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ERRATUM.

On page 61 line 8, for *Swift-Borelly* read *Block-Swift-Borelly*.
Page 248, line 7 from foot, for *depth* read *heat*.
Page 335, line 10 from foot, for the period insert a comma.
Page 426, line 3, for EATON read CATON.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. I.—*Contributions to Meteorology, being results derived from an examination of the Observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Seventh paper. With plates I, II and III.

[Read before the National Academy of Sciences, Washington, April 18, 1877.]

Rain-areas—their form, dimensions, movements, distribution, etc.

IN my last paper I examined all those cases in which the rain-fall was uncommonly great at any one of the Signal Service stations during a period of fifteen months (Sept. 1872, to Nov. 1873). I propose now to consider those cases in which the *total* rain-fall for all the stations was uncommonly great. The following table exhibits all the cases in which the total rain-fall at all the stations amounted to at least eight inches in a period of eight hours. Column 1st contains the number of reference; column 2d shows the day and hour of observation (the numeral one denotes the observation at $7^h\ 35^m$ A. M.; two denotes the observation at 4.35 P. M.; and three denotes 11 P. M.) column 3d shows in inches the total rain-fall at all the stations during the preceding eight hours; column 4th shows the station at which the greatest rain-fall was recorded; column 5th shows the amount of rain observed at the station mentioned in column 4th; column 6th shows the state of the barometer at the same station; column 7th shows the state of the barometer at the nearest center of minimum pressure; column 8th shows the direction of the rain center mentioned in column 4th from the center of low pressure mentioned in column 7th; column 9th shows the distance of the rain center from the center of low

Total rain-fall at all the stations amounting to at least eight inches in eight hours.

No.	Date.	Total rain-fall.	Station of greatest rain.	Rain at do.	Bar. at do.	Low bar.	Rain center from Low. Direction.	Distance.	Wind at prev.ob.	Wind at date.
	1872.									
1	Sept. 11.3	10·76	Marquette.	1·91	29·80	29·74	N. 5° W.	287	S.E. 1	W. 1
2	12.2	9·93	Saugeen.	1·74	·74	·68	N. 40 W.	78	S. 3	Calm.
3	Oct. 6.3	8·75	Vicksburg.	1·05	30·02				N. 8	E. 3
4	7.2	8·58	Montreal.	1·35	29·90	·81	North.	156	S.W. 2	N.E. 3
5	22.3	8·30	Jacksonville.	2·43	·99				N.E. 12	E. 13
6	23.1	9·34	Jacksonville.	2·05	·83				E. 13	W. 1
7	25.1	8·91	Norfolk.	3·41	·95	·95	*	0	E. 13	S.E. 8
8	26.1	8·80	Philadelphia.	2·09	·78	·74	S. 65 E.	137	E. 20	S.W. 12
9	Nov. 6.3	9·91	Montgomery.	2·73	·95				E. 3	S..E 22
10	7.1	13·52	New York.	2·50	·68	·33	S. 54 E.	777	S.E. 4	N.W. 10
11	Dec. 18.2	8·77	New Orleans.	2·20	30·08				S.W. 6	N.E. 8
12	20.1	14·49	New York.	1·70	29·78	·43	S. 55 E.	287	N.E. 17	N.W. 20
13	26.1	9·46	Norfolk.	2·08	·46	·46	*	0	N.E. 21	N. 20
	1873.									
14	Jan. 2.2	9·12	Keokuk.	1·63	·35	·23	S. 44 W.	134	Calm.	W. 12
15	3.1	8·63	New York.	1·80	·83	·09	S. 57 E.	761	N.E. 16	E. 6
16	5.1	12·74	Lake City.	2·00	·89				S.E. 4	S.E. 7
17	5.2	16·25	Philadelphia.	2·18	·61	·45	S. 58 E.	218	N.E. 20	N.E. 8
18	16.1	10·08	New Orleans.	2·01	·92				S. 8	N.W. 12
19	17.1	8·05	Philadelphia.	1·07	·80	·54	S. 36 W.	630	S.W. 18	N.W. 18
20	Feb. 16.1	10·57	Louisville.	1·60	·56	·49	East.	195	N.E. 8	Calm.
21	16.2	9·87	Cape May.	1·54	·66	·55	N. 87 E.	448	E. 18	S. 6
22	26.2	8·88	Knoxville.	1·23	·80	·36	S. 39 E.	507	E. 5	Calm.
23	Mar. 29.1	10·65	Lake City.	2·00	·97				N.E. 8	N.W. 12
24	29.2	10·48	Oswego.	1·48	·01	·01	*	0	S.E. 12	N.E. 12
25	April 8.1	8·70	Indianapolis.	1·08	·71	·64	N. 46 E.	343	N.E. 7	E. 4
26	8.2	8·57	St. Louis.	1·65	·64	·52	N. 82 W.	245	N. 34	W. 9
27	May 1.2	9·37	Montgomery.	3·05	·87				S.E. 4	S.E. 4
28	2.1	11·78	Wilmington.	1·01	·88				S. 12	N.E. 2
29	2.2	8·49	Wilmington.	1·02	·68				N.E. 2	S.W. 30
30	8.1	8·33	Lynchburg.	1·37	·98	·59	S. 57 E.	562	N.E. 12	N.E. 8
31	June 23.1	8·65	St. Paul.	2·30	·57	·52	S. 67 E.	93	S.E. 18	S.W. 2
32	30.2	9·23	Port Stanley.	1·81	·56	·36	S. 60 E.	591	S.W. 3	S.W. 3
33	July 17.3	10·88	Buffalo.	2·00	·64	·64	*	0	S.W. 14	S.W. 7
34	27.2	9·63	Washington.	2·12	30·11	·72	S. 63 E.	1175	S. 10	W. 8
35	Aug. 12.2	8·45	Galveston.	1·68	·04				N. W. 4	W. 2
36	13.1	9·52	Philadelphia.	2·31	·04	·92	N. 73 E.	346	E. 16	N.E. 12
37	13.2	8·27	Philadelphia.	2·17	29·97	·85	N. 41 E.	348	N.E. 12	N.E. 22
38	18.2	8·58	Wilmington.	1·50	30·05				Calm.	S.W. 6
39	21.1	9·56	Galveston.	3·67	29·95				E. 5	Calm.
40	Sept. 19.2	11·39	Cape May.	1·92	·70	·57	S. 12 W.	487	E. 3	N.W. 8
41	19.3	8·96	Mt. Washington.	2·20	·86	·59	North.	202	S.W. 24	W. 12
42	24.1	9·51	Mt. Washington.	1·55	30·12	·86	N. 7 E.	222	W. 6	N.W. 12
43	28.1	8·69	Fort Gibson.	1·01	29·75				E. 7	S.E. 6
44	Oct. 19.3	9·82	New London.	2·25	·80	·52	N. 34 E.	329	S.E. 2	S.E. 24
45	20.1	17·65	Philadelphia.	1·96	·47	·45	N. 16 W.	89	E. 12	N. 12
46	20.2	12·27	Rochester.	1·38	·65	·26	N. 26 W.	273	N. 20	N.E. 25
47	20.3	9·86	Buffalo.	1·23	·35	·30	N. 54 W.	160	N. 23	N. 14
48	27.1	8·30	Knoxville.	1·24	·79	·29			N.W. 24	W. 25
49	27.2	8·68	Cape May.	0·90	·63	·22	S. 35 W.	410	S. 26	S.W. 4
50	Nov. 8.1	8·64	Boston.	1·75	·58	·48	N. 84 E.	225	E. 12	N.E. 17
51	18.1	8·23	Boston.	1·50	28·69	28·66	N. 48 E.	101	N.E. 28	W. 16
52	18.2	9·23	Sydney.	1·37	29·09	28·47	N. 75 E.	332	E. 10	S.E. 18
53	24.1	11·16	Nashville.	1·08	·86	29·49	S. 48 W.	520	Calm.	W. 8
54	24.2	14·69	New London.	2·80	·30	·27	S. 61 W.	90	S.E. 14	N. 12
55	27.2	9·71	Charleston.	1·75	·91				Calm.	N. 8

