chologaster and a few of the lower forms of articulates, as the Lernæan, parasitic on the blind fish, may have been inhabitants of the subterranean streams for a much longer period, is worthy of consideration on the following grounds:

First, the blind fish family has no immediate allies existing in the interior waters,* the only species of the family, in addition to the three found in the Mammoth Cave, being known at present only from the rice ditches of the low coast of South Carolina.

Second, the Lernæan parasite is much more common on marine fishes than on strictly fluviatile species, and is more decidedly a marine than a fresh water form. These facts may therefore be taken as at least indicating the probability of the early origin of some part of the great cave system of the region of the Ohio Valley, and while there may be nothing in the present structure of the caves to indicate their having been formed in part while in contact with salt water, the supposed erosion of the limestone and the

* In common with others I have considered the Heteropygii as belonging to the same order with the Cyprinodontes, but I now have, from further information of their structure, doubts as to their close association with that group. This subject will be presented on another occasion.

modification of the early formed chambers by later action should be carefully considered before it can be denied that the caves were not, in some slight part, for a time, supplied with marine life. Until a specimen of Chologaster, or some other member of the family, has been obtained in the external waters of the Ohio Valley, it is hardly logical to regard the family to which the blind fishes belong as one originally distributed in the rivers of the Ohio Valley, and afterward becoming exterminated in the rivers and only existing in two such widely different localities as the coast of South Carolina and the subterranean streams of the southwestern States. That marine forms of life are found in our fresh water lakes and rivers is known to be the case. The specimen of a shrimp exhibited was secured in the Green River, near one of the outlets of the Mammoth Cave. The fact that in some of the waters of Florida fishes once marine are now confined to the fresh water lakes of comparatively recent formation, and that in the St. John's River, and others of that State, many marine and fresh water species are found associated, are evidence of the change that may take place in the habits of some marine animals, while a recent announcement of the Gobiosoma found in the Ohio River* is another instance of a marine fish living in fresh waters.

5. *Proceedings of the Cleveland Academy of Natural Sciences*, 1845 to 1859. 296 pp. 8vo. Cleveland, Ohio. Published by a gentleman of Cleveland.—The valuable papers which were read from time to time before the Cleveland Academy, previous to 1860, by Dr. J. P. Kirtland, Dr. J. S. Newberry, Col. C. Whittlesey, and others, and which have hitherto been published only in part in any scientific journal, are now for the first time gathered into a volume by the Society. The volume contains among its articles descriptions of species of fossil coal plants by Dr. Newberry, and of recent fishes by Dr. Kirtland, with important notes on the distribution and habits of birds, fishes, butterflies and other species by Dr. Kirtland; a paper on the Allegheny Coal field by Col. C. Whittlesey; notes on the Drift by Dr. Newberry and Col. Whittlesey, and short contributions on other topics of interest, including several valuable letters by Agassiz, Harris, and Bachman.

6. *Annual Record of Science and Industry for* 1874. Edited by SPENCER F. BAIRD, with the assistance of eminent men of science. 666 pp. 12mo. New York, 1875. (Harper & Bros.).—The Annual Record for 1874 by Prof. Baird comes well laden with the scientific news of the year past. A long introductory chapter contains a brief review of the chief stages of progress in the various sciences, theoretical and industrial; and then follow abstracts of various papers in science, announcements of new discoveries, statements of new facts about old discoveries and new illustrations of principles, accounts of scientific expeditions and institutions recently established, an obituary chapter, and a list of new works. The book has facts of interest for all classes of readers.

* Putnam, notice of *Gobiosoma molestum* from the Ohio. Amer. Nat., viii, Feb., 1874.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XLIII.—*Brief Contributions to Zoology from the Museum of Yale College.* No. XXXII.—*Results of Dredging Expeditions off the New England Coast in* 1874; by A. E. VERRILL.

DURING the summer of 1874 Prof. S. F. Baird, U. S. Commissioner of Fish and Fisheries, established the headquarters of the Commission at Noank, Conn., a village situated on Fisher's Island Sound, a few miles east of New London. A large party of naturalists, who were invited to take part in the investigations of the commission, availed themselves of the unusual facilities there offered for the study of marine life. The investigations of the invertebrate animals, in general, were placed in charge of the writer, but several others, especially Mr. S. I. Smith, Prof. A. Hyatt, and Mr. S. F. Clark, took a prominent part in this work. Extensive dredging operations were carried on from this station, by means of the U. S. steamer "Bluelight," under Commander L. C. Beardslee, U. S. N. These dredgings extended from 30 to 40 miles from Noank, in different directions; westward to the mouth of the Connecticut River; southward to Gardiner's and Peconic Bays and the waters south of Montauk Point; and eastward to the banks several miles south and east of Block Island, so as to connect with the dredgings of 1871. Temperatures of the surface and bottom waters were taken at more than ninety stations, and dredgings were made in a still larger number of localities.

A very large and interesting collection of invertebrate animals was secured. Among these are over 100 species new to the fauna of southern New England. Most of these are northern species, but many are undescribed. A large collection of algæ was made by Prof. D. C. Eaton and others. Prof. Baird, with several assistants, took direct charge of the fishes and fisheries, and made many interesting discoveries. He also obtained a valuable collection. A more detailed account of these investigations will be given in a future article.

During part of the month of September the Superintendent of the U. S. Coast Survey offered Prof. Baird the use of the steamer Bache, Capt. Platt commanding, to continue the dredging operations off the coast of Maine. This work was put in charge of Dr. A. S. Packard, as in 1873, and he was assisted by Mr. C. Cooke and Mr. Robert Rathburn. They made dredgings at about forty stations in the Gulf of Maine, off the coasts of Maine and New Hampshire, at various depths down to 125 fathoms. These localities may be conveniently grouped in five series.

a. Several dredgings on hard bottoms, near the Isles of Shoals and on Jeffrey's Ledge, in 25–51 fathoms (see Nos. 44, 46, 48, 77, 78).

b. An interesting series of dredgings on Cashe's Ledge, about 90 miles off Mt. Desert I., in 27 to 39 fathoms, hard and rocky bottoms.

c. One dredging on a new bank, discovered by Capt. Platt, in 32 fathoms, sandy bottom (No. 69).

d. Several dredgings in 36–48 fathoms, muddy bottoms, between Cape Ann and the Isles of Shoals (Nos. 38–41, and 78 in part).

e. Numerous localities in 50 to 125 fathoms, muddy bottoms, including most of the localities not already mentioned, over a wide area, both east and west of Jeffrey's Ledge, and extending from No. 62, off Pemaquid, Me., to the deeper parts of the Gulf of Maine, south of Cashe's Ledge.

Hard bottoms.—The collections from the hard bottoms (included under *a*, *b*, *c*) are much like those from similar and adjacent localities explored in 1873, of which nearly complete lists were published in this Journal (vol. vii, p. 502, May, 1874). Cashe's Ledge, as before, proved to be a rich dredging ground, remarkable for large numbers of rare northern species. Locality 78, in 35 fathoms, near Jeffrey's Ledge, was, properly speaking, a mixed bottom, mud predominating; but the dredge brought up some stones and large quantities of masses of firmly consolidated ferruginous mud and sand, most of which were irregularly broken and curved pieces, but some had the form of large, slightly conical tubes, 3 to 6 inches in diameter, and 12 to 15 inches long, the walls often being an inch or more thick. These are probably old uninhabited tubes of *Cerianthus borealis*, which have become firmly consolidated by some chemical action. Upon these fragments of tubes numerous species of Bryozoa, Ascidians and Sponges had established themselves, causing the collection from this place to resemble that of certain rocky bottoms.

Table of Stations in the Gulf of Maine, where dredgings and temperature determinations were made, in 1874.

Current No.	Date. Sept.	Hour.	Locality.	Nature of bottom.	Depth in fathoms.	Temperature.* Air.	Sur-face.	Bot-tom.
38	2	12 M.	Thatcher's I. Light, about 10 miles south	Soft blue mud.	41	70° F.	66°	45°
39		1.38 P.M.	Do., about 13 miles south	Mud,	48	70	69	45·5
40		2.23 "	Do., 16 miles south	Blue mud,	43	70	69	47
41		3.00 "	Do., 18¾ miles south	Mud—rocks,	36–27	70·5	69	45·5
42	3	11.35 A.M.	Boon I. Lt., 6 m. N.W. by W. ½ W.	Brown mud,	68	69·5	67	52·5
43		2.32 P.M.	Boon I., N. by E.; hotel on shoal S.W. by W. ½ W.	Brown mud,	43	75	65	47
44		5.00 P.M.	Star I., S.W.; Duck I., W.	Rocky,	25	75	67·5	51
45	4	0.50 "	Boon I., 12½ miles W.N.W.	Soft mud,	88	65	67	40
46		2.28 "	Agamenticus Mt., N.W. by W. ½ W.	Hard, sandy mud,	51	65	69·5	42
47		4.00 P.M.	Jeffrey's Ledge, near last,	Sand & gravel,	25	64	58·5	45·5
48		4.30 "	Near last, Agamenticus N.W. ½ W.	Gravel,	36	64	56·5	47·5
49		--------	Boon I., W.N.W. 27 miles,	--------	113	64	65	40
50		7.00 P.M.	Lat. 43° 01′ 20″, lon. 69° 45′,	--------	100	60	56	40
51	5	2.15 A.M.	Lat. 42° 56′, lon. 69° 08′,	Mud & gravel,	105	60	55	41
52		5.10 "	Cashe's Ledge	Rocks & grav.	27	60	55	42
53		7.00 "	Cashe's Ledge	Soft mud,	73	63	55	42
54		8.24 "	Do. 3¾ miles N.W.	Mud,	110	61	61	42
55		2.00 P.M.	Do. 2½ miles S.	Gravel,	40	60·5	65	43
56		2.50 "	Do. 1½ miles S.S.E.	Gravel,	30	62	59	46
57		3.15 "	Near last	Rocky,	37	----	---	---
57a		4.00 "	Near last	Rocky,	39	----	---	---
58		7.00 "	Lat. 42° 03′, lon. 69° 05′,	Mud & gravel,	65	60·5	57	40
59		12.00 "	Lat. 43° 22′, lon. 69° 17′,	Mud,	92	61	55	41
60	6	4.00 A.M.	Lat. 43° 17′, lon. 69° 24′,	Mud and sand,	65	61	57	41
61		7.30 "	Boothbay, Me., harbor,	--------	5	64	58	51
62	7	--------	Pemaquid Pt., 10 miles N.	Mud,	48	62	62·5	47
63		0.40 P.M.	Pumkin I., 4 miles N.E.	Brown mud,	42	68	65	48
64		2.45 "	Pemaquid, 12 miles N.	Mud,	58	61·5	57	42·5
65		4.28 "	Monhegan I., 2 miles E by N.	Soft mud,	47	64·5	59	44
66	8	1.20 "	Do., 14 miles N.E. ¾ E.	Brown mud & gravel,	65	66	64	40
67		3.30 "	Seguin Lt., 19 miles N. by W.	Brown mud,	86	68	64	40
68		6.00 "	Do. N.W.; near last,	Mud,	91	64·5	59	40
69		8.30 "	Lat. 43° 11′, lon. 69° 35′,	Sand,	32	64	60	46
70		11.00 "	Lat. 43° 03′, lon. 69° 36′,	Mud,	91	61·5	58	40
71	9	1.00 A.M.	Lat. 42° 55′, lon. 69° 36′,	Brown mud,	96	61	58	40
72		4.03 "	Lat. 42° 57′, lon. 69° 50′,	" "	125	61	57	39·5
73		6.30 "	Lat. 42° 58′ 30″, lon. 70° 00′,	" "	102	62	59	40
74		8.00 "	Lat. 43° 01′, lon. 70° 09′,	" "	88	62	60	39
75		9.30 "	Lat. 43° 02′, lon. 70° 15′,	" "	92	64	64	40
76		11.10 "	Lat. 43° 03′, lon. 70° 25′,	Mud & gravel,	51	64	63	42
77		1.30 P.M.	White I. Lt., 3½ miles E. ¾ S.	Rocky,	33	69	65	44
78	12	12.00 M.	Agamenticus Mt., N.W. by N. ½ N.	Blue clay, mud and sand,	35	61·5	60	43

* I am informed by Dr. Packard that the surface temperatures cannot be regarded as perfectly reliable, for they were taken in a bucket of water in which the bulb of the thermometer was not always submerged. All the water-temperatures were taken with a Miller-Casella thermometer (numbered 18491), which was left down from 5 to 10 minutes for bottom temperatures. Our experience shows that these instruments should be down 10 to 20 minutes to insure perfect accuracy.

The following list includes the species additional to those enumerated last year. Those from Cashe's Ledge are marked C; those from Jeffrey's Ledge, J; those from Capt. Platt's new bank (loc. 69), P; those from locality 78 are marked loc. 78.

Additions to the list of hard-bottom species.

Crustacea.

Hippolyte Phippsii.	C. loc. 78.
Diastylis quadrispinosa.	J.
Pardalisca cuspidata.	loc. 78.
Stegocephalus ampulla.	J.
Epimera cornigera.	loc. 78.
Monoculodes, sp.	C.
Melphidippa, sp.	C.
Melita, two sp.	C.

Annelida.

Lagisca rarispina.	J.
Nephthys circinata V.	J.
Grymæa spiralis V.	J.
Sabella neglecta?	J.
Spirorbis valida V.	loc. 78.

Gastropoda.

Bela cancellata.	J.
B. violacea.	C.
Aporrhais occidentalis.	J.
Trichotropis borealis.	C. J.
Menestho albula.	C.
Adeorbis costulata.	J. loc. 41.
Diodora noachina, var. princeps.	C.
Onchidoris pallida.	C. J. J.
Dendronotus robustus V.	
Philine quadrata.	C. J.

Lamellibranchiata.

Neæra arctica.	P. loc. 69.
Thracia truncata.	C.
Cardium Islandicum.	J.
Nucula tenuis.	C. J.

Bryozoa.

Discofascigera lucernaria.	C. J. loc. 78.
Tubulipora serpens.	J. loc. 78.
T. hispida (=T. crates St.)	J. loc. 78.
T. incrassata.	J. loc. 78.
Diastopora hyalina.	C. loc. 78.
D. hyalina, var. simplex.	loc. 78.
Discoporella verrucaria.	J. loc. 78.
Cellularia scabra.	P. loc. 78.
C. Peachii.	C. loc. 54.
Bugula avicularia.	J.
Flustra papyracea.	J.
Membranipora unicornis.	C. J.
M. unicornis, var. Americana.	J.
Lepralia spathulifera.	loc 78.
Eschara verrucosa.	C. J.
E. verrucosa, v. propinqua.	C. J.
E. verrucosa, var. patens.	C. J.
E. elegantula.	C. J.
E. lævis (=*Porella l* Sm.)	C. J.
Hippothoa vulgaris.	C.
H. divaricata.	J.
Escharella porifera.	C. J. loc. 78.
E. auriculata.	C. J.
E. Landsborovii.	C. J. loc. 78.
E. candida (St. sp.).	C. J.
E. solida. =*Flustra solida* St., 1853. =*Eschara palmata* Sars, 1862.	C. J.
Discopora scabra, v. plicata.	C. loc. 78.
D. scabra, var. ovata.	loc. 78.
D. coccinea.	C. J.
D. coccinea, var. ovalis.	C. J. loc. 78.
D. Jacontini (=*Escharella J.* Sm.).	C. J.

Echinodermata.

Crossaster papposus. C

Hydroida.

Gonothyræa hyalina.	C. loc. 69.
Clytia Johnstoni.	C. J. loc. 69.
Calycella plicatilis (Sars, sp.)	J. loc. 46.
Lafoëa gracillima.	C.
Halecium tenellum.	C.
H. sessile.	loc. 69.

Muddy bottoms.—The dredgings on muddy bottoms agree closely with those of the previous year, as might be expected from the similarity of the localities, and their proximity. Most of the rare species previously obtained were again met with, so that for many species additional specimens of great interest were obtained. Thus a second specimen of *Pleurotomella Packardii* V. was dredged at loc. 54; and several of *Anachis Haliæeti* at loc. 58 and 60; *Caridion Gordoni* and large specimens of *Stegocephalus ampulla* at loc. 54 and 58, etc. A fine new species of *Asterina*, with dark dorsal spots, occurred at locality 54.

The following list includes most of the additional species, not enumerated in the lists published last year in this Journal (vol. vii, p. 411), though quite a number found on some of the muddy bottoms, but belonging properly on hard ones, are here omitted.

List of additions to the fauna of the muddy bottoms.

Crustacea.

Hippolyte polaris.	loc. 54.	Œdiceros lynceus.	loc. 41.
H. Phippsii.	loc. 54.	Syrrhoë crenulata.	loc. 41.
Crangon boreas.	loc. 41.	Metopa, sp.	loc. 54.
Stenothoë peltata.	loc. 54.	Byblis Gaimardii.	loc. 38–40.
Tritropis aculeata.	loc. 58.	Ampelisca macrocephala.	

Annelida.

Eunoa nodosa.		Amphitrite Grayi.	loc. 72.
Euphrosyne borealis.		A. intermedia.	
Ancistria capillaris V.			

Gastropoda and Lamellibranchiata.

Astyris rosacea.	loc. 63.	Glycimeris siliqua.	loc. 72.
Diodora noachina, var. princeps.	loc. 51.		

Bryozoa.

Diastopora hyalina.	loc. 38–40.	Bugula flexilis V., sp. nov.*	loc. 54.
Membranipora unicornis.	loc. 40.	Eschara elegantula.	loc. 62–65.

* *Bugula flexilis*, sp. nov. Plate VII, figures 1, 2.

Several rather long, slender, flexible, dichotomously divided branches radiate from close to the point of attachment, making a stellate cluster. Zoœcia in two alternating rows, smooth, oblong, slightly swollen in the middle, with a short tooth or spine on the outer angle; aperture terminal, oblique, rounded or oval. Avicularia, on the front of the zoœcia, remarkably large, nearly as broad as the zoœcia and more than half their length, compressed, fusiform, tapering gradually to the point of attachment. East of St. George's Bank, 430 fathoms, 1872; off Casco Bay, 95 fathoms, 1873; Gulf of Maine, 110 fathoms, 1874.

Discopora nitida, sp. nov. Plate VII, figure 3. From Vineyard Sound and Long Island Sound.

Easily distinguished by the very small apertures with elongated processes projecting inward from the sides; and by the acute lateral avicularia.

Lepralia Americana, sp. nov. Plate VII, figures 4, 5. =*L. Pallasiana?* V., in former papers. Long Island Sound to Beverly, Mass., low-water to 30 fathoms.

ART. XLIV.—*On the Primordial Strata of Virginia;* by WM. M. FONTAINE.

[Concluded from page 369.]

Rockfish Gap.

THE railroad cuts at this place afford some good exposures of the lowest Primordial strata. In the deep cut made for the west entrance to the tunnel, the junction of these rocks with the massive chloritic argillites, which here form the mass of the Blue Ridge, is well shown. The strata are here all inverted, and dip southeast, but at a much higher angle than the Blue Ridge slates. These latter lie in heavy plates, produced by the consolidation of numerous laminæ, with a dip of about 40° southeast. As described in a previous paper, they are of a dark greenish-gray color, the green being caused by films of chlorite. They are firm and hard, resisting decomposition and degradation quite well. The first stratum of the Primordial rocks which adjoins these slates presents a strong contrast with them, the line of junction being strongly defined. This stratum, No. (1) of the section here, is composed of very thinly laminated slates or shales, much compacted by pressure. They are not crystalline and hence not true slates. They are pale yellowish-gray, and are of the variety called by the Professors Rogers, "feldspathic slates with talcose matter." They decompose, or rather lose their coherence, much more easily than the argillites. Hence at their junction with these rocks, the height of the walls of the cut suddenly diminishes from twenty to five or six feet. Thickness 300 feet. (2.) On the west of these is a band of more siliceous composition. On the side next to (1), the layers of this rock, in color, do not differ much from (1), but are thicker than the preceding slates, and more sandy. The bedding thickens, and the amount of siliceous matter increases to the west, until we have a fine-grained white kaolin sandstone in pretty thick layers. Thickness 75 feet. (3.) The last rocks are suddenly succeeded by a conglomerate of brownish red color, indicating a sudden change in the conditions of sedimentation at this point, while the two preceding rocks graduate into each other, showing a gradual change of the material deposited, which was plainly the product of slow decomposition and accumulation. Nos. (1) and (2) are the equivalents of the highly metamorphosed sandstone, No. (1), of the Balcony Falls section, while (3) is the representative of the feldspathic conglomerates and their included shales seen there. The conglomerate here presents some very interesting points of difference.

This rock is well exposed in a quarry near the railroad, from which a large amount of stone has been removed. Its structure and composition is thus fully exposed. It lies in massive plates five to six feet thick, with thin seams of shaly matter between several of the plates. These thin seams are the diminished representatives of the shales which separate the beds of conglomerate at Balcony Falls. Some small veins of quartz, the result of metamorphic action, fill cracks in the mass. The coarser materials are rounded grains of quartz of the size of a garden-pea and under. Rarely is a particle of fresh feldspar seen. This feldspar has the same character with that found in the equivalent rock at Balcony Falls. On the other hand, numerous grains and lumps of this feldspar, in a condition of almost complete decomposition, are seen. These larger particles are imbedded in a slaty cement of highly ferruginous, decomposed, felsitic matter, which when scratched with a knife gives a decided cherry-red streak. Besides, distinct particles of hematite appear. Enclosures of angular fragments of the slates of the Blue Ridge are not rare.

The more decomposed condition of this material in this vicinity is explained by the fact that it was probably brought by currents from the southwest, and thus for a considerable time subjected to agencies tending to disintegrate it. At Rockfish Gap the shores of the Primordial sea were probably formed by argillites, while farther southwest, coarse syenites containing red feldspar and quartz were washed by the waters. The fresh state of the feldspar at Balcony Falls shows that this sediment must have been rapidly formed and poured into the sea. I have already given some account of an eruptive syenite which, in the vicinity of the Peaks of Otter, has penetrated the older metamorphic syenites, and have stated also that the lowest Primordial rock at Balcony Falls has been highly altered by contact action of a similar rock. It is probable that this rock is the product of deep-seated metamorphic action, produced by the sinking, in its earliest stages, of the bottom of the Primordial sea. This would cause great pressure against the resisting syenitic border, and might fuse a portion of it and squeeze this out, shattering the upper and firmer mass. An igneous rock capable of delivering feldspathic and quartzose material exists also at Rockfish Gap, as is disclosed in the tunnel. It is, however, small in amount, and being entirely enclosed in slates, was probably not exposed to any extent to the action of the waves. There is no evidence to fix its age, but if it was formed at this period, it probably caused a fracturing of the slates, which was the source of the fragments found in the conglomerate. The thickness of the conglomerate rock is 60 feet, and like the two preceding, it has a dip of 70° to the southeast. The strata so far form the western base of the Blue Ridge. The succeeding rocks form a series of low hills, which for a space of 2½ miles at this point lie between the mountain and the valley of South River, a branch of the Shenandoah.

(4.) We have next to the conglomerate No. (3), a partially concealed interval of 200 feet, in which the rocks are, when seen, kaolin shales and kaolin sandstone, principally the former. Hence from their softness, they occupy a valley. To the west of this is a band of kaolin sandstones, with layers of cellular, much indurated quartzite, and some subordinate beds of an indurated, gray, coarse sandstone, to be described farther on. This series, in which the quartzites predominate, has undergone much local metamorphism, apparently from hot siliceous solutions, which has rendered the material more resisting to denuding agencies. It occupies a range of hills of considerable height. It contains one bed of the gray sandstone 20 feet thick. Thickness 420 feet, or including the partly concealed band, 620 feet. This series of strata is the equivalent of No. (8) in the Balcony Falls section. The dip is high to the southeast; it is somewhat confused by the consolidation of the beds.

(5.) The first rock in this series is a highly indurated gray sandstone, the type of the beds above mentioned as forming occasional layers in No. (4). It is of dark gray color, and is composed of coarse grains which are by metamorphic action changed nearly to a compact texture. Specks of decayed feldspar occur, also numerous seams of quartz, and occasional impregnations of chlorite and epidote. The bedding is almost obliterated. This is the next most highly altered rock seen by me in the Primordial area. Next to this occurs a bed of diorite 20 feet wide, which has aided in producing the metamorphosis of the sandstone and the strata of (4). The thickness of the sandstone is 50 feet. The diorite is composed of hornblende principally, with a rather scanty amount of feldspar, apparently albite. The hornblende occurs in pretty large particles, while the albite cements them together. Next is a band of bluish-gray, coarse shales, 75 feet wide; then a partially concealed interval of 300 feet, occupied by similar rocks; then for 200 feet, several alternations of the same shales with bluish argillaceous sandstones. In these a layer 6 feet wide of red argillaceous hematite is found. Then a second bed of diorite 12 feet wide, resembling in all respects the first. All of these rocks have a comparatively low dip of from 30° to 40° to the southeast.