pressure expressed in English miles; column 11th shows the direction and force of the wind at the place mentioned in column 4th and at the date given in column 2d; and column 10th shows the direction and force of the wind at the observation next preceding the date mentioned in the table.

For each of the cases named in this table, the curves of equal rain-fall have been accurately drawn upon maps of the United States, and these curves have been carefully compared. The following table shows the geographical extent of some of these rain-areas. Column 1st shows the number of reference taken from the preceding table; column 2d shows in English miles the greatest and least diameters of the area over which the rain-fall was at least one inch in eight hours; and column 3rd shows the greatest and least diameters of the area over which the rain-fall was at least half an inch, in eight hours.

Dimensions of Rain-areas.

No.	Area of one inch rain.	Area of half inch rain.	No.	Area of one inch rain.	Area of half inch rain.	No.	Area of one inch rain.	Area of half inch rain.
10	720–230	920–398	17	443–167	714–393	20	338–173	890–406
9	605–334	668–430	16	440–160	858–356	54	338–194	458–358
45	546–318	724–350	27	380–296	468–390	7	320–288	394–312
39	490–188	514–236	32	374–150	796–340	5	312–276	394–394
55	468–162	652–312	6	360–304	440–402	11	300–174	494–300
31	446–216	774–332	8	354–144	436–266	18	242–162	858–224

The form of these rain-areas is sometimes quite irregular but generally it approximates to an ellipse of which the major axis is not quite double the minor axis. This elongated form of rain-areas is more noticeable in storms which prevail near the Atlantic coast, than it is in regions remote from the ocean. It will be seen that in three cases the area of one inch rain-fall exceeded 500 miles in length, and in six cases the area of one half inch rain-fall exceeded 750 miles in length. In number ten, the area of one quarter inch rain-fall was 1,180 miles by 500 miles; in number twenty, this area was 1,000 miles by 572 miles, and in two or three other cases the dimensions of the rain-areas were nearly as great. Frequently the entire rain-area is an oval figure whose length exceeds 1,000 miles, and whose breadth exceeds 500 miles.