(6.) The above beds, which are mostly sandy shales, and are rather thickly-bedded in layers of from one to several feet, are succeeded by a band of very thinly-laminated, firm, olive slates or shales, in which the dip rises to 75° to the southeast. These slates, which in fact are highly compressed shales, are in places much crushed, and show on their faces fine wrinkles. They are 300 feet thick. We then have 30 feet of indurated brown sandstone, with some chlorite, and a good deal of partly decomposed feldspar interspersed in it. Then an interval of concealed rock occurs for 100 feet. We then have for 150 feet several alternations of brownish argillaceous sandstones, with greenish shaly beds, in which the dip comes down to 50° southeast. Then very finely fissile, pink-colored slaty shales, which weather purplish red. Thickness 200 feet. About 50 feet (on the east side) of these shales differ from the rest in color alone, being greenish when fresh, and taking a yellow tint on weathering. Then for 100 feet a bluish shale is found. The two last series of beds, (5) and (6), appear to be the equivalent of No. (9) at Balcony Falls. Their combined thickness is about 1450 feet, that is, provided no reduplication from folding occurs. This is possible, though not probable, I think. It will be seen that these rocks are characterized by the large amount of ferruginous matter which they contain, by which they are sharply distinguished from those which precede and follow them.

(7.) The dip in the preceding series gradually declines until it attains on the west side 40° S.E., which is still more decreased in No. (7), where it varies from 30° to 40° S.E. The strata now to be described are the equivalent of the Potsdam sandstone, and resemble No. (10) at Balcony Falls in their almost total freedom from iron and other coloring matters, also in the great amount of siliceous matter and kaolin present in them. But while at Balcony Falls we find many layers of very considerable thickness to be pure quartzite, all the strata here have some kaolin, and this substance forms by far the greater part of the rock. The system here consists of a vast number of thin layers, in which we may distinguish three classes of rock. *a.* A shale, pale gray to bluish-gray when fresh, composed almost entirely of kaolin, and occurring in thin plates. *b.* This is associated with a very fine-grained kaolin sandstone, the quartz grains being now perceptible to the naked eye. The kaolin still predominates, but this rock occurs in slabs four to eight inches thick, and with *a*, forms layers or beds interstratified with *c*, which is a kaolin sandstone of moderately fine grain, and has often a thickness of several feet in the individual layers. The quartz grains are mixed with an equal amount of kaolin, which here serves as a cement for them, and forms a peculiar, mealy-looking rock, which can be easily crushed and crumbled to a loose grit. All of these varieties assumed a drab or pale yellow color on weathering, from the oxidation of the minute amount of iron present. *c* is almost always present in some portion of the Potsdam strata, and may be considered in this part of Virginia to be characteristic of this formation. So clearly marked are the features of this material that a fragment of it may be recognized at a glance wherever found. *b* and *c* are, when fresh, very light gray in color.

The entire mass of this material is so shattered and broken that it lies in angular fragments in the beds, so that it may be removed with the pick and shovel. The Messrs. Rogers, in their descriptions of the composition of the lowest Silurian strata, often speak of their containing talc and imperfectly developed feldspar, which they regard as the product of incomplete metamorphism. While it may be true that such partial regeneration of minerals may occur on the large scale in these strata, I have seen no instance of it. This "imperfectly developed feldspar" is simply kaolin, which has lost more or less of its plasticity. A qualitative analysis of a fragment of *c* gave me as essential components: 1, Uncombined silica (sand); 2, combined silica; 3, alumina; 4, a little water, and no potash. The slaty shales of No. (1) in this section, which agree with the rocks called by Prof. Rogers talcose slates, have no magnesia, but are mainly composed of combined silica and alumina, with a marked amount of potash and iron, and a small amount of water and lime. The rock, *c*, contains also a trace of iron, and a little mica in fine scales. The conglomerate near the base of the system does not contain crystalline feldspar, because of the greater metamorphic action to which it has been subjected. The finding of feldspar in all stages of decay shows that this mineral is undergoing a process just the reverse of regeneration, and that strata composed of the fresh particles of degraded crystalline rocks have been mistaken for rocks partially crystallized by metamorphic action.

The beds last described have a thickness of 300 feet, and are succeeded by a partially-concealed interval, in which 50 feet of a similar rock are shown. From this point, for the space of half a mile no cuttings exist.* The space outside of the valley in which the road runs is occupied by low rounded hills, covered to a great depth by fragments of the rock last described. So great is this mass of matter that in some places where it is removed to be used as ballast for the railroad, excavations to the depth of thirty feet do not penetrate through it. This interval up to the valley of the South Branch of the Shenandoah, so far as can be judged from the partial exposures, is occupied by No. (7). Much of the loose matter on the surface seems to have

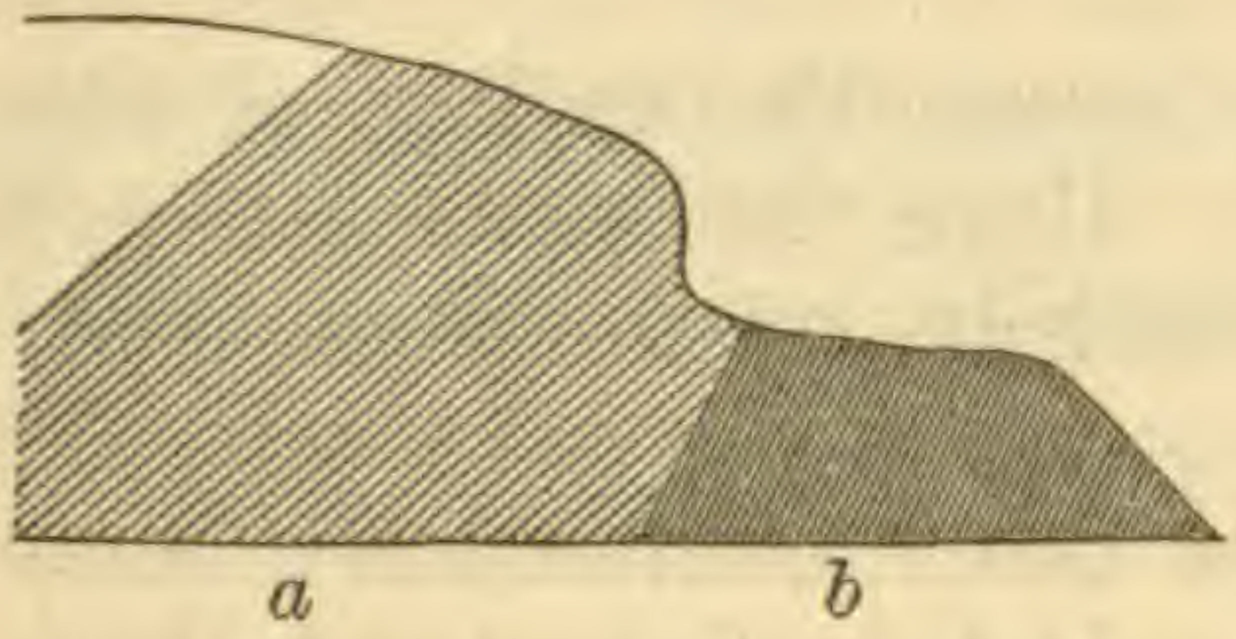
* No reliable estimate of the thickness of (7) can be given. It is perhaps 800–1000 feet.

been subjected to the action of some transporting agent, since it is mixed with more or less clayey matters. Its sharp angular condition shows that it has not been moved far. Large boulders of the metamorphosed quartzite occurring in No. (4) are found in it.

Next to the hills occupied by (7) occurs the valley of the South Branch, about 500 yards wide. Here the strata are not exposed. This space was occupied entirely, or in great part, by the shales overlying the Potsdam strata. No very reliable estimate can be given of their thickness, but it cannot have been under 700 to 800 feet. They seem to have been of the same character, except the calcareous matter, with those associated with the Calciferous strata, which are found immediately on the west side of the stream. Here, at the town of Waynesboro, we have the following succession of strata, in which the dip is again high, viz: 60° to the southeast: first, purplish slaty shales, 50 feet; then dark gray, argillaceous limestone of earthy texture, 5 feet; next, greenish slaty shales, 15 feet; then dull purple, calcareous shales, 8 feet; next, very fissile, yellowish, calcareous shales, 40 feet. Argillaceous limestone follows, 5 feet thick; then very fissile, dark gray shales, 15 feet; then 10 feet of dark gray, thin-bedded limestone; then dark gray, very fissile shales again, 12 feet; lastly, slabby, argillaceous limestone, passing into the coarse, massive siliceous limestone which usually closes this series, 60 feet. It will be seen that this series is closely like that of similar age at Balcony Falls. To these rocks succeeds a wide belt of purple, greenish and gray shales, belonging probably to the same epoch. Then follows the Great Limestone of the Valley, the Auroral, or No. II, of the Messrs. Rogers.

It will be seen by a comparison of this section with that given at Balcony Falls, that the thickness of Nos. (5) and (6) in the section here is much greater than that estimated for their equivalent, No. (9), in that section. A disparity, no doubt, exists, though probably not to such an extent as it thus appears to do, since I have under-estimated rather than over-estimated the thickness of (9). Still there remains the fact that the proportion of shaly matter in the entire group at Rockfish Gap has greatly increased. This may be due to the nature of the shores of the Primordial sea, which, as we have seen, were probably composed of the fine chloritic argillites of the Blue Ridge. What could have been the source of the immense quantity of kaolin found here and everywhere in the Primordial strata, and what caused the almost total freedom of such kaolin rocks from iron, forms an interesting problem.

The following section represents the junction of No. (1) of the series with the argillites of the Blue Ridge, as seen in the west approach to the tunnel at Rockfish Gap. At *a* are the heavily-bedded slates of the mountain, while at *b* the thinly-laminated slaty shales, the lowest of the Primordial strata, are represented.



In the two detailed sections given above at Balcony Falls and Rockfish Gap I have been thus minute in my descriptions, in order that the reader may determine for himself how far the one confirms the other. At the same time, the strata at the two places may be taken as types which best represent the normal and inverted positions, and also the changes which result from the different development of certain members of the series.

Harper's Ferry.

The exposures at this place are not sufficient to admit of a detailed section. Enough, however, may be seen to show considerable changes.

The argillites, described in a former paper, extend to the west about a mile and a half from the railroad bridge. They are then succeeded by the lower Primordial strata, the change being quite abrupt. The line of junction is well shown on the Virginia side of the Potomac, on the railroad. The massive dark gray beds of argillite are seen here, with a dip of about 40° to the southeast, to abut against the highly inclined, more fragile lower Primordial strata. The change in the character of the rock is at once seen in the altered topography. The hills no longer present abrupt faces of firm rock close to the road, but recede with rounded slopes, which are so covered with earth and fragments of stone that it is difficult to find the strata *in situ*. The interval between the limestones of the Calciferous and the argillites is about 1,100 feet. These crushed rocks are succeeded immediately by a high cliff of Calciferous limestone, between whose massive walls and those of the argillites the more fragile lower Primordial rocks seem to have been compressed and crushed.

On the Maryland side the exposures are better. The rock forming the lower strata next to the argillites seems to be a variety of the lowest slates seen at Rockfish Gap. It differs from them in containing a greater proportion of siliceous matter in the form of very fine sand, intimately mixed with argillaceous matter and kaolin. This material produces a fine-grained, slaty sandstone and slate, which, when fresh, has a pale greenish-gray color, but weathers with a gray or yellowish-gray color. The dip of these strata is about 75° to the east-southeast. They, as far as seen, occupy most of the space below the Calciferous. These rocks, in their upper or more westerly portion, are succeeded by a highly-altered sandstone of brownish color and rather coarse grain. About forty feet of this are shown. It lies in rather thin laminæ, and has the same dip with the preceding. No other strata were seen until the Calciferous limestone, distant one or two hundred feet, was reached. This latter series also shows important modifications. The entire thickness of the strata lying below the Calciferous at Harper's Ferry cannot be much over 1,000 feet. So far as seen, only two varieties of rock occupy this space, viz: the slaty rocks above mentioned, which form by far the largest portion, and the sandstone, which much resembles some of the quartzites of the lower strata at Rockfish Gap. It will thus be seen that, along with the greatly diminished thickness of the formation, the disappearance of most of the coarser material seen to the southwest is to be noted here. It is not impossible that some of the beds have been engulfed in their upheaval, since on the Virginia side the manner in which the argillites abut against the Primordial indicates that the former were crowded in a solid mass over against the latter.

The Calciferous rocks at this place are almost entirely limestones. Instead of the numerous alternations of shale and impure limestone, which elsewhere form the lower beds, we have here only limestone. This is well shown in the high cliff on the Virginia side, which presents a vertical wall close to the railroad. This rock is of dark blue color, and is quite thinly stratified. The laminæ stand at an angle of about 80° E.S.E. It is much metamorphosed, with crypto-crystalline texture, and has numerous small seams of calc-spar penetrating it in every direction. Numerous small particles of fluor-spar occur interspersed in the mass. About 120 feet were seen. The only other member of the Calciferous seen here is the curious, rough, massive limestone which forms the upper member of the series everywhere, and which at every exposure presents the same physical features. This rock at Harper's Ferry contains workable deposits of iron ore. The excavations made on the Maryland side of the Potomac for the procuring of the ore have well exposed its character. It lies immediately to the west of the rock last described. From the examination made in the open cuts in the iron mine about two miles above the bridge, its character seems to be as follows: color dark gray, fracture rough and glistening, from its sub-crystalline texture. The hardness and weight are much above those of ordinary pure limestone. It lies in masses of the thickness of thirty feet and more, without bedding. Without close examination, it would be mistaken for a variety of igneous rock. The ore is an argillaceous limonite, occupying a seam varying in width from six to ten feet. This seam is the decayed outcrop of an argillaceous layer highly charged with pyrites, for at the depth of forty feet the ore is cut off by pyrites. This, and the other features of the rock, indicate that the entire mass of limestone has been metamorphosed by the action of water holding mineral matters in solution.

To the west of this limestone the usual formation of variegated shales occurs. The thickness of the limestone seen was about ninety feet.

The section at Harper's Ferry thus indicates an increase in the proportion of fine material over that shown to the southwest, along with a great diminution in the total amount of sedimentary deposits. This fact explains the absence in Pennsylvania (as noted by H. D. Rogers) of the conglomerates which occur in Virginia, and, according to Safford, reach their greatest development in Tennessee.

I have given the above sections in greater detail than I would have otherwise done, from the fact that Prof. Wm. B. Rogers, in his Virginia reports, does not (with the exception of the strata at Balcony Falls) give detailed descriptions of the individual members, and the order of succession of the lowest Primordial strata, the nature of his report forbidding such details. With the single exception of the *Scolithus*, there are no fossils to be seen in these lower rocks which can indicate their age. It will be seen from the above notes that in Virginia we have below the Calciferous limestones a great development of sandstones, shales and conglomerates, which attain in the middle portion of the State a thickness of over 2,000 feet, and increase in the proportion of coarse materials to the southwest. They probably attain greater thickness in that quarter, while to the northeast the amount of sediment diminishes, and the proportion of fine matter increases. This change is plainly due to the increasing development to the southwest of the syenitic rocks which formed the shores of the ancient seas, and to the greater violence in that direction of disturbing forces. The Potsdam sandstone forms one of the upper members of this group. Much further study of these strata is required to settle the question whether the entire series is a great expansion of the Potsdam, or whether divisions may be made corresponding to other epochs. The fact that at Rockfish Gap, and to the southwest, a great body of ferruginous slaty shales separates the lower, highly siliceous and altered, sandstones from the upper kaolin sandstones of probable Potsdam age, seems to indicate a change in the conditions of sedimentation sufficient to justify such a division, in which the Acadian strata may be found.

General Remarks and Conclusions.

Having given the above brief indication of the possible relations of the lower Primordial strata to each other, I will devote a small space to pointing out the apparent relations of these strata to the metamorphic crystalline rocks of the Blue Ridge. I am aware of the fact that not enough has been done to justify in all cases positive conclusions.

In my paper on the Blue Ridge of Virginia, published in the January and February Nos. of this Journal, I gave a description of certain coarse syenites and granites, which, in the vicinity of Balcony Falls and the Peaks of Otter, compose a large portion of the Blue Ridge, and which appear farther to the east in the short ranges of Tobacco Row and No Business Mountains. From the stratigraphical relations and composition of these rocks, it is plain that they are of Laurentian age. Whether the gneisses along the east foot of the Blue Ridge, and the syenites near Lynchburg, which appear to break through the mass of slaty rocks which occupy most of the country, belong to this system or to the slates, remains to be determined. These Laurentian rocks evidently increase in their development from the northeast portion of the State to the southwest.

Lying along and upon the eastern slopes of the syenites of the Blue Ridge, in the region of Balcony Falls, a formation of argillites occurs, which, in the northeast, occupy the entire space up to the Primordial strata. These rocks are covered to the east by a series of mica slates, schists, gneisses, etc., disposed in a great synclinorium which has its axis in the vicinity of the Catoctin Mountains. This axis is occupied by talcose limestones, quartzites, mica slates, hydromica slates, etc., standing nearly vertical. These latter strata in every respect bear a most striking resemblance to the rocks described by Prof. Dana as found in Berkshire Co., Mass. This entire belt of slaty, semi-metamorphic strata, is bounded on the east by a line drawn from northeast to southwest, and passing through a point four or five miles west of Alexandria, the eastern part of Louisa Co., and by Columbia, on James River. It will be readily seen that these rocks have all the characteristics of the Green Mountain series. I think that in this broad belt at least two systems exist, one older than the Primordial strata, and the other composed of metamorphosed Silurian. The argillites of the Blue Ridge belong to the former. Whether these are of Laurentian or Huronian age, I cannot undertake, in the present lack of detailed examinations, to decide. Their unconformability with the coarse syenites apparently shows them to be of later formation. How much of the mica slates and schists, if any, is of the same age with the argillites remains to be seen. I need not repeat here the evidence given elsewhere in this paper, proving that the argillites are more ancient than the Primordial rocks. The evidence for the supposed fact that the limestones and associated rocks found in the axis of the synclinorium are metamorphosed Silurian strata, is by no means so positive. The following points lead me to such a conclusion: 1. The position of the strata, since they occupy the center of the synclinorium. 2. Their nature, associations and dip. The rocks here found associated do not exist in other parts of the belt. Stated briefly, they consist of two ledges of limestone, 80 to 100 feet thick, enclosed in a vast mass of mica slate, and separated from each other by an interval of from two to three miles, principally occupied by the mica slates, in which occur two ledges of quartzite, each about 100 feet thick. This mode of occurrence indicates reduplication by folding. The dip is nearly vertical, while on each side the strata dip toward them. 3. Prof. Rogers states that in certain parts of the quartzites of this series he saw enclosed fragments of mica slate. 4. At a slate quarry in the rocks of this series, occurring in Buckingham Co., on the east of the Catoctin Mountains, Credner states that he found undoubted specimens of a cyathophylloid coral. He does not give a more particular description. He also states that they were badly preserved. I have not visited this quarry, but propose to do so. Should Credner not have been mistaken, his discovery would of course indicate the Silurian age of the slates of the quarry.

Before closing this paper, I will add a few remarks on metamorphism, suggested by my studies of the Virginia rocks. Some writers on the subject attribute regional metamorphism mainly to three agencies, viz: 1. Increased heat and pressure, caused by thick deposits. 2. The saturation of the strata with moisture. 3. The change of motion into heat, which involves a considerable disturbance of the metamorphosed region. I have not observed that close connection between the first and third of the above-mentioned agents, and the degree of metamorphism in a given region, which should exist if these bear to each other the relation of cause and effect. In order to show this, I must compare the condition of the strata in certain parts of the State, which, in the amount of metamorphism possessed by them, stand in strong contrast. For the purpose of this comparison I shall call the belt of country lying between the western edge of the great valley of Virginia and the Blue Ridge Mountains, a portion of which is described in this paper, the Primordial belt. The region extending from the Blue Ridge eastward, and bounded by the northeast and southwest line given above, may be styled the Middle belt. On the east of this belt, and between it and the Tertiary strata which extend some distance inland from the Atlantic, is a third belt, occupied by rocks of very different character from any occurring on the first and second belts. This region may be called the Eastern belt. The general character of the strata occupying it closely resembles that of the rocks of the "White Mountain system." The structure of this belt, stated briefly, seems to be as follows: The lowest strata are certain heavily-bedded granitoid gneisses, composed of a little quartz, black mica, and the feldspars, albite and orthoclase. These show themselves abundantly near Richmond and Petersburg. Passing to the west, these strata seem to be disposed in broad undulations, which sometimes bring them up through the overlying schistose strata, especially along certain lines where true igneous eruptive rocks penetrate them. These massive beds are covered by a comparatively thin formation of typical gneisses and mica schists, abounding in quartz and mica. The overlying rocks are gneisses in the eastern portion of the belt and mica schists in the center, which become hornblendic toward the western edge. These schistose rocks are disposed for much of the distance in broad anticlinals and synclinals, the strata over considerable spaces having generally a dip of 40°–50°, except where it is steepened by the protrusion of the underlying rocks, caused by local disturbances. This entire system is remarkable for the thorough metamorphism of the rocks, all the constituents being well segregated in large particles.

Now if we compare the amount of metamorphism existing in the strata of the several belts, we shall find it increasing in a remarkable manner as we proceed from the Primordial, through the Middle, to the Eastern belt.

I have already in this paper pointed out the difference in the amount of alteration shown in associated argillaceous and siliceous Primordial beds, and stated that I have seen nowhere in the *Primordial* belt the production over extensive areas of anything more than the first stages of metamorphism. It is true that certain strata exhibit a higher degree of change, but this is always due to intensified local action. If we pass from the lowest Primordial strata into those of the Middle belt, we note an abrupt change. The metamorphism of this belt is universal, but still not complete. The rocks are all crystalline, but the individual particles are small, and the masses which they form show more or less want of cohesion. In the thin quartzites of the east slopes of the Blue Ridge the texture is compact, and impregnations of metamorphic products occur. But in the quartzites along the Catoctin Mountains we may easily detect the separate grains of sand. The mica schists and gneisses of the entire belt rarely show scales of mica more than four or five millimeters long, and quartz in free particles is not common.

The disturbance of the strata in this area is much less than that which is found in the Primordial belt. The strata over considerable spaces are disposed in wide arches and extensive rolls, lying at a comparatively low angle. Yet in such regions they are as fully changed as where they stand on end, and, indeed, are often more so. From many indications, I am convinced that the most disturbed portions were thus affected, *after* the regional metamorphism had been produced, and that these later convulsions produced only intense local change. In the absence of measurements, no positive conclusions can be drawn as to the comparative thickness of these semi-metamorphic strata, but the indications are that it does not surpass, if it equals, the united thickness of the more highly convulsed rocks which lie to the west of them.

In the Eastern belt the strata are thoroughly altered, and in the coarseness of the crystallization, and firm, unyielding character of the rock, contrast strongly with those of the Middle belt. The massively bedded, underlying granitoid rocks are apparently of different age from the overlying schistose strata, being probably Laurentian. Still, in the amount of metamorphism exhibited, they do not surpass the latter. These schistose strata, which, as previously stated, have the general character of the "White Mountain series," do not exhibit that increased amount of disturbance and of thickness that should exist if these were the principal causes of their highly altered condition. On the contrary, these deposits appear to be thinner than those of either of the other belts, and are plainly less disturbed than the Primordial strata. As to the presence of moisture sufficient to produce metamorphism, the most favorable conditions must have existed in the Primordial belt, as this is known to have been covered with the water of the ancient seas certainly to as late a period as either of the other belts.

In examining the geological structure of the State from east to west, I have not found any such connection between the flexures as would justify the conclusion of Prof. H. D. Rogers, that the Appalachian system of folds extends to the Atlantic, and that they are more compressed next to the ocean, while they open out in proceeding west. Indeed, I do not see how he himself could have come to any such conclusion, after an inspection of his "Susquehanna Section" alone.

Such a connection between the flexures of the Silurian, Devonian, and Carboniferous areas does exist, but the Blue Ridge is the initial point on the east, and it may be accounted for by the fact that their flexures were mainly produced by a common cause acting in one period.

On the contrary, the folds of the eastern belt are mostly wider than those found in the other belts, and independent of them.

ART. XLV.—*Preliminary Inquiry into the Existence of Elements in the Sun not previously traced;** by J. NORMAN LOCKYER.

IN a paper communicated to the Royal Society on December 12, 1872 (Phil. Trans. 1873, p. 253), I have shown that the test formerly relied on to decide the presence or absence of a metal in the sun, namely, the presence or absence of the brightest and strongest lines of the metal in question in the average solar spectrum, was not a final one, and that the true test was the presence or absence of the longest lines of the metal: this longest line being that which remains longest in the spectrum when the pressure of the vapor is reduced.

Of the test in question I have said in the paper already mentioned, "It is one, doubtless, which will shortly enable us to determine the presence of new materials in the solar atmosphere, and it is seen at once that to the last published table of solar elements—that of Thalén—must be added zinc, aluminium, and possibly strontium, as a result of the new method."

In order to pursue the inquiry under the best conditions, complete maps of the long and short lines of all the elements are necessary. It is, however, not absolutely necessary for the purposes of a preliminary inquiry to wait for such a complete set of maps, for the lists of lines given by the various observers may be made to serve as a means of differentiating between the longest and shortest lines, because I have also shown that the lines given at a low temperature, by a feeble percentage composition, or by a chemical combination of the vapor to be observed, are precisely those lines which appear longest when the complete spectrum of the pure dense vapor is studied.

Now with regard to the various lists and maps published by various observers, it is known (1) that very different temperatures were employed to produce the spectra, some investigators using the electric arc with great battery power, others the induction spark with and without the jar; (2) that some observers employed in certain cases the chlorides of the metals the spectra of which they were investigating,—others used specimens of the metals themselves.

It is obvious, then, that these differences of method could not fail to produce differences of result; and accordingly, in referring to various maps and tables of spectra, we find that some include large numbers of lines omitted by others. A reference to these tables in connection with the methods employed shows at once that the large lists are those of observers using great

* Extract from a memoir presented to the Royal Society in November, 1873, which has just been printed in the "Philosophical Transactions;" here cited from Nature of Feb. 25, 1875.

battery power or metallic electrodes, the small ones those of observers using small battery power, or the chlorides. If the lists of the latter class of observers be taken, we shall have only the longest lines, while those omitted by them and given by the former class will be the shortest lines.

In cases therefore in which I had not mapped the spectrum by the new method of observation referred to in my paper, I have taken the longest lines as thus approximately determined; for it seemed desirable, in view of the very large number of unnamed lines, to search at once for the longest elemental lines in the solar spectrum without waiting for a complete set of maps.

A preliminary search having been determined on, I endeavoured to get some guidance by seeing if there was any quality which differentiated the elements already traced in the sun from those not traced; and to this end I requested my assistant, Mr. R. J. Friswell, to prepare two lists showing broadly the chief chemical characteristics of the elements traced and not traced. This was done by taking a number of the best known compounds of each element (such, for instance, as those formed with oxygen, sulphur, chlorine, bromine, or hydrogen), stating after each whether the compounds in question were unstable or stable. Where any compound was known not to exist, that fact was indicated.

Two tables were thus prepared, one containing the solar, the other the more important non-solar elements (according to our knowledge at the time).

These tables gave me, as the differentiation sought, the fact that in the main the known solar elements formed stable oxygen-compounds.

I have said in the main, because the differentiation was not absolute, but it was sufficiently strong to make me commence operations by searching for the outstanding strong oxide-forming elements in the sun.

The result up to the present time has been that *strontium*, *cadmium*, *lead*, *copper*, *cerium*, and *uranium*,* in addition to those elements in Thalén's last list, would seem with considerable probability to exist in the solar reversing layer. Should the presence of *cerium* and *uranium* be subsequently confirmed, most of the iron group of metals will thus have been found in the sun.

As another test, certain of those elements which form unstable compounds with oxygen were also sought for, gold, silver, mercury being examples. None of these were found.

The same result occurred when the lines due to the jar-spark taken in chlorine, bromine, iodine, and those of some of the other non-metals were sought, these being distinguishable as a group by formation of compounds with hydrogen.

* Potassium has since been added.

Now other researches, not yet completely ready for publication, have led me to the following conclusions:

I. The absorption of some elementary and compound gases is limited to the most refrangible part of the spectrum when the gases are rare, and creeps gradually into the visible violet part, and finally to the red end of the spectrum, as the pressure is increased.

II. Both the general and selective absorption of the photospheric light are greater (and therefore the temperature of the photosphere of the sun is higher) than has been supposed.

III. The lines of compounds of a metal and iodine, bromine, &c., are observed generally in the red end of the spectrum, and this holds good for absorption in the case of aqueous vapor.

Such spectra, like those of the metalloids, are separated spectroscopically from those of the metallic elements by their columnar or banded structure.

IV. There are in all probability no compounds ordinarily present in the sun's reversing layer.

V. When a metallic compound vapor, such as is referred to in III, is dissociated by the spark, the band spectrum dies out, and the elemental lines come in, according to the degree of temperature employed.

Again, although our knowledge of the spectra of stars is lamentably incomplete, I gather the following facts from the work already accomplished with marvelous skill and industry by Secchi of Rome.

VI. The sun, so far as the spectrum goes, may be regarded as a representative of class (β) intermediate between stars (α) with much simpler spectra of the same kind, and stars (γ) with much more complex spectra of a different kind.

VII. Sirius, as a type of α, is (1) the brightest (and therefore hottest?) star in our northern sky: (2) the blue end of its spectrum is open; it is only certainly known to contain hydrogen, the other metallic lines being exceedingly thin, thus indicating a small proportion of metallic vapors; while (3) *the hydrogen lines in this star are enormously distended*, showing that the chromosphere is largely composed of that element.

There are other bright stars of this class.

VIII. As types of γ the red stars may be quoted, the spectra of which are composed of channelled spaces and bands. Hence the reversing layers of these stars probably contain metalloids, or compounds, or both, in great quantity; and in their spectra not only is hydrogen absent, but the metallic lines are reduced in thickness and intensity, which in the light of V, *ante*, may indicate that the metallic vapors are being *associated*. It is fair to assume that these stars are of a lower temperature than our sun.

I have asked myself whether all the above facts cannot be grouped together in a working hypothesis which assumes that in the reversing layers of the sun and stars various degrees of "celestial dissociation" are at work, which dissociation prevents the coming together of the atoms which, at the temperature of the earth and all artificial temperatures yet attained here, compose the metals, the metalloids, and compounds.

On this working hypothesis, the so-called elements not present in the reversing layer of a star will be in course of formation in the coronal atmosphere and in course of destruction as their vapor-densities carry them down; and their absorption will not only be small in consequence of the reduced pressure of that region, but what absorption there is will probably be limited wholly or in great part to the invisible violet end of the spectrum in the case of such bodies as the pure gases and their combinations, and chlorine. (See I, *ante.*)

The spectroscopic evidence as to what may be called the plasticity of the molecules of the metalloids, including of course oxygen and nitrogen, but excluding hydrogen, is so overwhelming, that even the absorption of iodine, although generally it is transparent to violet light, may (as I have found in a repetition of Dr. Andrews' experiments on the dichroism of iodine, in which I observed the spectrum) in part be driven into the violet end of the spectrum, for iodine in a solution in water or alcohol at once gives up its ordinary absorption properties, and stops violet light.*

A preliminary comparison of the ordinary absorption spectrum of a stratum of 6 ft. of chlorine renders it not improbable that chlorine at a low temperature is the cause of some of the Fraunhofer lines in the violet, although, as said before, I have not yet obtained certain evidence as to the reversal of the bright lines of chlorine seen in the jar-spark.

There is also an apparent coincidence between some of the faint Fraunhofer lines and some of the lines of the low temperature absorption-spectrum of iodine.

Should subsequent researches strengthen the probability of this working hypothesis, it seems possible that iron meteorites will be associated with the metallic stars and stony meteorites with metalloidal and compound stars. Of the iron group of metals in the sun, iron and nickel are those which exist in greatest quantity, as I have determined from the number of lines reversed. Other striking facts, such as the presence of hydrogen in meteorites, might also be referred to.

An interesting physical speculation connected with this working hypothesis is the effect on the period of duration of a star's

*** I have since obtained the same result by observing the absorption of I. vapor in a white-hot tube.**

heat which would be brought about by assuming that the original atoms of which a star is composed are possessed with the increased potential energy of combination which this hypothesis endows them with. From the earliest phase of a star's life the dissipation of energy would, as it were, bring into play a new supply of heat, and so prolong the star's light.

May it not also be that if chemists take up this question which has arisen from the spectroscopic evidence of what I have before termed the plasticity of the molecules of the metalloids taken as a whole, much of the power of variation which is at present accorded to metals may be traced home to the metalloids? I need only refer to the fact that, so far as I can learn, all so-called changes of atomicity take place when metalloids are involved, and not when metals alone are in question.

As instances of these, I may refer to the triatomic combinations formed with chlorine, oxygen, sulphur, &c., in the case of tetrad or hexad metals.

May we not from these ideas be justified in defining a metal, provisionally, as a substance, the absorption-spectrum of which is generally the same as the radiation-spectrum, while the metalloids are substances the absorption-spectrum of which, generally, is not the same? In other words, in passing from a cold to a comparatively hot state, the plasticity of these latter comes into play, and we get a new molecular arrangement. Hence are we not justified in asking whether the change from oxygen to ozone is but a type of what takes place in all metalloids?

My best thanks are due to Mr. R. J. Friswell for the valuable aid he has afforded me in these investigations.

Art. XLVI.—*On the occurrence of the Brown Hematite Deposits of the Great Valley*; by Frederick Prime, Jr.*

The Great or Cumberland Valley, which (under a variety of names) extends from Canada, through Vermont, Massachusetts, Connecticut, New York, Pennsylvania, Maryland, Virginia and East Tennessee to Alabama, is composed in part of limestones lying immediately above the Potsdam sandstone. Geologically, they belong to the era between the Potsdam and Trenton, and are commonly termed Calciferous. A peculiarity of these limestones is their great richness in limonite or brown hematite ores, which form a large part of the charges of the many blast-furnaces situated on their outcrops. The mines from which the ores are obtained are (properly speaking) only pits or quarries,

* A paper read before the Amer. Inst. of Mining Engineers at New Haven, Feb. 25th, 1875.

from which the ore is extracted by means of picks or shovels, powder never being employed.

The ore does not occur casually at any point in the limestone, but forms regular lines, following apparently the outcrops of certain beds. In Lehigh County, Penn., where I have been engaged on the geological survey of the State during the past season, there are three or four of these lines. During the progress of the survey I was much struck by the fact that the two most important and promising lines of outcrop were—one, at the base of the crystalline schists (forming the South or Lehigh Mountain), and overlying the Potsdam sandstone conformably; the other, near the line of junction of the Calciferous limestone with the Hudson River slates. The mines along these two lines—following the topography of the country—were in place, richer and more permanent than those of the belts between, which had been more decomposed *in situ* and were generally leaner.

A peculiarity of these two lines of outcrop, and one to which I particularly desire to draw attention, is the occurrence of what I at first mistook for a highly altered slaty limestone, but which on subsequent analysis proved to consist in great part of damourite (hydrated potash-mica). The following are analyses of this damourite-slate:

I. From Fogelsville, Lehigh County, within a few hundred feet of the contact of limestone and slate, by Dr. F. A. Genth.

II. From Hensingerville, Lehigh County, within 300 feet of gneiss, by Mr. Sydney Castle of the University of Pennsylvania.

III. From Allentown, Lehigh County, within 150 feet of contact of the limestone with Potsdam sandstone: by Mr. Pedro G. Salom of University of Pennsylvania.

IV. From another quarry close to III; also by Mr. Salom.

	I.	II.	III.	IV.
SiO_2	49·92	45·40	59·30	39·80
CO_2	----	----	----	14.40
Fe_2O_3	0·91	5·06	} 30·30	2·40
Al_2O_3	34·06	24·69		23·95
FeO	----	----	----	*trace*
MgO	1·77	13·56	*trace*	1·94
CaO	0·11	*trace*	*trace*	9·85
Na_2O	0·74	0·27	1·51	0·52
K_2O	6·94	5·85	6·24	3·34
H_2O	6·52	4·80	4·70	6·00
	100·97	99·63	102·05	102·20

As typical damourite contains 11·77 p. c. of potash, it is evident from the above analyses that I. contains 55·40 p. c. of damourite; II, 49·70 p. c.; III, 53·02 p. c.; and IV, 28·30 p. c.

The remainder of the slate consists of ferruginous clay, quartz, and carbonates of lime and magnesia.

I have noticed that as a rule the fresh damourite-slate can only be observed where a mine is being worked; when fresh it is white to straw-yellow in color, has a greasy feel and very slaty texture, being composed of minute crystalline plates. As soon as work is stopped in a mine the slate commences to decompose and becomes rapidly converted to a white or yellow clay, the latter color being due to oxide of iron. Indeed, in many mines no slate can be observed at all, the whole of it being changed to clay prior to the opening of the pits.

I have made a qualitative examination of both white and yellow clays from the same mine as I, and close to the spot where the slate was obtained. I found them to contain the same ingredients as I.

That the damourite-slate belongs to the Calciferous and not to the Laurentian or Huronian periods, is evident from the fact that it is found forming a bed in the limestone immediately overlying the Potsdam sandstone and conformably to the latter. The ore is always found above the clay or damourite-slate, or at least in the upper portions of it, *never* below it; and usually in streaks or masses precisely in the manner noticed by Prof. W. P. Blake* at Ocoya Creek, California; and from the manner in which the ore occurs it appears to have been deposited by the percolation of waters containing iron in solution. The ore also occurs as so-called "bombshell ore," and this ore when hollow either contains water or the clay resulting from the decomposition of the damourite-slate. The interior surface of this bombshell ore is frequently glazed, apparently by a thin coating of manganese oxides, and often contains small stalactites, the ore clearly indicating its aqueous origin, and its formation *subsequent* to the rock or clay inclosing it.

So-called pipe ore is also found,—though more rarely in this district—but under different conditions, being always found underneath a bed of limestone, and evidently formed by the percolation of ferruginous waters through this bed. I have never seen the pipe ore in large quantities at any one point or associated with the slate or clay.

If this occurrence of the damourite-slate or clay and ore was merely local, it would be scarcely worth noticing; but in fact we find that the slates or clays are almost universally associated with the iron ores of the Calciferous epoch. They are therefore of the greatest importance.

Professor Dana, in a private letter to me, mentions the occurrence of slates with the brown hematite deposit of Richmond, Berkshire County, Massachusetts. Professor Shepard,†

* See Pacific R. R. Reports, vol. v, p. 168.

† A Report on the Geol. Survey of Connecticut, by C. U. Shepard, p. 20.

in writing of the ore bed at Kent, Connecticut, speaks of decomposed micaceous gneiss (?) called by the workmen "grey fuller's earth," and also of "decomposing quartzy mica-slate." We meet with this association of slate or clay and ore in Lehigh County, Penn.

Professor Lesley also speaks of this occurrence in his "Report on the Brown Hematite Deposits of the Nittany Valley, Penn." Here there are apparently *three* lines of mines, to judge from the map accompanying the report. Professor Persifor Frazer, Jr., informs me that he found the same association of white clay with ore in York County, Penn.

Professor Lesley † gives a sketch of what he calls "ore-bearing slates" lying between the Potsdam and Calciferous of the Cumberland Valley. These are evidently damourite-slates, for he proceeds in the article to speak of white clays formed by their decomposition. The same association is found in Maryland and Virginia in the valleys forming the Great Valley.

Professor Lesley* speaks of the occurrence of white clay with ore in the same formation at Embreeville, East Tennessee. It also occurs at Shelbyville, Alabama.

It is therefore evident that the occurrence of this slate or clay with the brown hematite ores of the Calciferous epoch is the rule, its absence the exception. As Professor Lesley† says: "They (the ores) never occur in any other relationships. They are the same ores, in the same rocks, arranged in the same way, the whole distance from Massachusetts to Alabama. Consequently what is geologically true of the ore beds at Salisbury and Amenia, east of the Hudson, is true all the way to Alabama."

Formerly the slates probably covered the sides of the mountain ranges now forming their south boundary, resting on crystalline limestone, which separated them from Potsdam sandstone. On account of the large amount of carbonate of lime which the slates probably contained and the ease with which they were converted to clay, they have suffered the most in the erosion which has taken place. My own experience has been that the slate and clay occur under the ore, and *not* the reverse.

From this constant occurrence of the slate with the ore it is evident that the former has exerted an important influence on the deposition of the ores; and I think that the presence of the slate was necessary to such deposition, in that it formed an *impervious bed through which the chalybeate waters could not percolate.* Whatever may have been the manner in which the ore originally existed, it was deposited in and above the slates from an aqueous solution. Under these circumstances, it will be

* Lesley, "The Iron Ores of South Mountain in Cumberland Co., Penn.," in Proc. Amer. Phil. Soc., Jan., 1873. † Proc. Amer. Phil. Soc., May, 1872.

highly improbable that we shall find continuous deposits of the brown hematite ores when the slate or clay does not occur with them.

With respect to the quantity of ore, Professor Lesley, in his paper on the Cumberland Valley, says it will depend: "First, on the original charge of iron in the strata; second, on the dip of these strata; and third, on the depth beneath water-level to which the mouldering decomposition of the strata and the peroxidation and concentration of the iron has extended."

There is much difference of opinion as to how these deposits of brown hematite ores can have been formed. Dr. Hunt, in a paper read before the National Academy of Sciences in November, 1874, gives it as his opinion that they were once beds of pyrites in *Huronian* schists, now decayed. I have shown in the commencement of this paper that they are *Calciferous* slates or schists; and were the ores formed by the alteration of pyrites *in situ*, we should find kernels of iron-pyrites which had escaped alteration, especially in the deepest mines. This is not, however, the case. Iron pyrites are found very rarely; as, for example, in Breinig's mine near Allentown, and one of the Glendon Iron Company's mines near Easton; and these mines are not the deepest we have, the former being quite shallow.

Professor Lesley * thinks the ores "were deposits *in loco originali* of the iron (as hydrated peroxide) set free from the limestone or dolomite rocks during their gradual erosion and dissolution;" agreeing in this respect with Dr. R. M. S. Jackson, who made the first geological survey of the Nittany Valley ore beds in 1838 or 1839. Of course, only the carbonates of lime and magnesia would be dissolved; the clay, iron and silica would remain behind. Were this, however, the case, should we find *fresh, undecomposed* damourite-slate conformably in position with limestones above and below it, as can be seen at the Lehigh Iron Company's limestone quarry at Allentown, Penn.? From what I have seen in Lehigh, Northampton and Berks Counties, Penn., I have been led to the following conclusions, which I advance with considerable reluctance, as I consider it extremely dangerous to argue from observations within a limited area to general conclusions.†

* Lesley, Report on the Brown Hematite deposits of the Nittany Valley.

† Prof. C. U. Shepard, in his Report on the Geological Survey of Connecticut, published in 1837, says: "The origin of limonite in these rocks ['mica slate, micaceous gneiss or quartz-rock'] may be attributed to the decomposition of the sulphuret of iron and other ferruginous minerals with which they are known to abound. It is obvious also that, in a majority of instances, this change took place in the original repositories of these minerals; since no perceptible derangement is discoverable in the layers of the ore-bed, or want of conformity in them to the adjacent rock." This view, adding limestone to the rocks, has been found by Dana to accord fully with the various facts in the limonite region of Western Connecticut and Massachusetts.—EDS.]

The damourite-slates, being the products of the decomposition of primary rocks containing orthoclase and probably oligoclase, or albite, were deposited in the Silurian sea during the Calciferous epoch and near its commencement. At Allentown and Bethlehem, Penn., the slates are but 50 to 100 feet above the Potsdam sandstone, with a blue massive limestone, generally crystalline, between the two. Limestone was again deposited above the slate. I am not yet prepared to say whether more than one bed of damourite-slate was formed, and reserve an opinion on this point until I have made further explorations.

The brown hematites were probably formed by the oxidation of iron pyrites, but the former are not in the same place that the latter were. My reasons for this assertion are twofold. In the first place, the animal carbon of the organisms, whose shells formed the enormous quantity of dolomite or limestone, exists in such quantities throughout the limestone as to color the rock, the zinc blende (of Friedensville) and the carbonate of iron a bluish grey. This same carbon would readily reduce the sulphate of iron carried into the ocean to iron pyrites. As a proof of this reduction I need only mention that iron pyrites have been found in the mud* of a pond. Secondly, the great majority of the brown hematites which I have had analysed, and they are many, contain a *trace* of sulphur, usually not more than a few hundredths of a per cent. I have also found minute (almost microscopic) crystals of iron pyrites in much of the limestone, where it is opened in quarries; and I have also seen in much of this same limestone, where weathered, minute cavities, which I have ascribed (perhaps erroneously), from their general appearance, to the decomposition of the pyrites.

It is at present impossible to say whether the pyrites from which the brown hematite ores were and are forming were thus minutely disseminated through the limestone, or whether there was a bed of the limestone—now decomposed,—especially rich in the pyrites.

In either case it would seem that the pyrites above water-level—and we must bear in mind the great erosion which the surface of the country has undergone since it was formed—would oxidize from the action of the water and the air carried in by it, forming protosulphate of iron. This being readily soluble in water, was carried down through the limestone, forming sulphate of lime (gypsum) and carbonate of iron wherever the solution came in contact with the fresh limestone. This reaction was, however, probably slight, owing to the rapid descent of the solution in seeking the water-level. It experienced no difficulty in its descent until it came in contact with

* Gmelin—Kraut's Handbuch der Chemie, 6th ed., vol. iii, p. 333.

the damourite-slate, when, meeting with an impervious bed, it could not descend any farther and was then obliged to follow the slates. This considerably retarded the rapidity of its flow, permitting the reaction between the limestone (and the carbonates of lime and magnesia in the damourite-slate) and protosulphate of iron to take place more completely. By this means carbonate of iron was deposited, being but slightly soluble; while the sulphate of lime (gypsum) formed, being very soluble, was carried off in solution.

No doubt many of the limestone caves—so common in the Calciferous limestones—were formed by the dissolving action of the water containing protosulphate of iron. The subsequent formation of the limonite is easily explained, being merely the oxidized and hydrated product of the carbonate of iron.

In fact, a bed of blue carbonate of iron, identical in appearance with the ordinary limestone and Friedensville zinc-blende, occurs with the brown hematite ores at Balliet's mine near Allentown and at one of the Hellertown mines near Bethlehem. It does *not* occur at many of the mines in the Lehigh Valley; those being the only mines where I know of its occurrence. The very fact of this occurrence would tend to show that the above-mentioned reaction has taken place and was the one by which the ore was formed. This reaction would also explain why the brown hematites which occur in limestone are almost always free from sulphur, merely containing a trace; and yet almost always containing *this trace*. As a proof of this, I give the analysis of a brown hematite which occurs at Katahdin Furnace, Piscataquis County, Maine. The analysis was made by Professor T. M. Drown of Lafayette College. It afforded

Fe_2O_3	H_2O and organic matter	SiO_2	H_2SO_4	P_2O_5
76·87	19·25	0·71	3·10	0·10=100·03

Professor Drown informs me that the rock underlying the ore was siliceous in character, thus giving the sulphuric acid no opportunity to combine with lime and be carried away.

The objection may be raised to this view of the case, that we do not anywhere find any deposits of gypsum. It must be borne in mind that gypsum is readily soluble, and would be carried a considerable distance in solution before being precipitated. I can also point to one very considerable deposit of gypsum in this formation; that of Saltville in Russell County, Virginia.

It may be urged—and I confess with much show of reason—that the iron was first present in the limestone as carbonate. As one example of this may be adduced the following instance, for which I am indebted to Professor Dana. "In one of the brown hematite mines at Richmond, Berkshire County, Massachusetts, there was exposed, about fifteen months ago, a great mass of massive carbonate of iron, which was once a part of the limestone of the region. It appeared to have resisted decomposition in consequence of its compactness and purity. There is limonite of great thickness all about it, which has been made by the decomposition of the limestone and its included carbonate of iron, or its carbonate of iron and lime; for an extensive ledge of limestone rises above the great pit or excavation on its north side, whose layers are conformable to that of the massive carbonate of iron in the bottom of the mine. The material between the two must have originally been calcareous: it is now gone and there is limonite in its stead."

The fact here mentioned tends to prove that the limonite was probably originally present as carbonate of iron and that the outer and possibly less compact portion of the deposit became changed.

It seems to me that in this instance, as in those at Balliet's mine and Hellertown, we have a case of alteration of the limestone to carbonate of iron particle by particle, or, so to term it, "a pseudomorph by replacement."

My objection to the original deposition of the carbonate of iron, as such, in the Calciferous epoch is threefold. In the first place, it should be uniformly distributed through the limestone and not confined merely to the horizon just above the damourite-slates. Then there should not be even the *trace* (the few hundredths of a per cent) of sulphur in the brown hematites, which we so uniformly find. And finally, there seems to be a lack of cause, such as exists in the case of the carbonates of lime and magnesia. For these were secreted by the marine animals to form their shells, &c., which would not be the case with carbonate of iron.

In conclusion, I would once more point to the fact that whatever the origin of brown hematites may have been, the cause of their deposition, where they are now found, must have been the damourite-slates.

Lafayette College, Easton, Pa., Feb. 22, 1875.

ART. XLVII.—*Note on some New Points in the Elementary Stratification of the Primordial and Canadian Rocks of South Central Wisconsin;* by ROLAND IRVING.

THE order always hitherto accepted for the Lower Silurian strata of Wisconsin has been as follows, beginning below:

I. *The Potsdam Sandstone*—500–700 feet in thickness; in its upper portions somewhat dolomitic; fossiliferous in localities near the Upper Mississippi and St. Croix Rivers.

II. *The Lower Magnesian Limestone*—200–250 feet in thickness; chiefly a pure dolomite, and almost without fossils.

III. *The St. Peter's Sandstone*—80–100 feet in thickness; for the most part a coarse quartzose sandstone; at times with ferruginous cement, at others loose and incoherent.