It was shown in my sixth paper, that south of latitude 36° rain-areas are as frequently under the influence of an area of high barometer as of an area of low barometer. In columns 7, 8 and 9, of the table on page 2, I have therefore left blanks for the southern stations. The numbers in column 8th, for the northern stations, show that in seventeen cases the rain center was north of the center of low pressure, and in sixteen cases it was south of this center. In twenty cases the rain center was east of the center of low pressure, and in twelve cases it was west of this center. If, however, we consider the middle of the rain-fall as corresponding to a date four hours preceding the barometric observation, we shall find that in four of these cases, viz: numbers 1, 2, 14, and 54, the principal rain-fall occurred when the rain center was east of the center of low pressure, or at least very near it. In several of the cases, however, the rain center was clearly west of the center of low pressure, and in some of the cases the rain-fall apparently had a decided influence upon the direction of the storm's progress. This was specially true of numbers 45, 46 and 47, in which case the center of minimum pressure moved *westward* instead of eastward. As this example is a very remarkable one, I will consider it particularly.

On the morning of October 19th 1873, along the coast of North Carolina, Virginia and New Jersey, light winds from the east, or southeast generally prevailed, while west of Virginia and Pennsylvania the winds were generally from the west or northwest. This opposition of the winds was attended by a rain-fall, which in the afternoon became general along the Atlantic coast from Wilmington to Boston and extended inland 300 or 400 miles. The barometer fell steadily during the day, and a center of minimum pressure which had prevailed for twenty-four hours near the coast of Florida, advanced rapidly northward. During the evening of the 19th the same winds continued with increasing strength; the rain-fall increased especially about Washington and New London; the barometer continued to fall, and the center of minimum pressure advanced to Norfolk. On the morning of the 20th the same system of winds prevailed but had advanced further northward, the southeast winds near the coast extending from New York to Nova Scotia, and having a velocity of twelve to twenty-five miles, and were opposed by fresh winds from the north and west in the vicinity of Lakes Erie and Ontario. At Quebec the wind blew from the east, forty-six miles per hour, and on Mt. Washington the wind blew from the southeast seventy-five miles per hour. The total rain-fall at all the stations during the preceding eight hours was greater than was recorded for any other equal period during the fifteen months under discussion. The center of minimum pressure had now reached Cape May, and the center of the rain area was 250 miles further north. During the 21st the system of east winds near the coast of New England and Nova Scotia had pushed further into the interior, and in the afternoon extended to Rochester, which was now the center of greatest rain-fall, while the center of minimum pressure moved slowly in the same direction. The wind at Quebec still blew from the east, forty-two miles per hour, and on Mt. Washington it blew from the southeast, seventy-eight miles per hour. During the evening of the 20th the same system of winds continued, but the center of the rain-area was at Buffalo, and the center of minimum pressure advanced in the same direction. The wind at Quebec still blew from the east forty-five miles per hour, and on Mt. Washington from the southeast fifty miles per hour. On the morning of the 21st, southerly and easterly winds extended from the coast of New England to Lake Erie, where was now the greatest rainfall, and also the center of minimum pressure. At Grand Haven on Lake Michigan, the wind blew from the north thirty-two miles per hour, and on Mt. Washington from the southeast fifty-five miles per hour. On the afternoon of the 21st the system of winds was nearly the same, but their intensity was sensibly diminished. On Mt. Washington the wind blew from the southeast thirty-eight miles per hour. The center of minimum pressure had now advanced westward nearly to Lake Michigan, a result which was apparently due to a second area of low pressure which came from the northwest and coalesced with the one which we have been considering. During the evening of the 21st the easterly motion of the winds near the coast of New England was very much diminished; the rainfall was also diminished, and the center of minimum pressure advanced a little to the north. On the morning of the 22d the rain-fall had nearly ceased, the winds were generally moderate, and the center of minimum pressure moved a little toward the north east. During the 22d there were two centers of maximum pressure in the southern part of the United States, and under their influence southerly winds generally prevailed east of the Mississippi, while in the northwestern States the winds were from the northwest. Hence resulted a circulation of the winds about Lake Superior, and the center of minimum pressure moved in that direction. On the 23d the pressure in the southern States increased; southerly winds generally prevailed throughout the Lake region, and the center of minimum pressure was apparently pushed still further toward the northwest, but as this center had now passed beyond the stations of observation, it is impossible to locate it with precision.