IV. *The Blue and Buff Limestones.*

V. *The Galena Limestone.*

VI. *The Cincinnati Group.*

During the past season I have been able to make some modifications in this scheme, as far as the Potsdam, Lower Magnesian, and St. Peter's are concerned, for the region of south central Wisconsin, especially in Dane and Columbia Counties. The succession now made out is as follows, beginning below:

I.	The Lower or Potsdam Sandstone	800	feet.
II.	The Mendota Limestone	30	"
III.	The Madison Sandstone	35	"
IV.	The Main Body of Limestone	80–120	"
V.	The St. Peter's Sandstone	80–100	"
VI.	The Buff and Blue Limestones.		

I. *The Potsdam Sandstone.*—In the region of the "Four Lake Country," about Madison, in Dane County, only the upper layers of this great formation are to be seen. Farther north, in southern Columbia County, the northerly rise of the rocks brings lower layers to view. In all this region the upper 50–100 feet of the formation are decidedly dolomitic, but nevertheless are very different and easily distinguished from the overlying *Mendota limestone.* Borings from artesian wells at Madison and Janesville go to show that some dolomitic admixture continues in the sandstone to within 200 to 300 feet of the Archæan, which is entered by two borings at Madison. The lowest layers seem, however, to be a coarse quartzose, non-dolomitic material. The dolomitic admixture in the upper layers amounts to 15 or 20 per cent. In the Janesville well there was some indication of the existence of a distinct layer of limestone at a very considerable depth in the Potsdam. *Scolithi* are the only indications of life.

II. *The Mendota Limestone.*—This limestone has everywhere in the region around Madison, and in fact wherever recognized, very marked characters. It has always a peculiar yellowish, dirty appearance, and is frequently stained by reddish patches and seams of non-hydrated oxide of iron. Layers of green sand occur, especially about the junction with the underlying sandstone. This limestone is usually heavy-bedded below and thin-bedded to shaly above. It is always to some extent arenaceous. In localities it is fossiliferous, carrying trilobites especially, and most common among them the *Dikellocephalus Minnesotensis*, or some very similar form. The fossil locality at Mazomanie, on the west side of Dane County, which is alluded to by Hall in his monograph on the Fauna of the Potsdam Sandstone,* is doubtless at the horizon of the Mendota limestone. The name *Mendota* is given from the exposures on Lake Mendota in Dane County, where the rock was first recognized as a separate stratum.

III. *The Madison Sandstone.*—This sandstone having been first recognized in the vicinity of the city of Madison, where it is largely used as a building stone, I have thought proper to give it this name provisionally. It is in its lower portions always, and in its upper most commonly, a very coarse quartzose sandstone, consisting of very much rolled grains of limpid quartz, without admixture of dolomitic material, or with only a very slight amount. Frequently the rock is an incoherent mass of white sand. In other cases there is an admixture, or cement, of hydrated oxide of iron, the rock having a brownish hue, the oxide staining the grains of limpid quartz superficially only. In some localities, again, the upper layers are decidedly dolomitic, and then the rock becomes a building stone of considerable value. This layer of sandstone has been recognized over a wide area south and east of the Wisconsin River. The dolomitic varieties contain from ten to twenty per cent of calcium and magnesium carbonates.

IV. *The Main Body of Limestone.*—This limestone is never more than 85 feet in thickness in the region around Madison. Farther north, in Columbia County, it reaches an extreme of 120 feet. It consists of three portions, not always well defined from one another, but still distinct. These are, beginning below: (1) thin, often irregular layers, carrying near the base persistent layers of green sand, and immediately at the junction with the Madison sandstone a very peculiar siliceous oolite layer, a few inches in thickness. This oolite consists of rounded granules $\frac{1}{40}''$ to $\frac{1}{20}''$ in diameter, closely packed in a pulverulent siliceous matrix, the whole having a milky white color. The smaller granules are seen under the microscope to be single grains of limpid quartz, the larger ones being aggregations of quartz grains. This layer is astonishingly persistent, having been seen everywhere where the base of this limestone is exposed, and at points many miles apart The whole thickness of this portion of the formation is about 20 feet. (2) Very heavily and indistinctly bedded light buff limestones, breaking with a conchoidal fracture and carrying considerable chert in nodules, in thickness about 20 feet; (3) the upper layers of the formation, in general consisting of (*a*) thin-bedded layers, (*b*) very heavily-bedded layers, carrying very numerous large chert concretions and continuous chert layers, and (*c*) concretionary

* 16th Annual Report, Regents of the University of the State of New York, on the condition of the State Cabinet of Natural History, Appendix D, 1863.

and brecciated layers. In none of these subdivisions have any fossils been seen.

V. *St. Peter's Sandstone.*—This formation appears with its usual characters, except that east of Madison it presents a very marked deviation from its usual very uniform thickness of 100 feet, being reduced as low as 40 feet.

On the Mississippi River bluffs, in the vicinity of Winona and La Crosse, and again farther south, there exists, so far as now known, between the Potsdam and St. Peter's sandstone, 200–250 feet of dolomite without sandstone layers. Farther northwest, there occurs in the valley of the Minnesota River—according to Professor N. H. Winchell, State geologist of Minnesota—the following succession of strata, beginning below:

I. The Lower or Potsdam Sandstone.
II. The St. Lawrence Limestone.
III. The Jordan Sandstone........................50 feet.
IV. The Shakopee Limestone ....70 "
V. The St. Peter's Sandstone.

His description of the characters of the Shakopee, Jordan, and St. Lawrence beds shows that these strata are respectively very strikingly like my Main Body of Limestone, Madison Sandstone, and Mendota Limestone. Future investigations may show that the Jordan and Madison sandstones are somewhere continuous, in which case Mr. Winchell's names would appropriately be extended to the Wisconsin strata. So far as now known, however, the two regions in which these similar alternations occur are separated by an area where all merge into a mass of limestone whose thickness is much greater than their combined thickness.

The following schedule serves to show the probable equivalence of the strata in these different regions:

	South Central Wisconsin.	Mississippi Bluffs.	Minnesota River.
Canadian.	St. Peter's Sandstone.	St. Peter's Sandstone.	St. Peter's Sandstone.
	Main Body of Limestone, 80 to 120 feet,	Lower Magnesian Limestone, 200 to 250 feet.	Shakopee Sandstone. 70 feet.
	Madison Sandstone, 35 ft.		Jordan Sandstone, 50 ft.
	Mendota Limestone. 30 feet.		St. Lawrence Limestone.
Primordial.	Lower or Potsdam Sandstone.	Lower or Potsdam Sandstone.	Lower or Potsdam Sandstone.

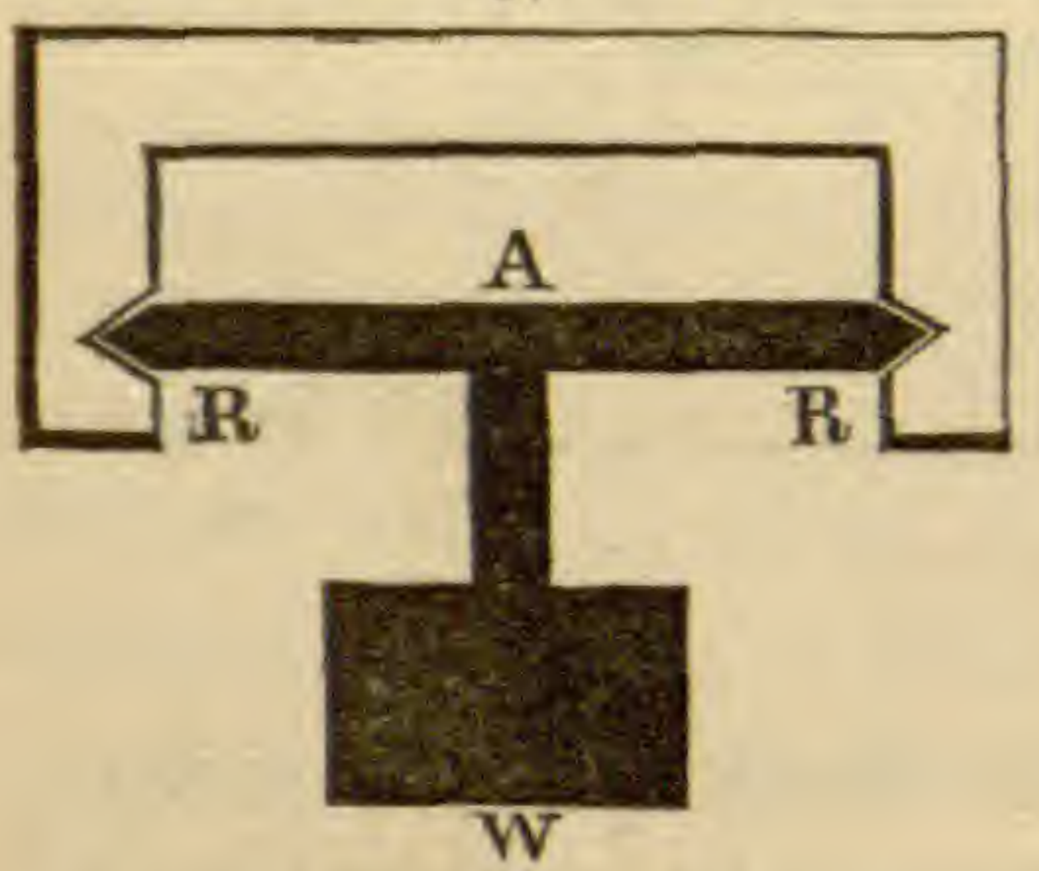
University of Wisconsin, February 13, 1875.

ART. XLVIII.—*On the application of the Horizontal Pendulum to the measurement of minute changes in the dimensions of Solid Bodies;* by O. N. ROOD, Professor of Physics in Columbia College.

[Read before the National Academy of Sciences, Nov. 4th, 1874.]

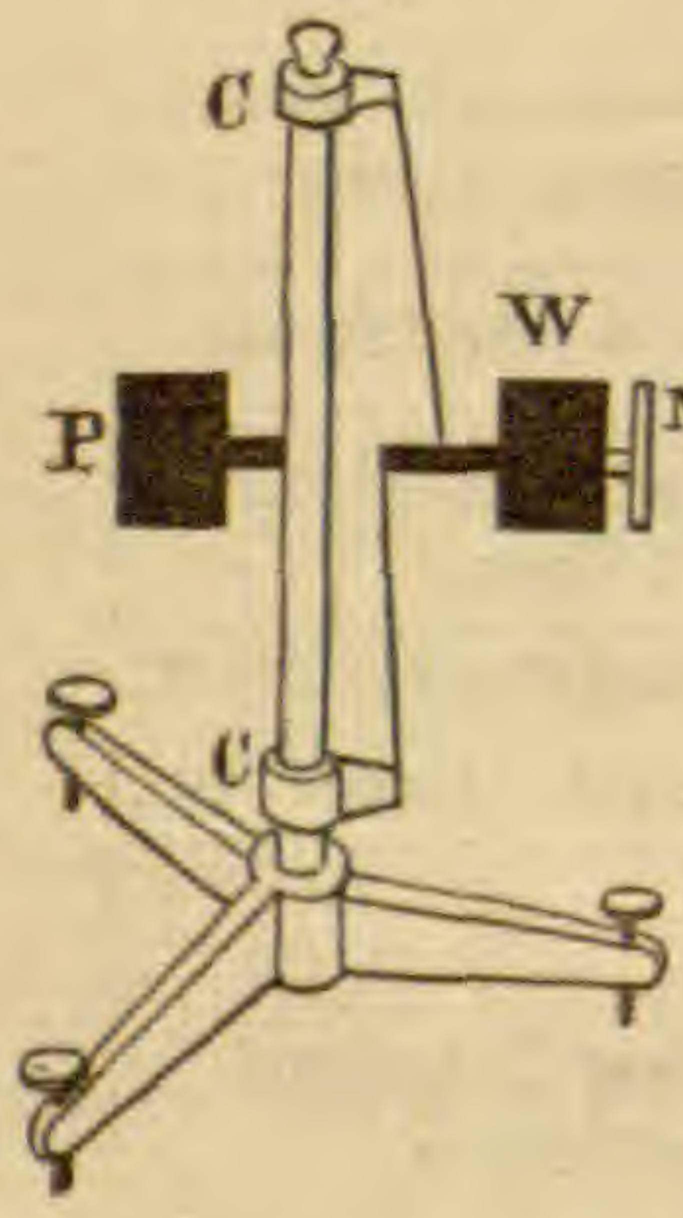
IN figure 1, let RR represent an inflexible rod of steel placed horizontally, and supported at its extremities by pivots on which it turns freely, and let W be a weight inflexibly attached to the rod as indicated. It is evident that WA when left to itself will assume a vertical position, and that the whole apparatus will constitute essentially an ordinary pendulum. If now an attractive or repulsive force be made to act on W, the pendulum will tend to be deflected from its vertical position, and if the force is sufficiently powerful a sensible deflection will be observed. In an arrangement of this kind, aside from friction, the opposing force to be overcome will of course be the attraction of gravitation; if, however, we gradually elevate the rod RR, the gravity component will diminish, and become zero when RR is vertical, and consequently AW horizontal. In his articles on the Horizontal Pendulum, Zöllner* has shown experimentally how this may be accomplished to an almost incredible extent, so that an apparatus of this general nature in his hands became capable of obeying even the feeble attractive force of the moon!

1.



I give here a diagram of Zöllner's horizontal pendulum; at W is the weight, the inflexible rod being replaced by fine steel wire or watch-spring, stretched as shown on the vertical column CC, the whole being supported by a tripod with leveling screws. P is a counterpoise; M a mirror for reflecting the divisions of a scale to a telescope. The height of this apparatus was about 30 inches; it was mounted on a pier like an astronomical instrument, and enclosed in a small building by itself, the observations being made from without.

2.



In the remarkable papers above referred to, Zöllner also pointed out the extreme sensitiveness of this apparatus to changes in level, and it at once occurred to me that by suitable modifications and additions, it could be converted into an instrument of unprecedented delicacy for studying minute changes in the dimensions of solid bodies.

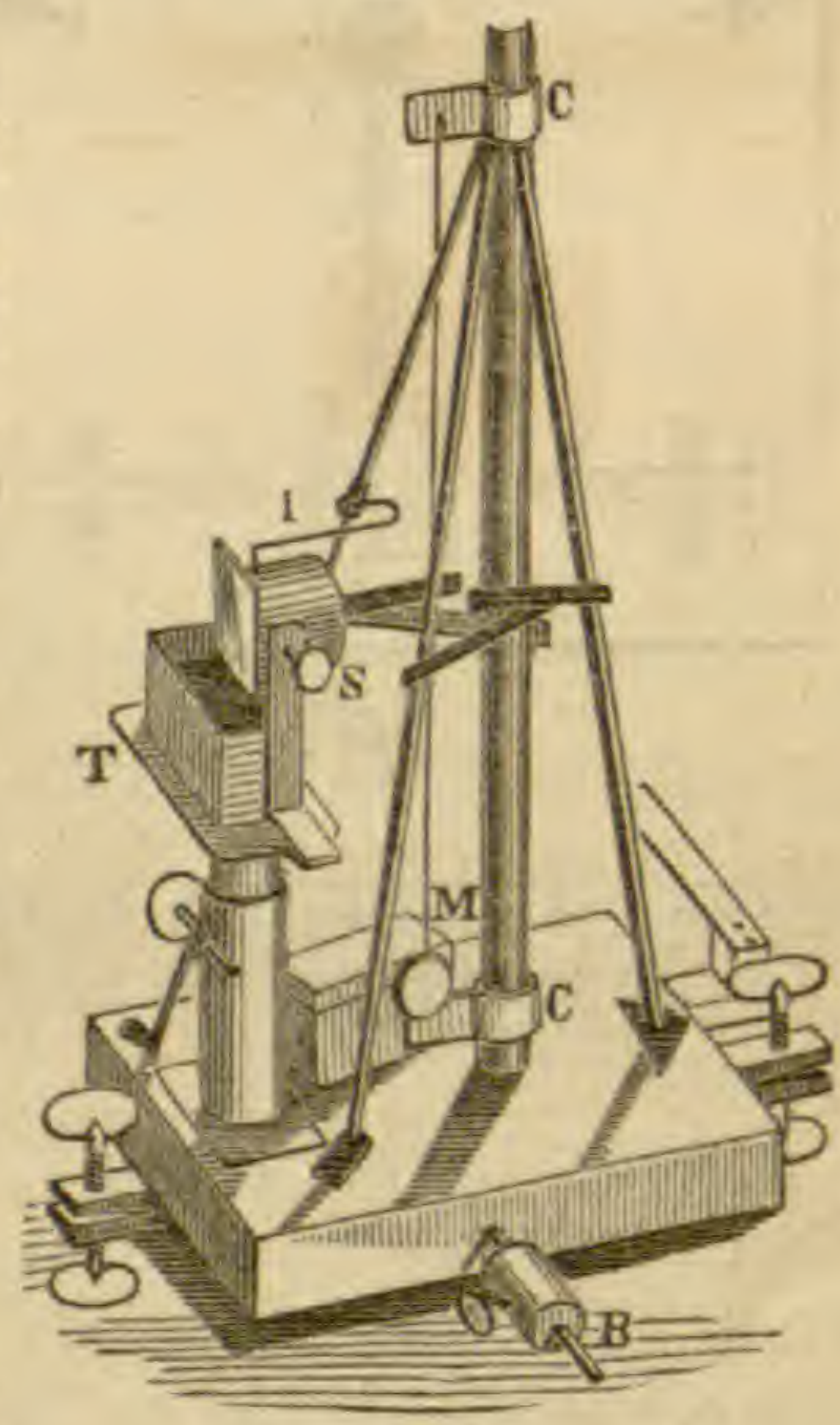
* Pogg. Ann. for 1873, cl, 131, 134.

Arrangement of a Horizontal Pendulum for measuring minute distances.

The apparatus constructed by me was almost entirely of brass; the dimensions were as follows: the height of the tubular column CC, fig. 3, was 350 mm.: distance *ab*, fig. 4, 5 mm.; distance *a*W, 58 mm.; weight of pendulum, 137 grams, nearly. The whole was supported on a well braced and firmly constructed wooden stand, which was hung by its upper end on the brick walls of the college-building, and again attached to them below, so as to prevent vibrations independent of the walls of the building itself.

An inspection of Zöllner's apparatus shows that its form was such as to render the column CC, fig. 1, quite liable to vibrations of its own; this I guarded against by the addition of three long and the same number of short cross-braces, as shown in fig. 3; they were found to make a most marked change for the better, and gave the instrument a stability which it previously did not possess.

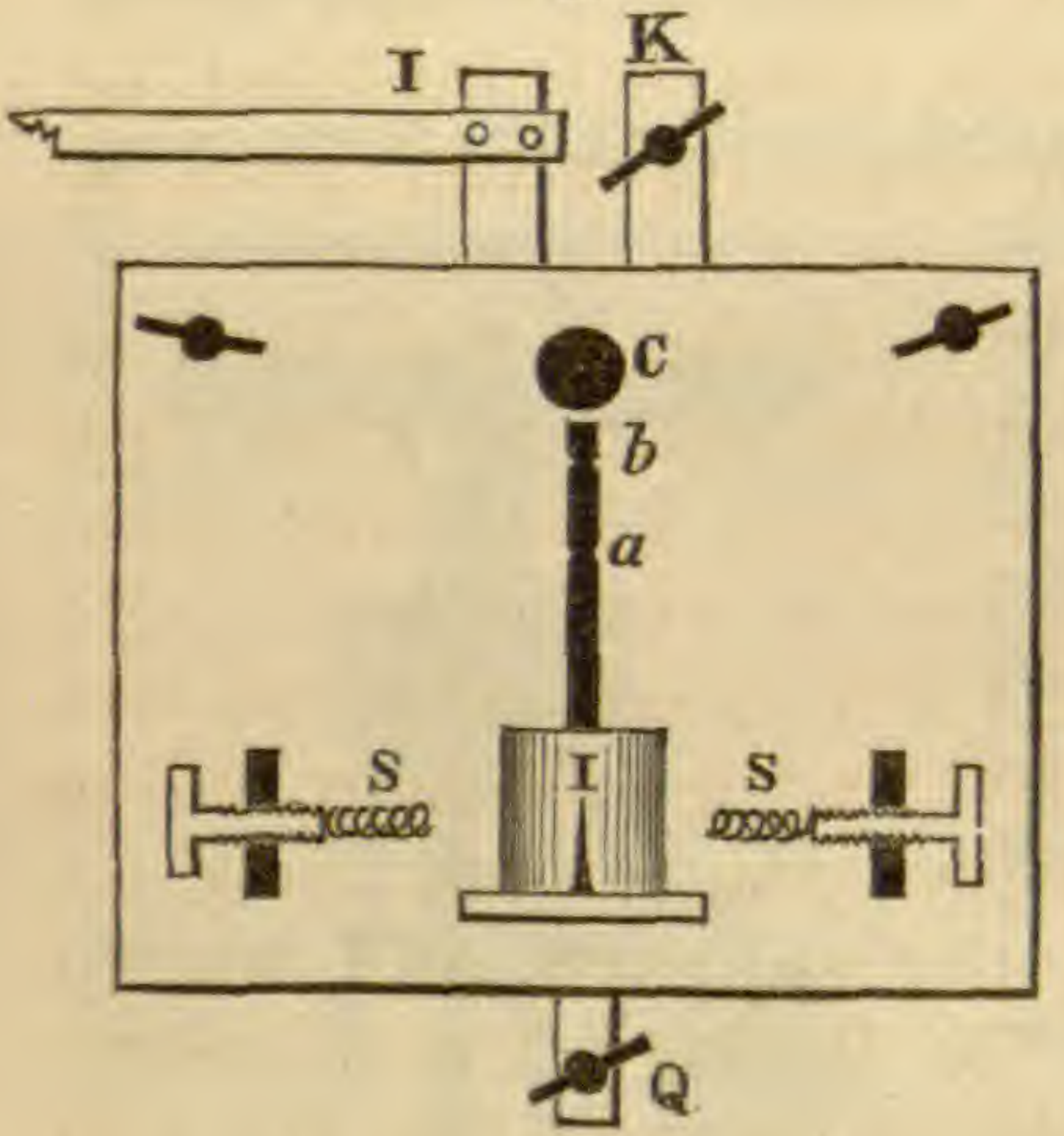
3.



Again, the German astronomer provided no means for bringing his instrument to rest, and in his published observations this actually never was the case, the extremes of the oscillations being employed for ascertaining the position of the pendulum. As this mode of taking readings was, in my case, owing to the locality and nature of the work, wholly out of the question, it became necessary to supply this defect. Very good results were obtained simply by attaching to the pendulum a wire bent in a series of zig-zags, and immersed in a box filled with olive-oil. By removing with the pliers successive portions of the wire, it was found that matters could be arranged so that the instrument came to rest after a couple of oscillations. The oil-box rested on a little table provided with rack-work to adjust its height and remove it when necessary; it is shown at T in fig. 3; its dimensions were as follows: length 70 mm., breadth 30 mm., depth 32 mm. The wire was placed of course as near the center of the box as possible, and the effects of capillarity were not sensible. The above arrangement is the one actually employed in making the experiments detailed below, but I have some reason to suspect that, owing to its viscosity, there was a tendency on the part of the pendulum, *after it had once come to rest*, to obey impulses from without more tardily than was quite right. To obviate this possible difficulty I afterward provided the pendulum with a paddle instead of a wire, and caused the former to move loosely like a piston in the interior of a suitable box, which was entirely submerged in *kerosene* oil; the results were very promising, but I have not had time to use this method in an extended set of experiments.

At SS, figs. 3 and 4, are stops which confine the motion of the pendulum within narrow limits; they consist of spiral springs, which are fastened in the prolongation of adjusting screws. The springs form an essential part of this indispensable arrangement, and without their aid it was often found impossible to complete the leveling, so as to give the instrument even a moderate degree of sensitiveness.

4.



At I, figs. 3 and 4, is shown an index or pointer, intended to facilitate the adjustment of the pendulum with regard to the scale, and readily bring it into the zero of position. It makes a very convenient addition, and is observed by a lens placed outside of the glass case enclosing the whole apparatus.

I may here remark, that the above-mentioned additions ought hereafter to be made to the horizontal pendulum, even when constructed solely for astronomical purposes, the oil-box being replaced by an air-box, contrived so as to reduce the tendency to oscillate. Compare Töpler, "Ueber einige Anwendungen der Luftreibung bei Messinstrumenten," Pogg. Ann., 1873, xlix, 416.

Mode of suspension.—In the first experiments fine iron wire was employed, but it was soon found that its presence rendered accurate magnetic observations impossible; and besides, although it was as fine as was consistent with safety, its torsion was noticeable. I afterward replaced it with narrow strips of elastic copper-foil, such as is used by jewelers, the ends being soldered to small thin plates of brass to prevent tearing, and these again connected with fine, hard-drawn brass wire. The copper-foil was adopted merely as a temporary expedient, but as it was found to answer well, and to be free from sensible torsion, it was retained. Experiments were made beforehand on its strength, and it was loaded up to within about two-thirds of its breaking strain.

At M, fig. 3, is a milled head for winding up the brass wire attached to the lower copper strip and thus bringing the pendulum into a horizontal position, i.e., its real object being to adjust the mirror of the pendulum with regard to the scale and telescope

Leveling screws.—These were made of brass with eighty threads to the English inch, the two rear screws being at a distance of only two inches apart. The front screw and one of the rear screws rested on plates of brass or glass, which were properly countersunk and cemented in a level position on the shelf. They were provided with the easily removable lever-arms 70 mm. long, and the leveling was always completed by giving gentle taps to these arms, with some light rod such as a lead-pencil.

Micrometer.—The left-hand rear screw, I, fig. 4, was used as a micrometer; it rested on a small leveled plate of glass and was provided with an arm 140 mm. in length, which was capable of moving over $\frac{1}{2}$ or $\frac{1}{3}$ of a degree of arc between two fixed points. To the extremity of the arm were attached two threads, one of which reached directly to the observer, while the other first passed over a small pulley; the threads were retained in a horizontal position by proper supports, and served to turn the micrometer-screw to and fro through some known fractional part of a degree. The distance traversed by the end of the lever-arm was measured with a compound microscope placed over its extremity; the length of this arm being known, and the number of threads of the screw, the actual upward motion could be calculated.

At B, fig. 3, is a counterpoise, its object being to remove most of the pressure from the micrometer screw.

Scale and Telescope.—A glass scale divided into millimeters was used; the telescope magnified about 60 diameters: the lines of the scale appeared to the observer, when referred to a distance of ten inches, to be about eight mm. apart, so that there was no difficulty in estimating tenths of a division.

Sources of error. — The main difficulties encountered in making the observations given below may be divided into two classes, viz: those due to accidental vibrations, and those dependent on changes of temperature. The apparatus, as may be imagined, was exceedingly sensitive to vibration, and the locality used by me, in this respect, one of the most unfavorable in this country; for, apart from carriages and street-cars, locomotives and trains of cars passed at a distance of 300 feet continuously during most of the day and the greater part of the night. Hence, in spite of the oil-box, the pendulum was never completely at rest, except for three or four hours after midnight: during the day-time the vibrations were often so rapid as to render the scale-divisions invisible. Still, in spite of these disturbing causes, an extended series of experiments has shown that the inherent stability of the apparatus is such that these external influences produce, during a moderate interval of time, little or no permanent change in the instrument, and their effects can consequently be eliminated by making a sufficient number of observations. To illustrate the delicacy of the apparatus, I may remark that children playing on an iron bridge, 360 distant, caused temporary deflections of one or two divisions, and that similar deviations were caused by the lower notes of an organ in a neighboring church, the medium and higher tones producing no sensible effect. It was found, however, necessary to guard more sedulously against disturbances originating in the building itself, as they were more apt to produce permanent effects; this evil, however, practically only subjected the observer to temporary interruption.

Changes of temperature produce two different kinds of effect on the apparatus; in the first class we may place those which would be compensated by turning the leveling screw Q, fig. 4; in the second, those that would be neutralized by turning either of the other leveling screws. It is evident that changes of the first class alter the sensitiveness of the apparatus or the value of a scale-division, but on account of the comparatively large distance between IK and Q, these effects are small, and may be rendered almost insensible by attention to constancy of temperature; thus far they have not proved a source of annoyance.

The case is different with the second class; the leveling screws I and K being separated only by a distance of 50 mm., it is necessary, on their account mainly, to preserve the temperature of the apparatus as constant as possible. The means of accomplishing this I shall consider in the second part of this article, taking up in the present the method of eliminating errors that are introduced from this source. It is evident that changes of the kind now under consideration will communicate to the pendulum a continuous motion toward the right or left, and will finally drive it to the stops, and that all the readings will be affected with a constant or changing error. If the motion is so slow that the operation of reaching the stops consumes an hour or even less, it is not a source of serious inconvenience, and the errors thus introduced can easily be eliminated.

General mode of experimenting.—In all cases the micrometer screw rests directly or indirectly on the body the change in whose dimensions is the subject of study, and the first proceeding will naturally be to ascertain whether the different portions of the apparatus are at rest relatively to each other, or approximately so. Afterward the value of a scale-division can be obtained by repeatedly moving the arm attached to the micrometer screw, by the aid of the threads which reach to the observer seated at the telescope. When this has been satisfactorily accomplished, the body to be experimented on is subjected to the desired influence, and the change in its dimensions noted; for example, the change in the longitudinal dimensions of a bar of iron when magnetized produces with this instrument a large sudden deviation, and it is also possible to note the gradual increase in its dimensions, owing to the heat developed by the act of demagnetization, and I am at present engaged in studying with it the effect of magnetization on the *lateral* dimensions of iron bars; in short, the instrument as now arranged is applicable to the solution of a great number of delicate problems.

Mode of making and calculating the observations.—The best way of observing, whenever possible, is to make a continuous connected series of readings, so that the second reading is equally related to the first and third, the third equally to the second and fourth, etc. When this proceeding is used it is possible to obtain correct results, even though the pendulum have an independent motion of its own. To take a simple example, let us suppose that the object required is to determine the value of a scale-division, and that by the aid of the micrometer-screw a series of continuous readings have been obtained. We have then to consider four principal cases:

1*st*, *The pendulum had no independent motion of its own.*—In this case it is of course a matter of indifference what method is employed in working up the results; i.e., whether the readings are treated in independent pairs or as a continuous series.

2*nd*, *The pendulum has a uniform motion of its own.*—Call the actual readings A, B, A′, B′, A″, B″, etc.; let x = the true quantity, and let the motion be positive or tend to increase the readings; d = the distance passed over during the interval from one reading to the next following; let d be positive, and B, B′, B″, represent the larger readings. We then have for the readings:

$$
\begin{aligned}
A &= A \\
B &= A+x+d \\
A' &= A \quad\;\; +2d \\
B' &= A+x+3d \\
A'' &= A \quad\;\; +4d
\end{aligned}
$$

Then as the readings are continuous, subtracting the first from the second, the third from the second, the third from the fourth, the fifth from the fourth, etc., we obtain a set of differences alternately too large and too small, thus:

$$\begin{array}{ll} \text{Differences.} & \text{M}'. \\ \left.\begin{array}{l} B-A\ =x+d \\ B-A'=x-d \end{array}\right\} & \cdots\cdots x \\ \left.\begin{array}{l} B'-A'=x+d \\ B'-A''=x-d \end{array}\right\} & \cdots\cdots x \end{array}$$

The average of each pair of differences will give the true quantity, x, free from errors introduced by motion. In the case now under consideration the average of the column M′ will be equal to the average of the column differences, so that the final result will be identical whether we employ the average of one or the other, but by employing the column M′ we have before us the identical observations free from contaminations due to the independent motion of the pendulum, thus enabling the observer more readily to judge of the reliability of the observations, and to calculate their probable error.

2. *The distance passed over independently by the pendulum increases during each observation by a constant quantity.*—Retaining the same notation, etc., as before, we have:

$$\begin{array}{ll} \text{Readings.} & \\ A\ =A & =A \\ B\ =A+x+d & =A+x+d \\ A'=A+d+2d & =A\quad +3d \\ B'=A+x+d+2d+3d & =A+x+6d \\ A''=A+d+2d+3d+4d & =A\quad +10d \\ B''=A+x+d+2d+3d+4d+5d & =A+x+15d \end{array}$$

Taking, then, the differences according to the method above indicated, we have:

$$\begin{array}{llll} \text{Differences.} & \text{M}'. & \text{M}''. & \text{M}. \\ x+d & & & \\ x-2d & x-\frac{d}{2} & x+\frac{d}{2} & x \\ x+3d & & & \\ x-4d & x-\frac{d}{2} & x+\frac{d}{2} & x \\ x+5d & & & \end{array}$$

The column marked M′ is obtained by taking the average of pairs of differences as indicated by the vinculums on their left-hand side; the column M″ by using those on the right; the final column M by combining in pairs the quantities under M′ and M″. It is evident that the final column of means, M, will in this case give the correct value, or x, and that the average of the column of differences will be incorrect by $-\frac{d}{2}$ if an even number of readings be used; and if an odd number be employed, by $+d$, $\frac{2}{3}d$, $\frac{3}{5}d$, $\frac{4}{7}d$, etc.

3. *The distance passed over independently by the pendulum during each observation increases by an increasing quantity.*—This case may perhaps be most quickly illustrated by a numerical example arranged algebraically, the changes introduced being far larger than ever would be met with in practice.

Let the true number, x, equal 30; the first reading equal 25; we then have:

$$\begin{array}{llllll} & & & & & \text{Readings.} \\ 25 & & & & = & 25 \\ 25 + 30 & & & + 1 & = & 56 \\ 25 & & + 1 + & (1 + 2) & = & 29 \\ 25 + 30 + & & 4 + & (3 + 3) & = & 65 \\ 25 & & + 10 + & (6 + 4) & = & 45 \\ 25 + 30 + & & 20 + & (10 + 5) & = & 90 \\ 25 & & + 35 + & (15 + 6) & = & 81 \\ 25 + 30 + & & 56 + & (21 + 7) & = & 139 \end{array}$$

Differences.	M′.	M″.	M.
31			
27	29·	31·5	30·25
36			
20	28·	32·5	30·25
45			
9	27·	33·5	30·25
58			

It is evident in this case, that even the final mean will be affected with a small constant error; still for practical purposes this difference from the correct quantity will be far below the unavoidable errors of observation.

As the method with three columns applies to an increasing rate, it is evident that it will apply equally well to one which diminishes, and it hence follows that if the motion decreases till it is zero, and then begins to increase, being affected with the opposite sign, its effects will still be eliminated by the proceeding above described.

I proceed now to give some examples to show the character of the results that can be expected from the horizontal pendulum under very unfavorable conditions, i. e., when exposed to vibration and changes of temperature. All the observations given below were made in the day-time, the quietest portions being selected when comparatively few locomotives and trains of cars were passing; no extraordinary precautions with regard to temperature were employed, the pendulum not being enclosed except in its glass case. All the observations are in the form of determinations of the value of a scale-division, a proceeding well calculated to illustrate the capabilities of the instrument. The first four constitute a coherent series, the same adjustment of apparatus being used in them all; the others are independent sets made with different adjustments, and intended to illustrate the effects of change of temperature, etc.

Determinations of the value of a scale division.

In No. 1, after using the micrometer-screw, five readings were taken consecutively, the interval between them being only that required for making the record; in Nos. 2 and 3 single readings only were taken, but each reading is to be regarded as a mental average of at least two or three readings; in No. 4 twenty-five consecutive readings were taken on each occasion. The best mode, on the whole, seems to be to take in each case not less than five or more than ten rapid readings, and then again to use the micrometer-screw.

No. 1.

Actual readings.					Average.	Difference.
54·2	53·2	53·			53·4	27·8
81·5	80·9	81·6	80·8		81·2	27·8
53·5	55·	53·4	53·	52·	53·4	29·2
83·	82·3	83·	83·	82·	82·6	29·0
56·3	54·2	54·	51·6	52·	53·6	28·1
82·	81·	83·	81·3	81·5	81·7	29·6
53·2	52·7	51·	53·5	50·2	52·1	29·4
80·3	81·3	82·8	82·	81·2	81·5	28·2

Although in these observations the temperature seems to have been constant, yet for the sake of uniformity I have preferred to treat them according to the method above described.

M′.	M″.	M.
27·8	28·5	28·15
29·1	28·5	28·80
28·8	29·5	29·15
	Final average,	28·7

The probable error is 0·198 of one scale division; which, with the adjustment then employed, corresponds to $\frac{1}{17,300,000}$ of an English inch.

No. 2.

Actual readings.	Diff.	M′.	M″.	M.
21·	29·	28·	28·25	28·12
50·	27·			
23·	29·5	29·5	30·25	29·87
52·5	29·5			
23·	31·	31·75	30·25	31·
54·	32·5			
21·5	28·	26·75	26·	26·37
49·5	25·5			
24·	26·5	27·	27·9	27·45
50·5	27·5			
23·	28·4	27·75	28·5	28·12
51·4	27·1			
24·3	29·9		Final average,	28·48
54·2				

The probable error is 0·461 of a scale division, which corresponds to $\frac{1}{7,460,000}$ of an English inch.

No. 3.

Actual readings.	Diff.	M′.	M″.	M.
68·	26·	29·	30·25	29·62
42·	32·			
74·	28·5	29·25	30·1	29·67
45·5	30·			
75·5	30·2	32·2	32·1	32·15
45·3	34·2			
79·5	30·	29·55	29·70	29·62
49·5	29·1			
78·6	30·3	29·15	26·9	28·02
48·3	28·			
76·3	25·8	28·8	30·9	29·85
50·5	31·8			
82·3	30·	30·1	28·85	29·47
52·3	30·2			
82·5	27·5		Final average,	29·77
55·				

The probable error is 0·31 of a scale division, corresponding to $\frac{1}{11,300,000}$ of an English inch. It is to be remarked that while these last readings were being taken three heavy trains passed.

No. 4.

Av. of 25 read.	Diff.	M′.	M″.	M.
75·04	29·54	29·45	29·27	29·36
45·50	29·37			
74·87	29·17	27·93	29·75	28·84
45·70	26·70			
72·40	32·80		Final average,	29·10
39·60				

The probable error is 0·16 of a scale division, corresponding to $\frac{1}{21,950,000}$ of an English inch.

Combination of results, 1, 2, 3 *and* 4.

It is evident that the weights of these results are quite different; accordingly after taking all things into consideration, I assigned to Nos. 2 and 3 single weights respectively, to No. 1 a double weight, and to No. 4 a three-fold weight. Under these conditions the average of the four sets of observations is 28·99, with a probable error of $\frac{1}{10}$ of a scale division, corresponding to $\frac{1}{36,204,000}$ of an English inch.

In Nos. 1, 2, and in the first four readings of No. 4, there is no decided evidence that the pendulum had any independent motion of its own; in No. 3, its independent motion seems to have been nearly uniform.

I give now a case where the pendulum was affected with a rapid uniform motion: each reading given below is the average of ten rapid readings.

No. 5.

Readings.	Diff.	M′.	M″.	M.
101·5	23·1	33·4	32·3	32·8
78·4	43·7			
122·1	21·0	31·2	31·76	31·48
101·1	41·4			
142·5	22·12		Final average,	32·14
120·38				

The probable error is 0·44 of a scale division, corresponding to $\frac{1}{8,850,000}$ of an English inch.

No. 6.

Here each reading is the average of twenty-five rapid readings: the sign of the motion changed during the observations.

Readings.	Diff.	M′.	M″.	M.
92·5	53·36	48·81	47·82	48·31
39·14	44·26			
83·40	51·38	49·72	46·13	47·92
32·02	48·07			
80·09	44·19	48·14	45·35	46·74
35·90	52·10			
88·	38·60		Final average,	47·65
49·40				

The probable error is 0·31 of a scale division, corresponding to, $\frac{1}{18,500,000}$ of an English inch.

When it is recollected, that with the best optical and mechanical means, it has hitherto been hardly possible to measure quantities smaller than $\frac{1}{200,000}$ of an English inch, the field which the use of the horizontal pendulum, even under very unfavorable circumstances, opens, will be easily appreciated.

ART. XLIX.—*Contributions from the Sheffield Laboratory of Yale College* No. XXXIII.—*On Diabantite, a chlorite occurring in the trap of the Connecticut Valley;* by GEORGE W. HAWES.

IN my recent article upon the trap rocks of the Connecticut Valley,* it was shown, by means of analyses, that these rocks are of two kinds: 1st, the anhydrous dolerite; 2d, the chloritic dolerite, or diabase, which was formed from the same original melted mass as the dolerite by a process of hydration. The diabase is often amygdaloidal, and the cavities are filled with

* See this Journal, III, ix, 185, March, 1875.

various minerals, among which the most common are carbonate of lime, silica and chlorite; the two former substances being naturally produced in the change of the bisilicate, pyroxene, to the unisilicate, chlorite. At one point in the Farmington hills these amygdaloidal cavities are of very large size, often larger than an egg, and in them, with the quartz and calcite, there are large compact masses of chlorite, possessing a foliated and radiated structure and a dark green color. This association of minerals, which has often been recognized elsewhere, seemed to indicate that this was the chlorite which was distributed through the diabase, and an analysis was therefore made to determine to which member of the chlorite group it belonged.

A thin section of one of the masses under the microscope appeared to be perfectly homogeneous, and exhibited a very marked and beautiful dichroism. From a cavity in which the chlorite had thus been shown to be pure, the material was carefully selected for analysis. Its specific gravity was found to be 2·79; its hardness, 1; and its fusibility 3. The composition obtained was as follows:

	I.	II.	Mean.	Oxygen	
Silica	33·23	33·25	33·24	17·73	17·73
Alumina	11·13	11·02	11·07	5·16	5·83
Ferric oxide	2·37	2·15	2·26	·67	
Ferrous oxide	25·09	25·12	25·11	5·58	12·66
Manganous oxide	·40	·42	·41	·09	
Lime	1·07	1·15	1·11	·32	
Magnesia	16·48	16·54	16·51	6·60	
Soda	·25	·25	·25	·07	
Water	9·89	9·93	9·91	8·81	8·81
	99·91	99·83	99·87		

This analysis gives for the oxygen ratio of the protoxides, sesquioxides, silica and water, 4.3 : 2 : 6 : 3, showing that it approaches very closely to a unisilicate in its composition. In order to ascertain whether this composition remains constant, the analysis was repeated upon another sample selected with like care from another cavity; the following were the results:

	I.	II.	Mean.	Oxygen.	
Silica	33·65	33·70	33·68	17·96	17·96
Alumina	10·93	10·75	10·84	5·05	5·90
Ferric oxide	2·95	2·77	2·86	·85	
Ferrous oxide	24·24	24·43	24·33	5·40	12·39
Manganous oxide	·38	·38	·38	·09	
Lime	·72	·73	·73	·21	
Magnesia	16·56	16·48	16·52	6·61	
Soda	·33	·33	·33	·08	
Water	10·04	10·01	10·02	8·89	8·89
	99·80	99·58	99·69		

This analysis does not differ essentially from the preceding, and gives an oxygen ratio still nearer to 4 : 2 : 6 : 3. This ratio may therefore be taken as the correct one, making it a unisilicate of the pyrosclerite group with the formula:

$$(\tfrac{2}{3}\dot{R}^3 + \tfrac{1}{3}\ddot{\ddot{A}}l)'\ddot{S}i^3 + 3\dot{H}.$$

Although agreeing with pyrosclerite in oxygen ratio, the much greater proportion of iron appears to authorize its recognition as a distinct species.

Dr. K. L. Th. Liebe, in his article on the diabase of the Voigtland and Frankenwald,* gives analyses of a chlorite of like occurrence which he carefully selected from specimens collected at several different points, and which he named *Diabantachronnyn.* Although his analyses differ somewhat from those here given, it is evident that the material he worked upon was very similar to the above, and like it in mode of occurrence and probably the same species. But since his long name, "diabantachronnyn," which was intended, as he says, to express the idea that the mineral is the coloring ingredient of the diabase, does not convey that meaning, the Greek of the latter part of the word not signifying *color*, and since the name is not in accordance with the principles of mineralogical nomenclature, I have taken the liberty of shortening it to *diabantite*, which though not expressing all that Liebe intended to convey, still indicates its relation to diabase.

Chlorites approaching this species in composition have been often analyzed with varying results and have received various names; but the great ease with which decomposition takes place upon such material under surface action makes it easy to derive from it a great number of intermediate products. The seams and cracks of both the diabase and dolerite of this region are often filled with a soft ferruginous chlorite, but which contains varying amounts of sesquioxide of iron, and is not homogeneous. A chlorite of the kind analyzed could hardly be expected to withstand the influence of percolating waters.†

The amygdaloidal cavities afford additional evidence to that already given, proving that the hydration of these rocks was produced by vapors that gained access to the molten mass during its ascent to the surface. For these cavities often contain bitumen, which in all probability was derived from the bituminous shales of the region, and was carried up along with the other products received from the strata and the subterranean streams encountered, and deposited in the cavities. This bitumen is widely distributed in the amygdaloidal trap, as was

* Jahrbuch für Mineralogie, 1870, p. 1.

† Kenngott has endeavored to prove that Liebe's mineral was common ripidolite; but these analyses show that it has a very different oxygen ratio.

long ago observed by Percival. The composition of the pyroxene* makes it easy to see how the change to chlorite took place under the action of these vapors. The thirteen per cent of lime was separated as carbonate, and the excess of silica was removed, while the small amount of alumina required, and which was not furnished by the pyroxene, was derived through the slight decomposition of the feldspar, which under the microscope appears to have lost its transparency.

ART. L.—*The Re-discovery of the Double Star*, H I. 41; by S. W. BURNHAM.

THE double star entered as No. 41 of Sir William Herschel's Class I. was apparently not found by Struve, as it is not included in his great catalogue, *Mensuræ Micrometricæ;* nor in any of the modern lists of double stars. I have not been able to find in the various works consulted any reference to it by any observer since Herschel's discovery nearly one hundred years ago. Sir John Herschel, in the catalogue of his father's double stars (*Memoirs of the R. A. S.*, xxxv), gives the approximate place for 1880 as follows:

$$\left.\begin{array}{l} \text{R. A.} = 17^h\ 40{\cdot}7^m \\ \text{Decl.} = +\ 73°\ 0{\cdot}6' \end{array}\right\}$$

Nothing is said by Sir William Herschel of the magnitudes of the stars, or of the distance, further than that the pair belongs to his Class I. He made two measures of the position angle:

Aug. 29th, 1782, P = 350·0°
Mch. 7th, 1783, 354·3

A few weeks since this pair was searched for and readily found with a 6-inch refractor very near the place given above. It was identified as Lalande 32725, and its place from that catalogue, reduced to 1880, is:

$$\left.\begin{array}{l} \text{R. A.} = 17^h\ 42^m\ 16{\cdot}9^s \\ \text{Decl.} = +\ 72°\ 59'\ 10'' \end{array}\right\}$$

I made three sets of measures of the angle, a mean of the result giving, P=340·2°. The components are of the 8th and 9th magnitudes, and separated about 1·2″, so that now it is not a difficult object even with a small aperture. A considerable diminution in the angle would seem to be beyond doubt, but further observations are necessary to determine positively whether or not this fine pair is a binary. It is about 46′ north of the well known double star, Ψ' Draconis, and easily found without an equatorial mounting.

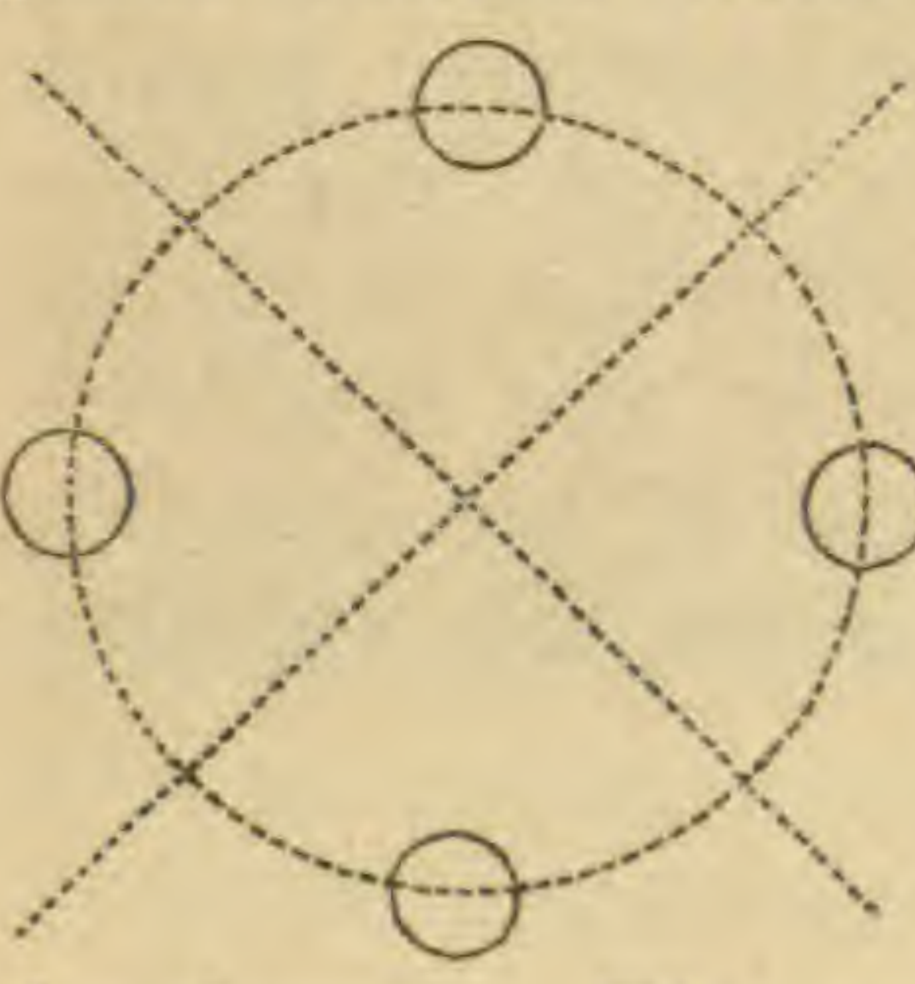
Chicago, May, 1875.