Plate I shows the curves of equal rain-fall for October 20, 7.35 A. M. The outer curve shows the extreme limits of the rain-area during the preceding eight and one-half hours; the next curve shows the limit of one half inch rain-fall; the third curve shows the area over which the rain-fall was at least one inch; and the inner curve shows the area of one and a half inch rain-fall. At Philadelphia and Burlington the rain-fall was 1·96 inch during the eight and one-half hours, and it is probable that near the center of the rain area the rain-fall exceeded two inches. The successive positions of the center of minimum pressure are indicated by the figures 19·2, 19·3, 20·1, etc., and the undulating line connecting these points represents the path of the center of minimum pressure from October 19th to October 22d. The arrows at the several stations represent the direction of the winds for October 19th, 11 P. M., which was the time of commencement of the rain-fall represented upon the map.

This example presents a very unusual case of a storm center traveling for several days toward the northwest. This result was apparently produced by a wind of unusual violence setting in from the Atlantic Ocean, and meeting with opposing winds from the interior caused a very unusual rain-fall, and the center of minimum pressure followed the center of the rain-area. These facts seem to indicate that a heavy rain-fall extending over a large area has a decided influence in determining the course of a storm center.

In No. 26 the principal rain-fall was on the northwest side of the center of minimum pressure but not over 150 miles from it. In No. 53 the principal rain-fall was on the southwest side of the center of minimum pressure, and these two cases, together with No. 12 on page 15 of my last paper, indicate that in the neighborhood of Kentucky it is not uncommon for the principal rainfall to occur after the center of low pressure has passed eastward.

In Nos. 40 and 49 the rain-fall at Cape May was greater than at any other station, but there was at the same time another rain-area of much greater extent near the center of minimum pressure. The rain-fall at Cape May was apparently the result of a local cyclone which did not greatly affect the height of the barometer.

In No. 19 there was a center of low pressure in Nova Scotia, but it seemed to have little influence upon the winds near Philadelphia. There was a center of high pressure in Iowa, and the winds near the Lake region were generally from the northwest. At Norfolk the wind was from the south, and a new center of low pressure was forming near the coast of North Carolina. The rain about Philadelphia on the morning of January 17th was apparently due to a local cyclonic movement, more than to the influence of the low center in Nova Scotia.

The average distance of the center of greatest rain-fall from the center of low pressure for cases north of latitude 36°, is 300 miles, but it sometimes exceeds 750 miles.

In 19	cases	the distance was	less than 250 miles.
11	"	"	between 250 and 500 miles.
5	"	"	" 500 and 750 miles.
3	"	"	over 750 miles.

In No. 34 (page 2) there was a center of low pressure in Minnesota, but it seemed to exert no control over the winds in the eastern and southern parts of the United States. Here there were five centers of local cyclonic movement, each of which became the center of a rain-area as shown on Plate II. Neither of these centers became a center of low pressure although the rain-area near Washington continued for sixteen hours.

In No. 10 there was a center of low pressure over Lake Superior, but this was so distant that it exerted but little influence over the winds near the Atlantic coast. On the evening of November 6th, winds from the south and east generally prevailed along the entire Atlantic coast, and these being opposed by westerly winds (the result of a high barometer in Tennessee), there was an extensive rain on the night of November 6th, which was especially heavy along the coast from Georgia to Massachusetts. This rain-fall seemed to have a decided influence in accelerating the movement of the center of low pressure, as was mentioned in my last paper, p. 16.

No. 15 was in many respects similar to No. 10, but it did not produce the same effect on the movement of the low center, perhaps owing to the influence of another rain-area which prevailed near Montreal.

No. 19 has already been referred to; see preceding page.

In No. 32 the center of lowest pressure was beyond Lake Superior, but the barometer was quite low (29·56) at Port Stanley, and here there was apparently a local cyclone resulting in a heavy rain-fall.

No. 30 shows the influence of an area of high pressure combined with an area of low pressure. On the 7th of May there was an area of low pressure near the mouth of the Ohio River, and an area of high pressure in New England, which gave rise to a system of southeast winds along the Atlantic coast, and extending to the Lake region. The result was a slight rain-fall over a large area of territory, but the rain was greatest about Lynchburg, near which place there was some evidence of cyclonic motion. Perhaps the Alleghany Mountains had some influence in determining the upward movement of the southeast current near this place.

No. 22 appears to have resulted from east winds along the Atlantic coast opposed by west winds near the Mississippi valley, on the south side of an area of low pressure.

No. 53 has already been referred to on page 6, and it is remarkable that the center of low pressure moved towards the northeast at the rate of 54 miles per hour, leaving the center of principal rain-fall almost exactly in its rear. There were, however, at the same time two other rain areas of considerable extent on the northeast side, one about Baltimore and the other about Montreal.

From the preceding statement we perceive that in the United States, south of latitude 36°, great rain-falls are accompanied by a cyclonic movement of the air which sometimes appears to be the result of a neighboring area of low pressure, and sometimes of an area of high pressure, and the latter case is about as frequent as the former. North of latitude 36° rain-areas are most frequently associated with areas of low barometer and generally they are found on the east side of the center of low pressure; but occasionally they are found on the west side of the center of low pressure, and this case occurs most frequently in the neighborhood of the Ohio valley. Extensive rain-areas sometimes occur in the Northern States at a great distance from a low center, where they appear to be as much under the influence of a center of high pressure as of a center of low pressure, and in these cases there are generally indications of a local cyclonic movement of the atmosphere.