* This volume, March, p. 187.

ART. LI.—*Brief Contributions from the Physical Laboratory of Harvard College.* No. 17.—*On the Distribution of Electrical Discharges from Circular Disks;* by C. J. BELL.

THE peculiar figures produced by the electrification of solid dielectrics have been studied by Lichtenberg; by W. V. Bezold (*Untersuchungen über elektrische Staubfiguren*, Pogg. Ann., cxl, 145, 1870); by Prof. Kundt, Pogg. Ann., cxxxvi, 612; by Theodore Karrass, Pogg. Ann., cxl, 160, 1870; and by H. Schneebeli, Archives des Sciences Phys. et Naturelles, xlvi, 269.

If a small circular disk is connected with the inner coating of a charged Leyden jar, and is suspended vertically over a glass plate coated with lycopodium, which rests upon a metallic plate connected with the outside coating of the jar, a number of points of disturbance will be seen on the glass beneath the rim of the circular disk, as in the accompanying figure.



The following investigation was undertaken to discover the law which regulates the number of points of greatest electrical disturbance shown by the small circles in the figure. The apparatus used was arranged as follows: the telescope of a cathetometer was removed, and an insulated arm substituted for it. To this arm was clamped in a vertical position a copper wire, at the lower end of which were attached the various circular disks used in the experiments. These disks were connected with one pole of a Ruhmkorf coil. Upon an insulated tripod below the disk was placed a plate of metal, from the bottom of which ran a wire to the other pole of the Ruhmkorf coil. The dielectrics, consisting of glass plates, 17 cm. square and 1 cm. thick, rested upon the plate of metal.

Six circular disks of different diameters were used, which were placed above the glass plate, at a constant distance from it. Six experiments were made with each plate. The results are contained in the following table:

Diameter of plates.	1	2	3	4	5	6	Calculated number.
41 mm.	14	14	13	14	14	14	----
34	12	12	11	10	12	12	11·6
29	10	9	10	10	9	10	10·
20·5	7	8	7	7	8	7	7·
15·5	6	5	5	6	6	5	5·
11·25	4	5	4	5	3	4	4·

The number of discharges was closely proportional to the diameter of the circular disks, or to their circumferences. The last column of the above table was calculated on this assumption. The area of the space on the glass affected was proportional to the area of the upper plate. Although the shape of the spots on the glass was not the same in all the experiments, yet the angle between them, subtended by their arc, was constant for the same plate. Much care and patience was necessary to produce the figures. The battery which was found to give the best results consisted of one Grove cell, the platinum of which was 14 cm. by 5 cm., and the zinc 30 by 7, with an internal resistance of ·25 of an ohm. The coil would give with this battery a spark of about 4 cm.

In order to obtain perfect figures the glass plate must be very clean, and perfectly dry. The best results were obtained when the plates were heated slightly. The lycopodium dust was sifted on the plate after the discharge, produced by lifting the breaker of the coil. If it is spread over the glass before the discharge, the figures lose their sharp outline. The glass plate must be 4 or 5 cm. larger than the lower plate of metal, otherwise a spark will pass around the edge from the terminals of the coil. The distance of the upper circular disks from the glass does not appear to have any effect upon the number of figures, but if they are placed at too great distance the figures are indistinct. The circular disks must be exactly parallel to the plate of glass.

ART. LII.—*Preliminary Note on an Examination of Gases from the Meteorite of February* 12, 1875; by ARTHUR W. WRIGHT.

BY the courtesy of President Thacher, of the State University of Iowa, the writer has received some fragments of this meteorite, an examination of which has yielded some very interesting results. The meteorite is of the stony kind, containing numerous small grains of metallic iron, and not greatly differing in appearance from others of its class.

A quantity of the iron, having been separated, was found to contain several times its volume of gaseous substances, much of which it yielded on a very moderate elevation of temperature. The spectroscope plainly indicated the predominance of carbon compounds, and an analysis showed that very nearly one half the gas was made up of the two oxides of that element, the approximate percentages being; CO_2, 35; CO, 14; the two together, 49 per cent. The residue consisted largely of hydrogen, but the exact proportion was not determined. These relations show a marked difference between the iron and the stony meteorites as to their gaseous contents, as in the former the hydrogen is most abundant, while in the latter the oxides of carbon are the characteristic constituents.

The spectrum of the gases, at a few millimeters pressure, gave the carbon bands very brilliantly, the hydrogen lines being comparatively weak and inconspicuous, though at a very low pressure they became relatively stronger. The brightest carbon bands were the three in the green and blue, the red one being much feebler. Now these are precisely the ones most conspicuous in the spectra of some of the comets, and this fact is a remarkable confirmation of the received theory as to the meteoric character of these bodies. A more extended and particular account of the investigation will be given in the next number of this Journal.

Yale College, May 22, 1875.

ART. LIII.—*On Limonite with the Color and Translucency of Göthite;* by Prof. J. W. MALLET, Univ. of Virginia.

THE specimen which is the subject of this notice was received with other minerals from Capt. F. M. Imboden, of Richmond, Va., having come from the land of Dr. F. H. Griffin, near Big Lick, Roanoke Co., Va.

Passing through ordinary compact limonite there were veins of a quarter to half an inch in thickness, distinctly translucent on the edges of splinters, and having a deep blood-red color by transmitted light—by reflected light nearly black, with a luster between adamantine and resinous. Streak yellowish brown. Massive, with no traces of crystalline or fibrous structure. Hardness a little over 5. Sp. gr.=3·76 at 15° C.

Analysis gave

Fe_2O_3	81·52
Mn_2O_3	·11
Al_2O_3	·26
P_2O_5	2·38
SiO_2	·51
H_2O	14·95 =99·73

The water was lost at the following rate with increasing temperature:

At 100° C. (for three hours),	1·70 p. c.
" 150° " "	·90 "
" 200° " "	3·60 "
" 250° " "	5·01 "
" Red heat	3·74 = 14·95 p. c.

If 2·68 p. c. of Fe_2O_3 be deducted as combined with the 2·38 of P_2O_5 to form ferric ortho-phosphate ($FePO_4$), and the water lost at 100° (supposed hygroscopic) and the other minor constituents be neglected, we have left:

			Calc. for $Fe_4H_6O_9$ (limonite).
Fe_2O_3	78·84	85·61	85·56
H_2O	13·25	14·39	14·44
		100·	100·

The assumption of the P_2O_5 existing as a *hydrated* phosphate, with even as much water as in cacoxene or the basic salts described by Rammelsberg, will not suffice to bring the remaining ferric hydrate into accordance with the formula of göthite.

The mineral is obviously limonite in chemical composition, while the blood-red color has not, so far as I am aware, before been noticed in connection with this species, but has been looked upon as characteristic of göthite. How far the large amount of phosphorus present may have any relation to the peculiar appearance of the mineral may be questioned.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Composition of the so-called Hydrate of Chlorine.*—In many of the most recent text-books on Chemistry it is stated that the composition of the hydrate of chlorine, ordinarily given as $Cl_2+(H_2O)_{10}$, may also be written as $HOCl+HCl+(H_2O)_9$. The ground for this assumption is not entirely satisfactory; it seems to have arisen from a statement of Hiller, that the hydrate is formed when hydrochloric acid gas is passed into a solution of hypochlorous acid cooled to 0°. But since HCl and HOCl react upon each other to produce chlorine and water, the arrest of this action at 0° cannot be accepted as a fact in the absence of direct evidence. Göpner has undertaken to decide between these formulas. Since, were the formula $Cl_2+(H_2O)_{10}$ correct, the sole product when the solution is agitated with mercury would be mercurous chloride; and were the formula $HOCl+HCl+(H_2O)_9$ the right one, that product must be mercuryl chloride, and finally, in presence of hydrochloric acid, mercuric oxide, the matter may readily be tested. Experiment proves the latter view to be in fact the true one; though by the subsequent action of the metallic mercury, some mercurous chloride was formed. In a lecture the above experiment may be useful in order to show that the reaction with water is the same as with potassium oxide or hydrate:

$$Cl_2+HOH=HCl+HOCl.$$
$$Cl_2+KOK=KCl+KOCl.$$

To this view Hugo Schiff, in a subsequent paper, decidedly objects, deeming the proof entirely insufficient. He gives quite a number of facts to prove the contrary.—*Ber. Berl. Chem. Ges.*, viii, 287, 419, March, April, 1875. G. F. B.

2. *On the Constitution of Ammonium Compounds.*—The question of fixed or variable equivalence is yet a vexed one in Chemistry. V. MEYER and LECCO have made an investigation to ascertain whether nitrogen has in the ammonium compounds an equivalence of three or five. On the former hypothesis the constitution of ammonium chloride would be $N \equiv \vdots \equiv H_3 + H - \cdot - Cl$; on the latter it would be $H_4 \equiv \vdots \equiv N - \cdot - Cl$. The method by which the authors purposed to test the question was to submit to minute comparison the two di-methyl di-ethyl derivatives of ammonium, which may be thus formulated: $N \begin{cases} CH_3 \\ CH_3 \\ C_2H_5 \end{cases} + C_2H_5Cl$, and $N \begin{cases} C_2H_5 \\ C_2H_5 \\ CH_3 \end{cases} + CH_3Cl$. If nitrogen be a pentad, these two bodies must be identical; if a triad, they are only isomeric. The two chlorides were prepared with care, the one from dimethylamine, the other from diethylamine. They were then examined: 1st, as to their physical properties and those of their derivatives; 2d, their characteristic reactions in the wet way; 3d, their distillation products; 4th, the solubility of their platinum salts; 5th, the crystallographic identity of these platinum salts; and 6th, the fusibility of their picrates. In all these particulars they were found to be identical. The hypothesis that ammonium chloride is a molecular compound would seem, therefore, to be negatived, and the quinquivalence of nitrogen in all the ammonium derivatives established.—*Ber. Berl. Chem. Ges.*, viii, 233, March, 1875. G. F. B.

3. *On Methyl aldehyde and Methyl formate.*—Methyl aldehyde was prepared by Hofmann, the discoverer, by passing a mixture of air and the vapor of wood spirit over a red hot platinum coil. VOLHARD proposes a simple modification of this plan, as a lecture experiment, by which, in the course of an hour, sufficient of the aldehyde can be obtained to show its reducing power. A Davy's aphlogistic lamp—which consists of an ordinary spirit lamp upon and above the wick of which is placed a small platinum wire coil—is filled with methyl alcohol, lighted, and after a minute the flame blown out; the slow combustion which then takes place produces methyl aldehyde. It is only necessary to place over the wick an adapter connected at its smaller end with a Liebig's condenser, a receiver, one or two wash bottles, and an aspirator. The current of air is regulated so that the coil does not appear red in daylight, while yet it is sufficiently hot to prevent condensation in the adapter. If the aspiration be continuous, it is only necessary to keep the lamp filled in order to have the process continuous. The author collected in his experiments 90 to 100 grams of liquid in the receiver in twenty-four hours. By the warmth of the hand it reduced in a few minutes a solution of ammonio-silver nitrate and

gave a brilliant mirror. Saturated with hydrogen sulphide, it became a magma of crystals of methyl sulph-aldehyde. Estimated by its reducing power, however, the liquid contained but a little more than ·5 of one per cent. of aldehyde. The author subsequently prepared methyl formate, by distilling methyl alcohol recently saturated with hydrochloric gas, from calcium formate, in order to ascertain whether it would yield methyl aldehyde by the action of heat; a reaction analogous to that by which its chlorine derivative, methyl perchloroformate, yields carbonyl chloride. But the results were negative, the ether yielding methyl alcohol, carbonic oxide, carbonic acid, and marsh gas, the two latter in small proportion.—*Liebig's Annalen*, clxxvi, 128, Feb., 1875. G. F. B.

4. *Composition of Gum Tragacanth.*—GIRAUD has made a minute examination of the chemical characters of gum tragacanth. He finds (1) that this gum is but very slightly soluble in water, and that the product in the filtrate is not a definite principle, like arabin, but is a mixture of several substances; (2) that, digested on the water bath for twenty-four hours, with fifty times its weight of water, much of it is transformed into a soluble gum, which no longer swells after drying; this new substance is pectin; (3) that under the action of water containing one per cent of acid, the production of pectin takes place in two or three hours. It becomes entirely soluble, and alcohol precipitates pectin, not arabin, from the solution. Alkalies change it into pectates and metapectates. Hence gum tragacanth consists for the most part of a pectic principle insoluble in water, apparently identical with Fremy's pectose. From it, by precipitating the pectin solution by barium hydrate, and decomposing by an acid, pure pectin acid was obtained. Upon analysis, gum tragacanth yields as follows: water, twenty per cent; pectic compounds, sixty per cent; soluble gum, eight to ten per cent; cellulose, three per cent; starch, two to three per cent; mineral matter, three per cent; nitrogenous matters, traces.—*Moniteur Scientifique*, III, v, 361, April, 1875. G. F. B.

5. *On the Occurrence of Cane Sugar in Malted Grain.*—The question of the occurrence of dextrin and sugar in the cereals, whether malted or unmalted, is yet an open one. KUHNEMANN has sought to throw some light upon it by carefully examining malted barley for both these substances. Five kilograms of finely bruised malted barley was extracted cold with eight kilograms ninety-five per cent alcohol, the expressed liquid mixed with twice its weight of ether, and agitated with a little more than one-fourth its weight of water. The lower aqueous layer, treated with a little barium hydrate, was evaporated, filtered, and polarized. It rotated to the right, but contained two sugars, one reducing the copper test, the other not. Upon evaporation to dryness and extraction with alcohol, the two sugars were separated by fractional crystallization. In this way 0·6 of one per cent of crystallized sugar was obtained from the malt. When pure, this sugar is white, is sweet to the taste, crystallizes in well-

defined forms, and does not reduce the copper test. In its optical behavior, therefore, as well as in its physical and chemical properties, it appears to be identical with cane sugar. The malt-residue, extracted with water, yielded a solution from which alcohol precipitated a substance in white flocks, which is similar to, but is chemically not identical with, dextrin.—*Ber. Berl. Chem. Ges.*, viii, 202, March, 1875. G. F. B.

6. *Carbonyles, a new Class of Organic Bodies.*—M. BERTHELOT has recently instituted a new class of organic bodies, to which he has given the name of *carbonyles*, and to which he assigns three bodies hitherto rather ambiguous in chemical behavior. These are: allylene oxide (dimethylene carbonyle), $CO\left\{\begin{matrix}CH_2\\CH_2\end{matrix}\right)$ diphenylene-acetone (diphenylene carbonyle, $CO\left\{\begin{matrix}C_6H_4\\C_6H_4\end{matrix}\right)$ and ordinary camphor (terebutylene carbonyle, $CO\left\{\begin{matrix}C_5H_8\\C_4H_8\end{matrix}\right)$. Suberone, $C_7H_{12}O$, perhaps, belongs here also. The distinguishing feature of carbonyles is their double function. In the first place, they act like aldehydes, being able to fix hydrogen directly and to produce alcohols; while, like aldehydes, they are re-produced by the dehydrogenization of these alcohols. Again, like aldehydes, they may be formed by the direct or indirect oxidation of hydrocarbons; just as ethylene hydride and oxygen, $C_2H_4(H_2)+O$, produces ethyl aldehyde, $C_2H_4(O)$, so camphene hydride and oxygen, $C_{10}H_{16}(H_2)+O$, produces camphor, $C_{10}H_{16}(O)$, by indirect oxidation; and as ethylene by direct oxidation yields ethyl aldehyde, $C_2H_4+O=C_2H_4(O)$, so camphene, $C_{10}H_{16}+O$, gives camphor, $C_{10}H_{16}(O)$. But, secondly, it is to be observed that while aldehydes are produced by the indirect oxidation of saturated hydrocarbons, carbonyles result from the indirect oxidation of unsaturated hydrocarbons. This is a very material difference, since, beside its aldehydic function, the carbonyle molecule is unsaturated, and can unite directly with other unsaturated molecules. Hence, like carbonyl itself, from which these bodies take their name, they can fix directly the elements of water and form monobasic acids; as $CO+HOH=CHOH$, formic acid, so $CO\left\{\begin{matrix}CH_2\\CH_2\end{matrix}\right.+HOH=C_3H_6O_2$, propionic acid. So also, by reason of this unsaturation, they can unite directly with three atoms of oxygen to form dibasic acids; camphor, $C_{10}H_{16}O$, for example, forming with O_3,$C_{10}H_{16}O_4$, camphoric acid. So, conversely, the removal of water and carbon dioxide from a single molecule of a dibasic acid, yields a carbonyle, differing from the analogous production of acetones by the fact that the removal in the latter case is from two molecules of a monobasic acid. Regarding all hydrocarbons as derivatives of marsh gas, or formene, the formation of the three classes of aldehydes from them by indirect oxidation may be represented as follows:

Hydrocarbons.		Aldehydes.
CH_4	yield	CH_2O
$CH_2.CH_4$		$CH_2.CH_2O$
$C_2H_4CH_4$		$C_2H_4.CH_2O$
$C_6H_4CH_4$		$C_6H_4.CH_2O$

Hydrocarbons.		Secondary aldehydes or acetones.
$CH_2.CH_2.CH_4$	yield	$CH_2.CO.CH_4$
$C_6H_4.CH_2.C_6H_4$		$C_6H_4.CO.C_6H_4$
$C_6H_4.CH_2.C_6H_6$		$C_6H_4.CO.C_6H_6$

Hydrocarbons.		Carbonyles.
$CH_2[-]$	yield	$CO[-]$
$C_2H_4 . CH_2[-]$		$C_2H_4 . CO[-]$
$C_6H_6 . CH_2[-]$		$C_6H_6 . CO[-]$
$C_9H_{16}.CH_2[-]$		$C_9H_{16}.CO[-]$
$C_{12}H_8.CH_2[-]$		$C_{12}H_8.CO[-]$

The author gives in conclusion the evidence that camphor itself belongs to this class of bodies, and says that had he not hesitated to found a new class of bodies on a single compound, he would long ago have proposed to consider camphor as a carbonyle.—*Bull. Soc. Ch.*, II, xxiii, 146, Feb., 1875. G. F. B.

7. *Formation of Hydroxylamine by the reduction of Dinitro-compounds.*—Whenever a nitro-organic derivative, in which but a single nitro-group is united to any one carbon atom, is reduced with tin and hydrochloric acid, the nitro-group, as is well known, becomes an amido group. V. Meyer and Locher have experimented to ascertain what would be the result on reduction if two such groups were so united. For this purpose they selected the dinitropropane $CH_3{-}{-}C(NO_2)_2{-}{-}CH_3$ recently discovered by them, and introduced it into dilute hydrochloric acid containing metallic tin. In a short time the nitro-body had disappeared, and the solution, after removal of the tin by hydrogen sulphide, afforded on evaporation pure hydroxylamine hydrochloride. The organic reduction-product was acetone, so that the reaction is as follows: $CH_3{-}{-}C(NO_2)_2{-}{-}CH_3+H_8=CH_3{-}{-}CO{-}{-}CH_3+(NH_3O)_2+H_2O$. Ethyl-nitrolic acid reacts similarly, yielding nearly the theoretic quantity. Nitroform, however, combines both reactions, yielding beside hydroxylamine, hydrogen cyanide, and ammonia.—*Ber. Berl. Chem. Ges.*, viii, 215, March, 1875.

G. F. B.

8. *Viscosity of Gases.*—Capt. A. von Obermayer has compared the previous determinations of this quantity, and states that of the two hypotheses from which the dynamical theory of gases start, the older gives the co-efficient of friction of gases proportional to the square root, the newer (Maxwell's) gives it proportional to the first power of the absolute temperature. From the retardation of vibrating disks by the friction of the air, Maxwell found experimentally the power 1, O. E. Mayer the power $\frac{3}{4}$; by experiments on capillary tubes O. E. Mayer found the power $\frac{3}{4}$, J. Puluj the power $\frac{2}{3}$ of the absolute temperature.

For the more certain determination of this ratio, experiments on currents through four capillaries of glass and one of brass were undertaken; and together with the temperature of the room those of boiling water, congealing paraffin, and a mixture of salt and snow were employed. A first series of experiments, less accurate, were carried out, with the difference of pressure variable; a second, considerably more exact, with the difference constant. The results of the two series agree very well, and confirm those of Mayer's experiments in a perfectly satisfactory manner. For the co-efficient of friction μ at the temperature t there were found:

According to the first series, $\mu = \cdot 0001706\ (1 + \cdot 002735\, t)$.
According to the second series, $\mu = \cdot 00016477\ (1 + \cdot 002723\, t)$.
—*Roy. Acad. of Vienna*, Feb. 4th, 1875; *Phil. Mag.*, xlix, 332.

E. C. P.

9. *Specific Heat of Carbon, Boron and Silicon.*—Dr. H. F. Weber presented a paper on this subject at the fifty-sixth anniversary of the Royal Würtemberg Land and Forest Management Academy at Hohenheim. The law of Dulong and Petit, that the product of the specific heat by the atomic weight is constant, holds true for most of the solid elements. Carbon, boron and silicon, however, seem to deviate considerably from this law, and give different results in their various allotropic conditions. A comparison of the results of different observers shows that while they differ very greatly from one another, the larger the interval of temperature employed the greater the result.

Dr. Weber has accordingly made a series of measurements at temperatures from $-80°$ to 1,000°. The amount of heat was determined by Bunsen's ice calorimeter, and the temperature when below 300° by a thermometer; for higher temperatures the heat given out by a platinum bar in cooling served to determine the temperature by calculation.

The first experiments were on the specific heat of the diamond. The collections of the Universities of Berlin and Vienna were placed at his disposal. It was found that the specific heat increased with the temperature from ·07 at $-50°$ C., to ·23 at 100°, and ·46 at a red heat. A similar increase is found in the case of graphite, and leads to the following conclusions:—That from a red heat upward, the specific heat of carbon does not vary more than the specific heats of those elements which fulfil the law of Dulong and Petit, and at these high temperatures there seems to be no real difference in the specific heat of the graphitic and that of the diamond modification of carbon. All anomalies, therefore, disappear above 600° C., and carbon then obeys the above law. A comparison of the specific heats of graphite, of dense amorphous carbon and of porous carbon showed that they were identical within the temperature interval 0° to 225°. A unit weight of porous carbon, as far as possible free from water, evolves 4·16 heat-units when wetted with water.

In the case of boron two hundred small crystals were used, having a total weight of ·67 grams. The observations were extended from $-40°$ to $+230°$ and showed a similar increase to that of carbon. It is, therefore, very probable that at higher temperatures the specific heat attains a constant value of about ·50, and consequently the number 11, which is generally accepted as the atomic weight of boron, is really the atomic weight; further that the atomic heat of boron is about 5·5, and that therefore at a red heat boron obeys the law of Dulong and Petit.

Small brilliant steel gray crystals of silicon, weighing 1·123 grams, were next employed. From these it was shown that silicon does not form an extraordinary exception to the law of Dulong and Petit; so soon as the temperature passes 200° it comes within the sphere of this law. The smallest relative weight of silicon (28) hitherto found in the molecule of any of the gaseous compounds of this element is in reality the atomic weight of silicon.—*Phil. Mag.*, xlix, 161, 276. E. C. P.

10. *Action of Electric Currents on Alloys.*—M. E. OBACH, at the suggestion of M. Wiedemann, has tested the conclusions of Gerardin on the electrolytic decomposition of alloys. A series of experiments were made from which he concludes that the passage of the galvanic current produces no electrolytic effect either in amalgams or in alloys. After being traversed by a current, the sodium amalgam decomposes water at both poles exactly as before. The action of the current modifies neither the hardness nor the malleability of the lead and tin alloys, nor the fluidity of the potassium sodium alloys. It introduces in the neighborhood of the electrodes no change exceeding the limits of possible error in the analyses.—*Bibl. Univ.*, ccvii, 229. E. C. P.

11. *New Property of Aluminum.*—M. E. DUCRETET observes that on inserting in a galvanic circuit a voltameter with two electrodes, one of aluminum, the other of platinum, different effects are obtained according to the direction of the current. When the aluminum receives the negative electricity the water is decomposed and the current traverses the circuit freely. But on reversing the current the decomposition ceases and scarcely any electricity is transmitted. An electric bell inserted in the circuit in the first case rang violently, and in the second case did not move. Replacing the bell by an iron wire, in the first case it was melted, and not even heated in the second. A galvanometer gave in one case a deflection of 22° and in the other of only 2°.

The effect is produced instantly; it is constant and durable whatever the number of inversions of the current. If other metals are used instead of platinum, they are deposited on the aluminum and interfere with the experiment This stoppage of the current is not produced by a plate of gold, silver, platinum, copper, zinc, magnesium, tin, lead, etc., replacing the aluminum. A partial effect is produced with iron, but the surface is soon altered, with the disengagement of a bad odor. As to the aluminum, its surface appears to be preserved by a slight layer of alumina which is formed immediately, and remains, in spite of the inversion of the current.

Many practical applications of this property suggest themselves. Two messages may be sent over a telegraph line at the same time in opposite directions by using two voltameters with the aluminum on opposite sides. All trouble from variable resistance is thus avoided.—*Journ. de Phys.*, iv, 84. E. C. P.

II. Geology and Natural History.

1. *The Surface Geology of Ohio;* by J. S. Newberry. 80 pp. 8vo. (From the Report of the Geological Survey of Ohio, vol. ii. Columbus, 1874.)—Dr. Newberry here presents in detail the many facts which he has observed connected with the Quaternary of Ohio and the adjoining States, and the conclusions to which his various observations have led him. The successive events of the Quaternary, which he gives in the opening part of the chapter, are briefly as follows:

(1.) The period of cold and the great glacier over New England and the region west, north of the Ohio, during which the land stood above its present level.

(2.) A period of lower level, milder climate, retreating glaciers, great freshwater lakes; and also of the deposit of the bowlder clay, which is usually thinly laminated in Ohio and contains no bowlders; also of extended forests over much of the region left bare by the retreat of the glacier from Ohio, Indiana and Illinois, and of the formation of peat beds, in which occur the remains of the Mastodon, Elephant, Castoroides, etc.

(3.) A further subsidence, making the Mississippi an arm of the sea, and putting that part of the continent including Southern Ohio under salt water; the time when deposits of sand and gravel were spread over the peat beds of Southern Ohio, lacustrine clays laid down in Northern Ohio, and the lœss along the Mississippi Valley; when icebergs floated southward across the great lake region from the Canadian highlands, carrying bowlders, gravel and earth; when portions of the highlands of Ohio were low islands and shallows, and sand and gravel were accumulated and assorted about them by the waves; when certain drainage lines were determined, as those along the valleys of the Wabash, Scioto, Muskingum and the Beaver.

(4.) A very gradual "retirement of the sea," with "intervals of rest and recession;" and, as a consequence, the formation of terraces along river valleys, "by the arrest of their flow and the deposition of the materials they transported in the dead water which partially filled these valleys;" the gradual draining of the lake-region, leaving old shore lines around the lakes with terraces or lake ridges in some parts of their circuit.

The eras of elevation, subsidence, and subsequent elevation, indicated in § 1, 2 and 3, and 4, are those which the writer has defined as the Glacial, Champlain or Fluvial, and Recent or Terrace periods.

No marine relics of the era of submergence (§ 3) are stated to occur over the region that is supposed to have been then under the sea, or in the deposits then made; that is, in the lœss along the Mississippi River, or the beds of Southern Ohio. In fact, the fossils found are those of the land or of fresh water, and have led others to regard the deposits as simply of river origin. Indeed, this seems to be the opinion which Dr. Newberry presents in his chapter on the lœss, pages 36–38.

Dr. Newberry follows the announcement of his conclusions by an account of his observations on the Drift deposits of Ohio, the old deserted and buried river channels of the State and elsewhere, the heights and positions of the lake ridges, and on other topics of interest. The more prominent lake ridges south of Lake Erie, as shown on a map, are: the "North ridge," nearest the lake, 99 to 105 feet in height above the lake; the "Center ridge," 148 to 162 feet; and the "South ridge," 200 to 205 feet. Others also are named: the "Coe ridge," which may be identical with the last, 180 to 200 feet; the "Sugar ridge," 165 to 167 feet; the "Chestnut ridge," 189 to 191 feet. How far the different levels of these lake-ridges are due to differences, existing before the elevation, in the level of the high-water flats along the lake-borders, and to the existence of other mud or sand flats under water at different levels, it is hardly possible to determine. In bays and lakes having shallow shore regions, such flats, various in level, are common; and after an elevation, they would exist as terrace plains and be of different heights because retaining their former differences of level.

In the remarks on the origin of the cold of the Glacial period, Dr. Newberry gives his objections to the theory of Lyell, and states, in the course of his remarks, that this theory is that advocated by Prof. Dana. He has not appreciated the paragraphs in the last edition of Prof. Dana's Geology (pp. 541 and 755), in which the cold climate is attributed, not simply to an elevation of high-latitude regions, but to the effect which such an elevation would have on the oceanic currents, and thereby on the distribution by these currents of heat and cold, as noticed in this volume on page 314.

Dr. Newberry has labored long and zealously among the Quaternary deposits of Ohio and the adjoining States, and his chapter on the subject is one that may be studied with great profit. J. D. D.

2. *Prototaxites of Dr. Dawson, a genus related to the Taxineæ.*—Dr. Dawson's view that the *Prototaxites Logani* of the Devonian of Gaspé, cannot be regarded as a sea-weed, a surged by Carruthers, appears to be sufficiently sustained—independently of the argument from the structure—by the following facts which Dawson has published respecting the condition and general character of the fossil.* He says (in a paper in the "Monthly Microscopical Journal" for August, 1873) that "the mode of occurrence is sufficient" to convince any practical palæontologist that the plant cannot be a sea-weed. Its large dimensions, one specimen found at Gaspé Bay being three feet in diameter; its sending forth strong lateral branches, and gnarled roots; its occurrence with land plants in beds where there are no marine organisms, and which must have been deposited in water too shallow to render

*For a figure, see Dana's Manual of Geology, 1874, page 258.

possible the existence of the large oceanic Algæ to which Mr. Carruthers likens the plant—these are all conditions requiring us to suppose that the plant grew on the land. Further, the trunks are preserved in sandstone, retaining their rotundity of form even when prostrate; and are thoroughly penetrated with silica except the thin coaly bark. Not only are Algæ incapable of occurring in this way, but even the less dense and durable plants, as Sigillariæ and Lepidodendra are never found thus preserved. Only the extremely durable trunks of coniferous trees are capable of preservation under such circumstances. In the very beds in which these occur, *Lepidodendra*, tree ferns and *Psilophyton*, are flattened into mere coaly films. This absolutely proves to any one having experience in the mode of occurrence of fossil plants, that here we have to deal with a strong and durable woody plant."

The paper discusses also the microscopic structure of the fossil, and its probable affinities.

3. *Fossil Vertebrates of Cretaceous and Tertiary affinities in the same beds on the Saskatchewan.*—Prof. Cope has examined fossils collected by G. M. Dawson in beds of the "Fort Union Group," from a horizon 100 to 200 feet above the beds of Cretaceous No. 5. They include among Dinosaurs, *Cionidon stenopsis* Cope (about the size of *C. arctatus* Cope) and a species related to *Hadrosaurus*. But with these species of Cretaceous affinity there are two tortoises of the genus *Plastomenus* Cope (*P. coalescens* and *P. costatus* Cope), a genus of the Eocene, and scales of gars, closely resembling those of the genus *Clastes* of the Lower Eocene of the Rocky Mountains. "The list of species," says Cope, "short as it is, indicates the future discovery of a complete transition from Cretaceous to Eocene life more clearly than any yet obtained in the West" (or Rocky Mountain region).—*Proc. Acad. Nat. Sci. Philad.*, 1875, 9.

4. *Systematic Catalogue of Vertebrata of the Eocene of New Mexico, collected in* 1874. E. D. Cope, A.M., Paleontologist. 38 pp. 8vo. Washington, 1875. Geographical explorations and surveys under Lieut. Wheeler, of the Engineer Department, U. S. A. —Contains descriptions of some new genera and many species of Mammals, with some species of Reptiles, and embraces many details of importance.

5. *Daubrée on the Platiniferous rocks of the Urals.*—At a session of the French Academy of Sciences in March, Daubrée described the rocks of the Ural affording platinum. They have a base of chrysolite. The masses come from the conglomerates near Nischne Tagilsk, where platinum is obtained. Besides chrysolite, serpentine and chromic iron are intimately associated with the platinum. The facts seem to prove that the original platinum-bearing rock was a chrysolite rock more or less transformed into serpentine, and was accompanied with diallage, which is common in the specimens. The presence of chromic iron is also to be noted; for it appears to bear evidence as to the changes through which the gangue rock of the platinum had passed.

6. *The Geological Story briefly told, an Introduction to Geology for the General Reader and for beginners in the Science;* by JAMES D. DANA. 264 pages, 12mo, with numerous illustrations. New York & Chicago. 1875. (Ivison, Blakeman, Taylor & Co.) Price $1.50.—This work, although small, and different in arrangement from the author's Geological Manual and Text-book, gives the reader full illustrations of the principles of the science, of the methods of geological work, and of the course of geological history. It is simple in its language and full in its illustrations. After a few pages on the constituents, kinds, and structure of rocks, it takes up, in Part II, the subject of Causes in Geology and their Effects. Under this head it explains, *first*, the *making of rocks* (including the preparing of the material) through the agency of plants and animals, through the quiet work of air and moisture, through the work of the winds, fresh waters, ocean, and ice, and through heat,—the last topic including the effects of contraction and expansion, the formation of volcanic and other igneous rocks, and the subjects of solidification, metamorphism, and mineral veins. Then, *secondly*, it treats of the making of valleys and all depressions on the earth's surface; and, *thirdly*, of the making and shaping of hills and mountains, (1) by igneous ejections, (2) by the erosion of elevated lands, and (3) by the upturning and flexures of rocks, and bending of the earth's crust.

Part III, occupying 150 pages, takes up Historical Geology, describing the rocks that were forming, the most prominent kinds of plants and animals that were living, the mountains that were making, and other events, during each of the successive ages in the course of geological time; and ends with a brief review of the progress of life.

This volume is handsomely printed, and contains several cuts not in the Manual of Geology.

7. *Catalogue of Lower Silurian Fossils of the Cincinnati Group, found within* 40 *or* 50 *miles of Cincinnati, with descriptions of some new species of Corals and Polyzoa;* by U. P. JAMES, Cincinnati. New edition, much enlarged, 8 pp. large 8vo. Cincinnati, April, 1875.—The new species described by Mr. James are *Chætetes calycula*, *C. clavacoideus*, *C. Cincinnatiensis*, *C.* (?) *O'Nealli*, *Alveolites* (?) *granulosa*, *Ceramopora Nicholsoni*, *Ptilodictya acuminata* and *Alecto nexilis*.

8. *Origin of the Lower Silurian Limonites of York and Adams Counties, Pennsylvania;* by PERSIFOR FRAZER, Jr.—(Proc. Amer. Phil. Soc., March, 1875.)—Mr. Frazer, after describing the limonite deposits, attributes the origin of the ore to the presence of pyrites in the slates. The beds usually lie between the slate and Lower Silurian limestone, but the latter is generally little, if at all, acted upon or eroded, and often is not even stained.

9. BENTHAM, *Revision of the Sub-order Mimoseæ.*—This paper forms the third part of the 30th volume of the *Transactions of the Linnean Society*, fills over 300 quarto pages of letterpress, and is illustrated by five plates, exhibiting the principal varieties

in the legumes of *Mimoseæ.* The group, which now numbers 1200 species, under 29 genera, was first put into good order by Mr. Bentham about 30 years ago; and he has now taken occasion to revise it completely, while studying the South American species for the *Flora Brasiliensis*, after having re-examined the Australian ones for his *Flora Australica.* The generic characters, founded mainly on the stamens, of which he made happy use in the former monograph, have stood the test, as being the best as well as the readiest; and his facile arrangement has approved itself to other botanists (with one exception) as well as to his own enlarged experience. He has now brought in a new subsidiary character, that of the presence or absence of albumen in the seeds. This, for instance, is present in *Mimoseæ* but not in the *Acacieæ* and *Ingeæ*, i. e., the tribes with indefinite stamens. As to genera, the adage "by their fruits ye shall know them," however true it may be elsewhere, has little application here. This is illustrated by the figures of the pods of various *Mimoseæ* and *Acacieæ* subjoined to the memoir, and is shown in the letterpress by a general discussion of the facts. As to geographical distribution, it is interesting to note that Mr. Bentham reduces the number of species really common to the New and to the Old World, without any evidence or reasonable suspicion of recent transportation, to four species. *Entada scandens*, with its huge pods and hard seeds, not rarely wafted across the Atlantic by the Gulf Stream, is one; if of African origin, the trade-wind current may have given it to the West Indies. *Neptunia oleracea* is a tropical aquatic, conjecturally of South American origin, the seeds of which may have traversed the Atlantic; *Mimosa asperata*, probably also American, is not quite so readily accounted for in Africa; and the fourth, *Acacia Farnesiana*, is still more puzzling; but it would seem somehow to have found its way from Western South America to Australia and the Indian Archipelago before the days of Columbus; yet in all four cases, the want of differentiation is thought to indicate a comparatively modern dispersion. Of distinct but closely representative species in the two hemispheres, Mr. Bentham enumerates nine pairs. He might have added the case of two insular species, *Acacia heterophylla* of Mauritius, and *A. Koa* of the Sandwich Islands, only that he doubts if the two are sufficiently distinct. Seventeen of the 29 genera are restricted to one of the two hemispheres; but nine of these have only from one to three species, and but two (*Albizzia* in the Old World and *Inga* in the New) are at all numerous in species. Upon the more speculative discussion of the geographical data in reference to probable derivation, we cannot here enter. The subject is treated after the manner adopted in the memoir on *Cassia* and that on *Compositæ.* Remarking the great American predominance of the order in all its tribes, the author acutely remarks that "this high degree of recent luxuriance and prosperity of American races, however, can by no means be relied upon as evidence as to local origin, or even as to comparative remoteness of antiquity; for that may rather be sought for where there are the greatest number of highly differentiated monotypes or oligotypes of limited areas and fixed characters, exhibiting the last remains, as it were, of expiring races; and these are undoubtedly to be met with chiefly in the Old World—in the first place in East Africa and the Mascarene Islands, and secondly in the Malayan Archipelago." But the search for original birth-places, as he intimates, leads only through hazardous conjectures into thick obscurity. Our notice is confined to the few prefatory pages, on account of their general interest. As to the monograph itself, it is a model, in form and substance. The nominative specific characters make a most favorable presentation of that mode. Still, where condensation is important, the single sentence and the prevalent ablative case have some advantage in terseness. A. G.

10. *Flora of British India*, by J. D. HOOKER, C.B., etc., *assisted by various botanists.* Vol. I, pp. 740, 8vo. Reeve & Co., London. 1872–1875.—The third part, issued at the close of the past winter, brings this important work up to the close of the first volume, and nearly up to the *Leguminosæ.* This present part, which begins with *Geraniaceæ* and *Rutaceæ*, from the editor's own hands, is otherwise mainly the work of three or four English collaborators who have been enlisted in it, Messrs. Bennett, Hiern, and Lawson, and also Dr. Masters, the latter a botanist of no little experience. The younger botanists at all capable of this kind of work are few; accessions to the number are heartily to be welcomed. By their aid, under Dr. Hooker's efficient supervision, we may hope that this great undertaking will be duly carried through. A. G.

11. MIERS, *On the Lecythidaceæ.*—A splendid memoir, of 64 pages and 33 plates, large quarto, forming the second part of the 30th volume of the *Transactions of the Linnean Society*, 1874, a wonderful piece of work for a man of Mr. Miers' great age. He proposes to restore the *Lecythideæ* or *Lecythidaceæ* as an independent order. The plates illustrate the floral structure of the twelve genera which the author recognizes, and the fruits of most of them. It is a remarkably interesting group, consisting of huge trees, all tropical American, with singular flowers and large woody fruits, a sort of pyxis, containing numerous nut-like seeds, of which Brazil-nuts (from *Bertholletia excelsa*) and Sapucaia-nuts (from a species of *Lecythis*) are well-known examples. Few botanists have had the opportunity of properly studying these noble plants, and no one has devoted to them so much attention as the veteran Miers. A. G.

12. *Synopsis Filicum.*—The second edition of the *Synopsis of all known Ferns*, by HOOKER and BAKER (London: Robert Hardwicke), issued near the end of the year 1874, has just reached us. It bears Sir Wm. Hooker's honored name, for the work was planned by him, as an abridgement of the *Species Filicum*, and the first sheets had passed through the press before his death; but most of the volume was prepared by Mr. Baker, from

mere notes and indications by his predecessor and from his own studies of the rich materials which were ready to his hand. Accordingly, in any particular reference to the contents, after p. 48, Mr. Baker's name would be used. The original edition was issued, in successive parts, between 1865 and 1868. A new one has long been wanted, and still is so, in a certain sense. For, although the editor has "endeavored in this edition to briefly characterize and fit into their places the new discoveries and the plants found upon fuller information to have been inadequately dealt with in the first," he has not been able to deal with them quite freely. The pages are in stereotype, so that the body of the old work has been reprinted—no doubt with corrections as far as might be—and the additions are collected in an appendix of 75 pages, followed by a good new index to the whole. This must serve for the present, and fern-students will be very thankful for the new help. But we hope that Mr. Baker, in due time, will re-elaborate the order completely. A. G.

13. GRISEBACH, *Plantæ Lorentzianæ.*—An elaborate paper, of 213 pages and two plates, 4to, separately issued from the 19th volume of Transactions of the Royal Society of Sciences of Göttingen, 1874. It describes a good collection of plants of the Argentine Republic made by Prof. Lorentz of Cordoba. It is prefaced by a brief account of the region, followed by some remarks upon the more interesting plants of the collection, under their natural orders. Many new species are proposed and a few new genera. Under *Hydroleaceæ*, a name adopted instead of *Hydrophyllaceæ* (we know not why), a new *Nama* and a new *Phacelia* are described; also a new "genus, valde anomalum," *Sterrhymenia*, which is appended to the order, along with *Cardiopteris!* The suggested relationship is not apparent. A. G.

14. *Botanical Contributions* contained in the *Proceedings of the American Academy of Arts and Sciences*, vol. x, 1875.—This volume, just about to be issued, contains the papers communicated to the Academy and accepted for publication during the year ending in May. The botanical papers are,—

Conspectus of the North American Hydrophyllaceæ; by ASA GRAY. pp. 312–332. As this paper consists wholly of descriptive matter, some general considerations respecting the order, its distribution, affinities, &c., may hereafter be given in this Journal.

Revision of the Genus Ceanothus, and Descriptions of New Plants, with a Synopsis of the Western Species of Silene; by SERENO WATSON. pp. 333–350. The species of *Ceanothus*, mainly Californian, had become difficult of determination. They are here cleared up and arranged, under 28 species, two or three of which are still obscure or uncertain, and disposed under two groups (*Euceanothus* and *Cerastes*), which are well marked, but hardly worthy of subgeneric rank and substantive names.—The miscellaneous new species described are 32 in number, all western, but the first is a low *Clematis*, which belongs as far east as Kansas. Among them are eleven species of *Silene*, of Oregon and California, the determination of which led to a study of all our western Silenes. The results are briefly recorded in a foot-note, giving the diagnoses of 21 species. At this rate we may rival Europe.

List of the Marine Algæ of the United States, with notes of New and Imperfectly Known Species; by W. G. Farlow. pp. 351–280. The preceding papers bear the date of publication (April, 1875) as well as that of presentation, which it is well to know. It is omitted in Professor Farlow's neat and useful paper; but copies had reached us before the 1st of May. The species of the list being continuously numbered, we perceive that they amount to 430, of which 54 are additions to Dr. Harvey's Nereïs (1857), and three or four are new. The notes are numerous and critical. We understand that Professor Farlow intends to follow up this paper with other publications upon our *Algæ*. A. G.

15. Daniel Hanbury.—Not long ago we called attention to a most valuable book, the *Pharmacographia or History of Drugs*, by Prof. Flückiger of Strasburg and Daniel Hanbury of London, the first-fruits of much investigation, the precursor, as was hoped, of more extended similar works by the English author. We have now sadly to record the decease of Mr. Hanbury, of enteric typhoid, on the 24th of March, at his residence on Clapham Common, in the 50th year of his age. The obituary and biographical notices which have appeared in the London scientific journals, and in the Proceedings of the learned Societies, as well as loving individual tributes to an endeared memory, have given expression to the loss which has been sustained, and delineated the outlines of a most worthy and winning character. The loss is deplored, personally and scientifically, over wider circles and on this side of the Atlantic. The pupil and friend of Pareira and his successor in his line of work, an adept in pharmaceutical knowledge, a keen botanist, and a most assiduous and conscientious investigator, a man of simple and pure tastes, and happily of sufficient means, he had just withdrawn wholly from business in the noted house in which he had an inherited share, so that he might devote his powers and acquisitions without distraction to the natural history of drugs and useful vegetable products. He had already done much: more than sixty articles were contributed by him to a single journal, the editor of which declares that "the quality of what he did was almost faultless," that "he never wrote without having original information to impart, and his papers uniformly bear evidence of careful investigation and thorough knowledge." The Transactions and Journal of the Linnean Society (of which he was repeatedly a Councillor and the Treasurer at the time of his death) contain several of his papers. His first published paper, "On Turnsole," appeared in 1850; his latest, on the "Countess Chinchon and the Cinchona genus," appeared, since his death, in "The Academy" of the third of April. An ardent botanist and lover of plants, he travelled much in the south of Europe, accompanied Dr. Hooker in his explorations of Lebanon, and took an active interest especially

in the introduction of officinal plants and in ornamental cultivation. With one villa-garden on the shores of the Mediterranean—that of his brother at Mortola—his memory to us is indelibly associated. Although remarkably self-reliant, Mr. Hanbury was the opposite of self-asserting or ambitious; but his sterling worth was soon recognized by the principal learned societies and associations. He was early chosen into the Royal Society and served upon its Council in 1873. Born and educated in the Society of Friends, he remained a devout and attached member of it, while the graces and goodness of his character endeared him to all who knew him. With the sense of personal loss his scientific comrades mingle deep regrets that a career of unusual usefulness and promise is cut short, and that in a line in which, it is to be feared, he leaves no successor. *Hanburia Mexicana*, a striking Cucurbitaceous genus, commemorates his services to Botany. A. G.

16. *The Crustaceans of the Caves of Kentucky and Indiana;* by S. I. SMITH.—Through the courtesy of Dr. Packard of Salem, Mass., I have recently been enabled to examine the types of his *Crangonyx vitreus* from near Orleans, Ind., and also several specimens of an amphipod collected in Mammoth Cave by himself. All the specimens from Mammoth Cave are of a single species, which, there can be little doubt, is really the *Stygobromus vitreus* unintelligibly described from the same locality by Professor Cope. The species is really a *Crangonyx* and it should stand as *C. vitreus*, although very different from the one from Indiana which is referred to Cope's species by Dr. Packard and by him called *C. vitreus.* It is a small species, the largest specimen being less than a fourth of an inch (5·2 mm.) long, apparently wholly eyeless, and remarkable for the rudimentary character of the unibranched posterior caudal stylets, which are shorter than the telson. It seems to be near the typical species described by Bate, and it is closely allied in some respects to *C. tenuis*, also an apparently eyeless species, which I have described from wells at Middletown, Conn. Since this note was first written, I have examined several specimens of this last species, collected by Mr. J. K. Thacher, under stones in a small brook, near New Haven. From this it seems not at all improbable that the allied species from Kentucky and Indiana—and very likely also the eyeless, cave species of other groups—may still be found in the surface streams of the same region.

The specimens of Dr. Packard's species from Indiana are badly preserved but are sufficient to show that the species is very closely allied to *Crangonyx gracilis*, from Michigan, Lake Superior, etc., differing principally in the structure of the eyes, which are well developed and abundantly supplied with black pigment in *C. gracilis*, while in Dr. Packard's specimens they are observable with difficulty, are wholly without black pigment, are undoubtedly colorless in life, and are probably only imperfect organs of vision, although the structure of the facets can be distinctly made out.

The other differences are all very slight, scarcely sufficient to distinguish the subterranean form as a species, and certainly so slight that they would almost surely be overlooked if the two forms were found together.

As the crustaceans have recently been several times referred to as indicating the partially marine origin of the cave fauna of the Western States, a word in regard to their affinities may not be out of place. The species already described from Indiana and Kentucky are the following: *Cambarus Bartonii* Erichson, Mammoth Cave; *C. pellucidus* Erichson, caves in Ky. and Ind.; *Crangonyx vitreus* Smith, Mammoth Cave; *C. Packardii* Smith, wells, Ind.; *Cæcidotea stygia* Packard, caves and wells, Ind., and Mammoth Cave; *Euphiloscia Elrodii* Packard, caves, Ind.; *Cauloxenus stygius* Cope, caves, Ind. The genus *Cambarus* is strictly confined to American fresh waters, and *C. Bartonii* is one of the commonest species in the streams of the Western States. *Crangonyx*, as far as known, is wholly confined to fresh water. *Cæcidotea*, as far as we can judge from description and figures, is scarcely distinguishable, except in wanting eyes, from *Asellus*, a characteristically fresh water genus. The *Euphiloscia* was found also outside the caves and is allied to other terrestrial genera. The *Cauloxenus*, a Lernæan parasite of the blind fish, is so poorly described and figured, and the genera of the whole group to which it belongs are so difficult and imperfectly known, that it is useless to speculate on its exact affinities. In our Western and Southern States, species of perch, brook trout, the siscowet, lake white-fish, species of *Catostomus* and *Pomotis*, and other fresh water fishes, are infested with different species of Lernæans, and there is no more reason for regarding *Cauloxenus* as a "marine form" than any of these parasites. As well might we call a *Cambarus* or a *Crangonyx* a marine form because the great majority of the species of the orders to which they belong are marine. Considering the crustaceans alone, I can see no reason for supposing that the fauna of the caves of Kentucky and Indiana has been derived from any other source than the recent fauna of the surface of the neighboring region.