Of the fifty-five cases enumerated in the table on page 2, in thirty-eight cases the wind blew from some quarter between northeast and southeast, either at the date given in the table or at the time of the preceding observation. Of the seventeen remaining cases, in five of them the air was reported as *calm*; in three of them the wind was from the south, and two of the cases occurred on the summit of Mt. Washington. In one of the remaining cases the velocity of the wind was only two miles per hour; in another case the velocity was three miles per hour; in a third case it was seven miles per hour, and in a fourth case it was nine miles per hour. There remain only three cases in which at both the observations the wind was strong from some quarter between north and southwest. These cases are Nos. 19, 47 and 48.

In No. 19, the winds upon the Atlantic coast near Philadelphia were generally from the south or southeast, while at a distance of 300 miles from the coast, the winds were from the west or northwest. It seems probable that this northwest current crowded under the southeast current lifting it up from the earth's surface and thus condensing its vapor, and that the south wind at Philadelphia was the result of the meeting of the southeast wind from the ocean with the northwest wind of the interior.

In No. 47, as has been already mentioned on page 4, the center of the rain-area was on the northwest side of the center of low pressure. It seems probable that in this case the violent southeast wind from the ocean extended further west than Buffalo, and that its vapor was condensed by its being elevated from the earth's surface by the crowding of the northwest wind beneath it. This fact is distinctly indicated by the following observations for October 20th, 7.35 A. M., from stations west of the limits of the rain area.

	WIND.		Direction of upper clouds.	Amount of clouds.
	Direction.	Velocity.		
Alpena	North.	9 miles.	S.W.	$\frac{4}{4}$
Detroit	North.	12 "	South.	$\frac{4}{4}$
Louisville ...	North.	16 "	South.	$\frac{1}{4}$
Toledo	North.	15 "	S.E.	$\frac{3}{4}$

In No. 48, south winds generally prevailed in Georgia and the Carolinas, with cold winds from the west and northwest in the Northwestern States. This westerly current probably pushed under the south wind from the ocean and lifting it up from the earth's surface condensed its vapor, and it is presumed that this south wind prevailed as an upper current at many places where the northwest wind prevailed at the surface. We thus see that during heavy rain-falls the wind generally blows from some quarter between south and northeast, or if it blows from any other quarter its velocity is quite small; but occasionally a great rain-fall occurs with a strong wind from some quarter between north and southwest and in such cases it is presumed that at the same time an easterly wind prevails at those places as an upper current. This upper current from the east is generally concealed by the lower clouds whose motion is nearly the same as that of the surface wind; but when the lower clouds are broken, the movement of this upper current can sometimes be seen.

The average velocity of the wind at the date of the observations in the table on page 2, was ten miles per hour, and at the date of the preceding observations it was eleven miles per hour; and in only six cases did the velocity rise as high as twenty-five miles per hour, either at the date given in the table or at the preceding observation. Thus we see that the heaviest rain-falls are seldom accompanied by very high wind.

One of the most noticeable facts connected with extensive rain-falls is the tendency to the formation of several centers of precipitation. If in each of the cases mentioned in the table on page 2 we trace the boundary of that area over which the rain-fall was at least one inch, we shall find that in half of these cases there were two such areas distinct from each other, and in eleven cases there were three such areas. If we trace the area of a rain-fall of at least one-half inch, we shall find that in forty-five cases there were at least two distinct rain-areas, and in twenty-nine cases there were three or more such areas. If we trace the area of a rain-fall of one-fourth inch or more, we shall find that there are only three cases, viz:

Nos. 8, 24, and 45, in which there were not at least two distinct rain-centers. In No. 45 there was apparently a subordinate rain-center, near Charleston, and in No. 8 there was a fall of 0·14 inch at Alpena, which was beyond the principal rain-area. Thus we see that when there is an extensive rain-fall in the United States there is almost invariably more than one center of precipitation, and this fact suggests the idea that those conditions which are favorable to rain-fall at one locality, are generally favorable to rain-fall over a much larger district, and this often results in a simultaneous precipitation at several points remote from each other.

Plate II exhibits the rain-areas for July 27th, 1873, at 4.35 P. M. Here we find four rain-areas showing a rain-fall of at least one inch, and an equal number of areas showing a smaller rain-fall. The following table shows the greatest amount of rain observed at any station within each of these areas:

Rain-fall July 27, 1873, 4.35 P. M.

Washington	2·12 inches.	Shreveport	0·84 inch.
New York	1·54 "	Breckenridge	·45 "
Nashville	1·35 "	Wilmington	·18 "
Eastport	1·00 "	Denver	·09 "

It is possible that the Washington rain area was not entirely distinct from the New York area, but the observations clearly indicate two centers of greatest rain-fall. During the time of this rain-fall, the barometer was a little above 30 inches at all of the stations here mentioned, except Breckenridge. The arrows show the direction of the wind at 4.35 P. M. There were decided local cyclones near Washington, New York, and Nashville, and indications of opposing winds near Shreveport and Breckenridge. It is presumed that if the stations had been sufficiently numerous, the same fact would have been established for each of the rain-areas. As the largest of these cyclonic areas had a diameter less than a 1,000 miles, and the velocity of the winds was almost everywhere less than ten miles per hour, no perceptible effect was produced upon the barometer.

A considerable number of the cases mentioned in the table on page 2, exhibit a variety of rain-areas nearly as remarkable as that shown in Plate II. Among these may be mentioned Nos. 1, 2, 3, 12, 14, 33, 36, and 41.

In order to determine the duration of great rain-falls, I selected all those cases in which any of the rain-falls mentioned in the table on page 2, were followed by at least four inches of rain (total amount at the eighty stations) during a succeeding period of eight hours. The following table shows the result of this comparison.

Heavy Rain (four inches aggregate in eight hours) continuing more than eight hours.

Date.	Total rainfall.	Station of greatest rain.	Date.	Total rain.	Station.	Date.	Total rain.	Station.	Date.	Total rain.	Station.	Date.	Total rain.	Station.	Date.	Total rain.	Station.
1872.																	
Sept. 11.3	10·76	Marquette.[1]	12.1	4·02	Grand Haven[2]	12.2	9·93	Saugeen.[3]									
Oct. 6.3	8·75	Vicksburg.	7.1	5·91	Pittsburg.	7.2	8·58	Montreal.	7.3	6·05	Norfolk.						
22.3	8·30	Jacksonville.[1]	23.1	9·34	Jacksonville.[2]	23.2	4·45	Charleston.[3]									
25.1	8·91	Norfolk.[1]	25.2	7·09	New York.[2]	25.3	5·03	Pittsburg.[3]	26.1	8·80	Philadelphia.[4]	26.2	5·77	Mt. Wash'ton.[5]			
Nov. 6.3	9·91	Montgomery.	7.1	13·52	New York.[1]	7.2	6·27	New London.[2]									
Dec. 20.1	14·49	New York.[1]	20.2	5·31	Boston.[2]												
26.1	9·46	Norfolk.[1]	26.2	6·10	Philadelphia.[2]												
1873.																	
Jan. 2.2	9·12	Keokuk.	2.3	6·37	Port Stanley.[1]	3.1	8·63	New York.[2]									
5.1	12·74	Lake City.	5.2	16·25	Philadelphia.												
16.1	10·08	New Orleans.	16.2	6·23	Detroit.	16.3	4·95	Lynchburg.[1]	17.1	8·05	Philadelphia.[2]						
Feb. 16.1	10·57	Louisville.[1]	16.2	9·87	Cape May.[2]												
Mar. 29.1	10·65	Lake City.	29.2	10·48	Oswego.[1]	29.3	5·80	Rochester.[2]									
April 8.1	8·70	Indianapolis.[1]	8.2	8·57	St. Louis.[2]	8.3	4·48	Nashville.[3]									
May 1.2	9·37	Montgomery.	1.3	7·95	New Orleans.	2.1	11·78	Wilmington.[1]	2.2	8·49	Wilmington.[2]	2.3	4·46	Boston.	3.1	4·58	Pittsburg.
8.1	8·33	Lynchburg.[1]	8.2	7·14	Washington.[2]	8.3	4·89	Cape May.[3]	9.1	7·88	Indianola.	9.2	7·98	New London.	9.3	4·44	Grand Haven.
June 30.2	9·23	Port Stanley.[1]	30.3	5·23	Oswego.[2]	1.1	4·95	Denver.									
July 27.2	9·63	Washington.[1]	27.3	7·31	Philadelphia.[2]												
Aug. 13.1	9·52	Philadelphia.[1]	13.2	8·27	Philadelphia.[2]	13.3	7.81	Baltimore.[3]	14.1	7.42	Breckenridge.	14.2	5·89	Boston.[1]	14.3	4·61	Portland,[2] Me.
															[15.1	4·25	Denver.
21.1	9·56	Galveston.[1]	21.2	7·06	Mobile.[2]												
Sept. 19.2	11·39	Cape May.[1]	19.3	8·96	Mt. Wash'ton.[2]	20.1	6·32	Wilmington.									
28.1	8·69	Fort Gibson.[1]	28.2	6·28	Fort Gibson.[2]	28.3	4·27	Chicago.[1]	29.1	7·65	Alpena.[2]						
Oct. 19.3	9·82	New London.[1]	20.1	17·65	Philadelphia.[2]	20.2	12·27	Rochester.[3]	20.3	9·86	Buffalo.[4]	21.1	5.90	Cleveland.[5]			
27.1	8·30	Knoxville.	27.2	8·68	Cape May.												
Nov. 8.1	8·64	Boston.[1]	8.2	5·09	Eastport.[2]												
18.1	8·23	Boston.	18.2	9·23	Sydney.												
24.1	11·16	Nashville.	24.2	14·69	New London.												