17. *United States Commission of Fish and Fisheries. Part II. Report of the Commissioner for* 1872 *and* 1873, *with Supplementary Papers.* 8vo, cii, 808 pp., with 37 plates and four maps. Washington, D. C., 1874. Received April, 1875.—In this very valuable report Professor S. F. Baird, the Commissioner, has presented us with a vast amount of information concerning the fresh-water fishes and fisheries of the United States and other countries, together with extended accounts of what has been accomplished in the way of artificial propagation of the fishes, and their introduction into rivers and lakes in all parts of the United States, whether by the commissioners of the various States, or under his own authority. The scope of the work may be seen from the following summary of contents:—Inquiry into the decrease of the food fishes; Action in regard to propagation of food-fishes (shad,

Maine salmon, Rhine salmon, California salmon, white-fish); Multiplication of fish in general, including a history of fish-culture and the various modes of propagating fish of different kinds. The preceding subjects are treated in the special report of the Commissioner. In thirty-four supplementary papers the following subjects are treated: The fisheries of the Great Lakes, and the species of Coregonus, or white-fish, by J. W. Milner; Descriptions of the North American species of salmon and trout, by George Suckley; The Salmon of the Danube, or the hucho, and its introduction into American waters, by B. Hessel; Report of operations, in 1873, at the U. S. hatching establishment on the McCloud River, and on the California Salmonidæ generally, by Livingston Stone; several interesting papers on the salmon and trout of other parts of the United States and Canada, by Mr. Stone, Chas. Lanman, C. G. Atkins, A. C. Hamlin, A. S. Adams, Dr. H. C. Yarrow, and others; several valuable papers giving accounts of the shad and the shad fisheries in all the principal rivers, both southern and northern, together with accounts of the various experiments made in the artificial increase of shad; and a detailed account by Mr. Milner of the mode of propagation and extensive introduction of young shad into the various rivers and lakes, by the U. S. Commissioner; also a detailed history of fish culture, both in Europe and this country, and descriptions of the various methods and apparatus. Appendix E. is devoted to papers on obstructions preventing fishes from ascending various rivers, and on fish-ways, &c, by C. G. Atkins, E. M. Stilwell, M. C. Edmunds, M. McKennie, J. F. Ingalls, and J. W. Milner. Appendix F is devoted to invertebrate Zoology, and includes a descriptive paper on the higher fresh-water Crustacea of the northern United States, and one on crustacean parasites of fishes, with descriptions and figures of a number of new species, by S. I. Smith; a synopsis of the fresh-water leeches, by A. E. Verrill; Sketch of the invertebrate fauna of Lake Superior, by S. I. Smith; Food of fresh-water fishes, by S. I. Smith; Natural History of the gourami, by Theodore Gill; Notes on the grayling (*Thymalus*) of North America, by J. W. Milner. Also several miscellaneous papers relating to temperatures of the Gulf of Mexico; Fish-culture; Bibliography of reports relating to the fisheries, etc. The plates illustrate a great variety of traps, pounds, weirs and other devices for capturing fishes; fish-ways; hatching apparatus; crustacea; aquatic insect larvæ; the gourami, etc. V.

18. *On some Parasitic Worms*, by Dr. Leidy.—Dr. Leidy has identified the *Ascaris mystax* as an intestinal worm of a Bengal tiger. The species has been found "in many other feline species, including the domestic cat and lion."

A long thread-worm from an apple, submitted to Dr. Leidy, was found by him to be the *Mermis acuminata*, a species that is parasitic in the larvæ of many insects, including the codling-moth, or fruit-moth, of the apple. He states that "twenty-five years ago he described a worm (Proc. 1850, 117) belonging to the collections of the Academy, and labelled it as having been obtained from a child's mouth, which was evidently the same species. It having been in a child's mouth, is probably to be explained by supposing that the child had eaten an infected apple."

Two specimens of a tape worm, Tænia, were obtained by Dr. Leidy from the stomach of an Australian Wombat. He names it *T. bipapillosa.* An Australian Whallabee afforded, from its peritoneal cavity, a *Filaria*, which he has named *F. spelæa.—Proc. Acad. Nat. Sci.*, 1875, 14, 17.

19. *Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel, für die Jahre* 1872, 1873, *II und III Jahrgang.* Large 4to, with 12 plates and a chart. Berlin, 1875.—This report is a valuable contribution to the physical and biological history of the European seas. It consists of five parts. The first, upon the Physics of the Seas, is by Dr. H. A. Meyer. It discusses very fully the physical features of the waters of the North Sea, observed during the cruise of the "Pommerania," and especially the temperature and specific gravity. The instruments used are described and figured, and the chart of the North Sea gives the track of the expedition and the location of the various stations. The waters near the coasts of England, Scotland, and Norway were explored, as well as those of Holland. The second part, by Prof. Oscar Jacobsen, relates to the chemical composition of the sea-waters. The third part consists of a report on the marine botany, by Dr. P. Magnus. He gives a catalogue of the algæ, with their distribution, etc., and two plates. The fourth part is a report on the Diatomaceæ, by Adolf Schmidt; it is illustrated by three beautiful plates. The fifth part is devoted to zoology. It includes a report on the Rhizopods, by F. E. Schulze, with figures; on the Sponges, by Oscar Schmidt, with a plate; on Cœlenterata, with a plate, by F. E. Schulze; on Echinoderms, by Karl Mobius and Butchli; on Worms, with a plate, by Karl Mobius. Quite a number of new forms are described in several of the groups. Among the new Rhizopods there is a new genus and species called *Astrodiscus arenaceus*, which appears to be very closely related to a singular species,* evidently of the same genus, which occurs very abundantly on the sandy bottoms off the New England coast, in fifteen to forty fathoms. We have dredged it during the four seasons past in the Bay of Fundy, off Casco Bay, in Vineyard Sound, and off Fisher's Island. It consists of a flat, sand-covered, disk-like body, with a variable number (usually five to nine) of irregular projections radiating from the periphery, and emitting, during life, irregularly branching pseudopodia. Our species grows to nearly a fourth of an inch in diameter, and scarcely differs from the figures of *A. arenaceus*, except in being usually covered by coarser grains of sand, and in having the projections a little more irregular, and often branched.

V.

* See also the writer's Report on Invertebrata, in First Report of U. S. Commissioner of Fish and Fisheries, p. 503, 1873.

20. *Illustrated Catalogue of the Museum of Comparative Zoology.* No. VIII. *Zoological Results of the Hassler Expedition.* II, *Ophiuridæ and Astrophytidæ, including those dredged by the late Dr. Wm. Stimpson;* by Theodore Lyman. 34 pp., with cuts and five plates. Jan., 1875.—This work contains a list of 76 species collected by the Hassler expedition, and by Dr. Stimpson, in the Gulf of Mexico. Of these, 19 species were undescribed. Our knowledge of the distribution of the known species, both geographically and in depth, is much extended by this catalogue, while several genera are added to the West Indian fauna, among which is the northern genus *Ophioscolex*, of which a new species (*O. Stimpsonii*) is described, from 240 fathoms off Sombrero Key. The other new species belong to *Ophiomusium*, *Ophiozona*, *Ophioceramis*, *Ophiacantha* (three species), *Ophiomitra*, *Amphiura* (four new species, with notes on known species), *Ophiocnida*, *Ophioplax* (gen. nov.), *Astrotoma* (gen. nov.), *Astroschema*, *Astrophyton* (two species). An analytical table of the six recognized genera of simple armed Astrophytons is given on page 26, and also of the five species of *Astroschema*. V.

21. *The Elements of Embryology;* by M. Foster and Francis M. Balfour. 8vo, 272 pp., with 71 cuts. Macmillan & Co., 1874.—In this work the authors have given a very complete and detailed account of the development of the chick, from the egg up to the period of hatching. The work contains a large amount of original matter, and the different views on many points are freely discussed. At the end a chapter is devoted to practical instructions for studying the embryology of birds. The book forms an excellent introduction to the general study of embryology, as well as a very useful manual for the embryology of birds. V.

22. *Nature and Life; Facts and Doctrines relating to the Constitution of Matter, the new Dynamics, and the Philosophy of Nature;* by Fernald Papillon; translated from the second French edition by A. R. Macdonough. New York: D. Appleton & Co., 1875.—This book consists of a series of essays, which, in addition to the general subjects indicated in the title, discuss the constitution of Living Beings; the relations of Life to Light, Heat, Electricity, Odors, Medicaments, Ferments, etc. There are also essays on Animal Grafts and Regenerations; Great Epidemics; the Physiology of Death; Heredity in Physiology, in Medicine, and in Psychology. These essays are written in a popular style and cannot fail to interest and instruct a large class of intelligent readers. V.

III. Miscellaneous Scientific Intelligence.

1. *On Ancient Cave-dwellings in Kentucky;* by F. W. Putnam.—That some of the caves were used as places of, at least, temporary residence, was conclusively shown by my exploration of Salt Cave, which proves important in revealing a new phase in American archæology. This cave approaches the Mammoth Cave in the size of its avenues and chambers. Throughout one of the

principal avenues, for several miles, were to be traced the ancient fire-places both for hearths and lights. For the latter purpose, small piles of stones were made with a hole in the center of the pile to receive the bundle of dried fagots perhaps smeared with grease. Bundles of these fagots, tied up with twisted bark, were found in several places in the cave; and canereeds, probably the remains of ancient torches of the same character with those found in the Mammoth, Short, and Grand Avenue Caves, were also very abundant.

The most important discovery in this cave, however, was made in a small chamber, about three miles from the entrance, first noticed by my guides, Messrs. Cutlip and Lee. On the dry soil of the floor were to be seen the imprints of the sandaled feet of the former race who had inhabited the cave, while a large number of cast-off sandals were found, neatly made of finely-braided and twisted leaves of rushes.—*Eighth Annual Rep. Peabody Museum of Archæology and Ethnology*, Cambridge, 1875.

2. *The catastrophe of the Zenith.*—On the morning of the 16th of April last, under the auspices of the Academy of Sciences, the *Zenith*, containing the three experienced aeronauts, Captain Sivel, Crocé-Spinelli and Gaston Tissandier, and well equipped for scientific work, started on its ascent from the gas works of La Villette, Paris. By 1 o'clock, at noon, they had reached an altitude exceeding 5,000 meters, the barometer marking a pressure of 400 millimeters, and the thermometer 5° C. They had oxygen in bags for breathing in the upper rarefied air, and found it very beneficial. At $1^h\ 20'$ the barometer marked 320 mm., showing an altitude of 7,000 meters; the temperature was $-10°$ C., and soon afterward 7,400, with the temperature $-11°$ C. Sivel and Crocé were already pale and very feeble. By mutual consent Sivel with his knife cut the cords which kept closed three sacs of ballast of 25 kilograms each that were hanging outside. The three sacs emptying themselves, the balloon ascended rapidly, and near $1^h\ 30'$ all three of the aeronauts had fainted. Tissandier, as his consciousness was leaving him, read from the barometer 280 mm., but was already too much paralyzed to speak out his thought—8,000 meters. Tissandier and his friends partially revived, as the balloon was making a very rapid descent; but again all became asphyxiated. The survivor supposes that more ballast was probably dropped by one of them to prevent a fatal descent, and up the balloon went. At 3 o'clock the balloon was again descending rapidly, and Tissandier became conscious; and at 4 o'clock it struck the earth at Ciron near Le Blanche with a severe shock. Sivel and Crocé were dead, their faces black and their mouths full of blood. The greatest height reached, as indicated by the self-registering barometer, was 8,540 to 8,600 meters. The lessons taught to science are: that man cannot safely make a rapid balloon ascent to an altitude of 8,000 meters; that the only chance for reaching alive that altitude in a balloon is by making the rate of ascent above 7,000 meters very slow, giving 12 hours at least

to the next 1,000 meters, and a rate half as fast for the meters beyond; that better arrangements for carrying up air or oxygen to supply the breathers may be of service; that man reaches soon the upward limit of atmospheric investigation.

3. *Protracting Sextant.*—At a recent meeting of the California Academy of Sciences, Mr. T. J. Lowry, of the U. S. Coast Survey, described a new instrument invented by him which may prove of the highest value in surveying, especially in hydrographic surveying. It is based upon the principles of the common sextant, but by it *two* adjacent angles can be at once measured by one observer. Immediately after the observation, moreover, the instrument without change can be laid as a protractor upon the chart, and the place of the observer pricked down, the principle involved being that of the "three point problem."

4. *Mean Height of Europe.*—Dr. GUSTAV LEIPOLDT, in a recently published work on the "Mean Height of Europe," after an elaborate calculation founded on a broad basis of measurement, concludes that it is 296·838 meters, 92 meters higher than the calculation of A. von Humboldt, who indeed made out the average altitude of all the land on the earth to be about 308 meters. The mean height of Switzerland Leipoldt makes to be 1299·91 meters, while that of the Netherlands is only 9·61 meters. That of Great Britain is 217·70. Further interesting details will be found in the April number of Petermann's Mittheilungen.—*Nature*, April 15.

5. *Smithsonian Report for* 1873.—The papers in the Appendix to this Report, which give it special scientific value, are the following: Biographies of BABBAGE, AGASSIZ, TORREY, G. GIBBS; J. C. DALTON on the origin and propagation of disease; HELMHOLTZ on mathematical theories; CLERK MAXWELL on action at a distance; B. A. GOULD on the Cordoba Observatory; E. MAILLY, estimate of the population of the world; A. MORIN on warming and ventilating occupied buildings; E. L. DE FOREST, additions to a memoir on methods of interpolation applicable to the graduation of irregular series; SCHUMAKER on the Kjökken-Möddings of N. W. America; H. BERENDT on a grammar and dictionary of the Cavil language; H. GILMAN on the mound-builders and platycnemism in Michigan; T. M. PERRINE on the antiquities of Union Co., Illinois; W. H. DALL on explorations on the western coast of N. America; W. M. PIERSON on the discovery of a large meteorite in Mexico; F. R. BRUNOT on the habits of the Beaver; W. S. JEVONS on a national library; and a list of Prize Questions issued by Scientific Societies.

6. *Expedition for the Geological and Geographical Survey of the Territories, for* 1875.—The amount appropriated by the last Congress for the U. S. Geological and Geographical Survey of the Territories under the direction of F. V. Hayden was $75,000 for field work, and $20,000 for engraving illustrations, maps, &c. Six parties will take the field in various portions of Colorado about the first of June. Mr J. T. Gardner will carry the primary triangulation of the area between lat. 36° 45′ and 39° 15′; long.

104° 30′ and 109° 30′. Mr. A. D. Wilson, chief of field party No. 1, will survey an area in the southern part of Colorado, with a portion of northern New Mexico lying between lat. 36° 45′ and 37° 45′, long. 105° and 108°. Mr. Henry Gannet, in charge of field party No. 2, will occupy the area between lat. 38° and 39° 15′ and long. 108° and 109° 30′.

Field party No. 3 will survey the area in the southwestern Colorado between lat. 36° 45′ and 38° and long. 108° and 109° 30′. Field party No. 4 will complete unfinished areas in central and eastern Colorado. The photographic party under Mr. Jackson will make a study of the ancient rivers in southern and southwestern Colorado and also some special studies of remarkable mountain scenery in various portions of the Territory.

It is expected that at least four of the six sheets of the Colorado atlas will be completed this season, with portions of the other two. The maps will be issued as geological as well as topographical maps, in the final atlas.

7. *National Academy of Sciences.*—The following is a list of the papers read at the session of the National Academy of Sciences, held on the 20th to the 22nd of April, 1875:

Results derived from an examination of the U. S. Weather Maps for 1872–3–4; E. Loomis.

Notes on observations of the transit of Venus; G. Davidson.

On an improvement of the present civil or Gregorian calendar; J. P. Bradley.

Results of experiments on the set of rectangular bars of wood, iron and steel, resulting from a transverse stress; W. A. Norton.

Note on Goldschmid's Aneroid Barometer; J. E. Hilgard.

Progress of Second Geological Survey of Pennsylvania; J. P. Lesley.

Orography of the Catskill group of mountains; A. Guyot.

Report of the Committee on Weights, Measures and Coinage; F. A. P. Barnard.

On the observations of contacts in transits of Venus and Mercury; S. Newcomb.

New formula for the deflections of rectangular bars or beams, resting on supports and subjected to a transverse stress: W. A. Norton.

Size of the brain in extinct mammals; O. C. Marsh.

Account of researches in Solar Physics made at the Allegheny Observatory during the past four years; S. P. Langley.

Use of the Stereoscope in the study of Solid Geometry; James D. Warner.

On the interpolation of a change of sign by passage through infinity of a mathematical function expressive of a physical phenomenon; a curious particular case in the theory of tides; J. G. Barnard.

Discussion of the Laws of Atmospheric Circulation, by Prof. James H. Coffin (now deceased); Selden J. Coffin.

Influence of Arsenical compounds upon Vegetation; Wm. McMurtrie.

Preliminary account of results of a Magnetic Survey, made at the charge of the Bache Fund; J. E. Hilgard.

Relations of some of our ancient Fossil Fishes to living Forms; J. S. Newberry.

On areas of Cold; by A. Woeikof.

8. *Mastodon of Otisville, Orange County, N. Y.*—Prof. Marsh has secured, for the Peabody Museum of Yale College, the skeleton of a large mastodon, exhumed by Mr. A. Mitchell on his grounds at Otisville, seventy-five miles from New York and within a mile and a half of the Erie Railroad. The bones were found on and in clay beneath a deep bed of muck, and are in an excellent state of preservation. This Otisville mastodon is the sixth that has been found in the swamps of Orange County.

9. *Statistical Atlas of the United States, based on the results of the Ninth Census*, 1870, with contributions from many eminent men of science and from several departments of the Government. Compiled, under authority of Congress, by FRANCIS A. WALKER, M.A., Superintendent of the Ninth Census, Professor of Political Economy and History in the Sheffield Scientific School of Yale College. In large folio. (Julius Bien, Lith.)—The publication of Parts 2 and 3 of this Atlas has been already announced on page 74 of this volume. Part 1 completes the great work, and in a most satisfactory manner. Among its maps there is one of great interest showing the distribution of wood-land in the United States, by Prof. Wm. H. Brewer; another giving a hypsometric view of the surface, prepared from data furnished by Prof. Guyot and C. A. Schott of the U. S. Coast Survey; others illustrating the meteorological characteristics of the country; one giving the dis-distribution of the Coal fields, compiled by Prof. C. H. Hitchcock; and one which is an excellent geological chart of the United States, 19 by 28 inches in size, by Profs. C. H. Hitchcock and W. P. Blake. This geological chart has been prepared with care and is beautiful in its lithography and coloring. In fact, the whole work is highly creditable to the photolithographic establishment of Mr. Bien. The maps are accompanied by many pages of text giving explanatory, descriptive and statistical information. We defer to another number a more extended notice of the Atlas.

10. *Popular Science Library.*—Under this title D. Appleton & Co. are publishing a valuable series of small works in Science. The following have been issued: ***Health***, by EDWARD SMITH, F.R.S.; ***The Natural History of Man***, by Prof. A. DE QUATREFAGES; ***The Science of Music***, by SEDLEY TAYLOR; ***Outline of the Evolution Philosophy***, by Dr. E. CAZELLE, with an Appendix by E. L. YOUMANS, M.D., on ***Herbert Spencer and the Doctrine of Evolution***, giving a brief exposition of the views and claims of Spencer.

11. *New York Academy of Sciences.*—The Lyceum of Natural History of New York has recently changed its name to New York Academy of Sciences.

12. *Geological Society of London.*—Dr. F. V. HAYDEN has been recently elected Foreign Correspondent of the Geological Society of London.

Life of Murchison, by Archibald Geikie. 2 vols. London, 1875. (Murray.)

Statement and Exposition of certain Harmonies of the Solar System, by Stephen Alexander, Prof. Astron. Coll. of New Jersey. 96 pp. 4to. 1875. Smithsonian Contributions to Knowledge, No. 280.

Half-hour Recreations in Natural History of Estes and Laureat. Boston. 72 to 80 pages each.—Half-hours with Insects, Parts 6 and 7, by A. S. Packard, Jr.—The Glacial Epoch of our Globe, by Alexander Braun.—The Sun and the Earth, by Prof. Balfour Stewart, F.R.S.; Force electrically explained, by J. W. Phelps.—The first volume of these Half-hour Recreations, numbering 478 pages, has been issued by the publishers in a handsome form.

Catalogue of the Fishes of the East Coast of North America, by Theodore Gill. Washington, 1875. 52 pp. 8vo.—Smithsonian Miscellaneous Collections.

Astronomy by J. N. Lockyer, being No. VII of Science Primers, edited by Professors Huxley, Roscoe and Balfour Stewart. 120 pp. 16mo, with many fine illustrations. 1875. (D. Appleton & Co.)

INDEX TO VOLUME IX.*

* The Index contains the general heads Botany, Geology, Mineralogy, Zoology, and under each the titles of Articles referring thereto are collected.

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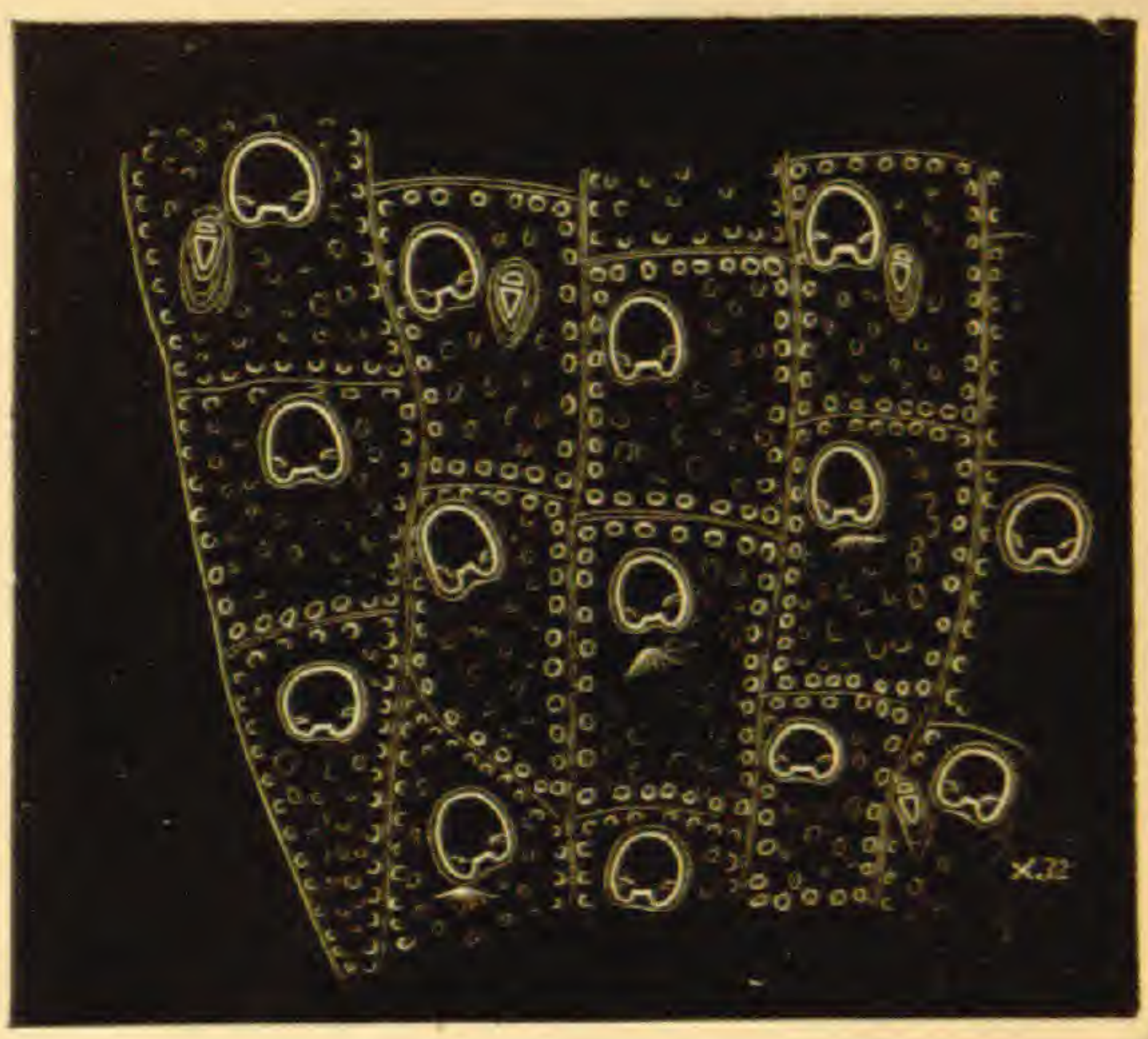

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Figs. 1, 2, *Bugula flexilis* V.; 3, *Discopora nitida* V.; 4, *Lepralia Americana* V.; 5, the same without ootheca. Drawn, from nature, by A. E. VERRILL.