We thus see that in a period of fifteen months there were twenty-six cases in which a total rain-fall of eight inches in eight hours was followed by a total rain-fall of more than four inches in the next eight hours; there were sixteen cases in which it was followed by a similar rain-fall for a third period of eight hours; there were eight cases of a fourth period of eight hours; five cases of a fifth period; three cases of a sixth period; and one case of a seventh period of eight hours. These rain-areas which succeeded each other in order of time, were not, however, in all cases apparently connected with each other; that is, they were not continuous rain-areas, or even adjacent to each other. Those cases which were apparently thus connected, I have indicated by the numerals 1, 2, 3, etc., attached to the names of the stations. It must not be inferred that these rain-areas had in all cases a proper movement of translation in the direction of the stations here indicated. In some cases this apparent movement resulted from a slight increase of precipitation in one part of an extensive rain-area, and a decrease in some other part. This remark will probably explain two or three of the cases in which the apparent movement of the rain-area was from east to west. In one case however, viz: October 19th, 1873, the rain-area did unquestionably advance westward for forty-eight hours as shown on page 4. The average rate of motion of the rain-areas indicated by numerals in the table, is 20·7 miles per hour.

This table shows that great rain-areas are seldom of long continuance. In twenty-three cases the same rain-area continued for at least two periods of eight hours; in seven cases it continued for at least three periods; and in only two cases did it continue for more than three periods, that is, twenty-four hours. We thus see that rain-areas with a total rain-fall of at least four inches in eight hours, for eighty stations, seldom continue for more than twenty-four hours, only two or three such cases occurring in the United States during a year. This fact seems to indicate that the causes which produce rain, instead of deriving increased force from the rain-fall, rapidly expend themselves and become exhausted. This fact cannot be explained by supposing that the vapor of the air has all been precipitated, because these cases chiefly occur near the Atlantic coast, where the wind which supplies the vapor comes from the ocean, and the supply is therefore inexhaustible. The facts seem rather to indicate that the forces which impart that movement to the air which is requisite to a precipitation of its vapor, become exhausted after a few hours exercise.

Of the fifty-five cases included in the table on p. 2, in twenty-seven cases the place of greatest rain-fall was on the Atlantic coast. But only one-fifth of all the stations are on the Atlantic coast; that is, the center of great rain-areas is found near the Atlantic coast *four times* as frequently as it is in the other portions of the United States. The center of great rain-areas is not found in the neighborhood of the great Lakes more frequently than it is at inland stations quite distant from the Lakes.

The distribution of these fifty-five cases by seasons was as follows:

Spring 8; Summer 9; Autumn 10 and 16; Winter 12;

showing a slight predominance of great rain-areas in autumn and winter. In my last paper it was shown that excessive rains at single stations were most common during the warmest months; but it appears that very extensive rain-falls are most common during the cooler months.

The distribution of these cases according to the hour of the day was as follows:

7.35 A. M. 25 cases; 4.35 P. M. 22 cases; 11 P. M. 8 cases.

After correcting these numbers for the inequality of the time intervals, we still find that from 4.35 to 11 P. M. great rain-falls are *not half as frequent* as during the remainder of the day. This result is quite similar to that found in my last paper with regard to great rain-falls at single stations south of latitude 36°. It is essential to the accuracy of this conclusion that the record in each case should show the actual rain-fall since the preceding observation. There are a few cases in which the last column of the record reports *heavy rain*, but the rain-column makes no mention of rain. It is presumed that generally in these cases the rain had but recently commenced, and the observer thought it would be equally satisfactory to report the entire rain-fall at the time of the next observation. There seems no reason to question the conclusion which these numbers indicate, viz: that the causes which produce excessive rain-falls in the United States, act with less intensity in the evening than during the remainder of the day.

Areas of low pressure without rain.

In order to compare the influence of a very small rain-fall with that of a very great rain-fall, I selected all those cases during a period of fifteen months (September, 1872 to November, 1873) in which the rain-fall did not amount to one-tenth of an inch in eight hours at any of the stations. The following table exhibits these cases. Column 1st contains the number of reference; column 2nd shows the day and hour of observation; column 3d shows the total rain-fall for the preceding eight hours at all the stations. In September, 1872, the num-

Rain-fall less than one-tenth of an inch in eight hours at any station.

No.	Date.	Total rain-fall.	Low Bar.	Station.	Low moved Direction.	Vel.	Rain in Low.	High Bar.	Station.
	1872.								
1	Sept. 2.3	0·04	29·65	Fort Sully.	*	0	0·00	30·25	Marquette.
2	3.1	·06	·67	Fort Sully.	East.	4	·01	·26	Escanaba.
3	14.2	·02	·71	Fort Sully.	East.	22	·00	·30	Saugeen.
4	14.3	·02	·66	Fort Sully.	East.	6	·00	·29	Toronto.
5	15.1	·06	·84	Duluth.	East.	28	·00	·35	Kingston.
6	20.3	·04	·63	Leavenworth.	N. 41 E.	15	·00	·23	Augusta.
7	21.3	·07	·77	Chicago.	*	0	·04	·22	Wilmington.
8	Oct. 1.2	·33	·67	Fort Sully.	N. 69 E.	24	·00	·22	Nashville.
9	1.3	·07	·86	Duluth.	N. 69 E.	24	·00	·27	Nashville.
10	4.2	·12	·68	Keokuk.	East.	7	·03	·07	Jacksonville.
11	5.1	·14	·82	Escanaba.	N. 18 E.	22	·05	·35	Portland, Me.
12	8.3	·13	·71	Marquette.	East.	17	·00	·21	Lynchburgh.
13	11.2	·04	·82	Fort Sully.	?	?	·00	·30	Cincinnati.
14	11.3	·00	·82	Duluth.	East.	15	·00	·30	Cincinnati.
15	12.1	·00	·71	Marquette.	East.	17	·00	·30	Lynchburgh.
16	12.2	·10	·69	Alpena.	S. 67 E.	24	·01	·15	Portland, Me.
17	14.3	·08	·59	Breckenridge.	N. 62 E.	42	·00	·24	Vicksburg.
18	15.1	·05	·49	Escanaba.	S. 68 E.	33	·05	·24	Knoxville.
19	15.2	·29	·47	Grand Haven.	S. 36 E.	30	·29	·15	Savannah.
20	15.3	·24	·53	Saugeen.	N. 86 E.	29	·24	·21	Augusta.
21	16.3	·08	·83	Fort Sully.	N. 82 E.	47	·00	·34	Philadelphia.
22	19.3	·03	·86	Omaha.	N. 54 E.	5	·00	·27	Cincinnati.
23	20.1	·00	·80	Omaha.	N. 52 E.	4	·00	·32	Nashville.
24	20.2	·00	·60	Breckenridge.	N. 47 E.	5	·00	·25	Norfolk.
25	20.3	·01	·58	Marquette.	N. 55 E.	45	·00	·27	Norfolk.
26	21.1	·07	·62	Escanaba.	S. 77 E.	15	·00	·32	Norfolk.
27	21.2	·10	·77	Milwaukee.	S. 16 E.	11	·00	·28	Norfolk.
28	31.2	·00	·77	Escanaba.	East.	?	·00	·24	Nashville.
29	Nov. 15.2	·39	·59	Quebec.	East.	?	·23	·67	Fort Benton.
30	15.3	·28	·75	Quebec.	East.	?	·15	·58	Fort Benton.
31	16.3	·16	·96	Quebec.	East.	?	·02	·65	Nashville.
32	17.3	·06	30·11	Alpena.	East.	?	·00	·71	Leavenworth.
33	21.1	·07	29·69	St. Paul.	S. 58 E.	36	·05	·44	Lynchburgh.
34	21.2	·05	·73	Alpena.	East.	35	·05	·30	Cape May.
35	21.3	·09	·76	Escanaba.	East.	6	·06	·24	Lynchburgh.
36	23.2	·10	·70	Denver.	S. 32 E.	15	·00	·42	Mobile.
37	27.3	·02	·91	Quebec.	East.	?	·02	·64	Breckenridge.
38	28.1	·00	30·09	Escanaba.	?	?	·00	·71	Breckenridge.
39	30.3	·17	29·32	Pembina.	East.	18	·16	·36	Jacksonville.
40	Dec. 3.3	·18	·99	Fort Sully.	East.	10	·00	·47	Nashville.
41	4.1	·11	·94	Fort Sully.	East.	14	·00	·51	Nashville.
42	4.2	·07	30·03	St. Paul.	S. 86 E.	42	·00	·38	Cincinnati.
43	6.2	·13	·04	Fort Sully.	East.	?	·00	·45	Davenport.
44	6.3	·04	·00	Fort Sully.	East.	?	·00	·41	Davenport.
45	7.1	·09	29·67	Pembina.	N. 49 E.	31	·05	·39	Memphis.
46	14.2	·11	·59	Milwaukee.	N. 73 E.	48	·06	·47	Breckenridge.
47	14.3	·22	·73	Alpena.	N. 69 E.	37	·12	·44	Omaha.
48	31.3	·43	·67	Santa Fe.	East.	14	·01	·43	Davenport.
	1873.								
49	Jan. 10.2	·13	·82	Montreal.	East.	?	·00	·62	Memphis.
50	11.3	·08	·55	Fort Sully.	S. 74 E.	15	·08	·57	Augusta.

Table continued.

No.	Date.	Total rain-fall.	Low Bar.	Station.	Low moved Direction.	Vel.	Rain in Low.	High Bar.	Station.
	1873.								
51	Jan. 12.3	0·10	29·73	Milwaukee.	S. 88 E.	50	0·08	30·56	Boston.
52	19.2	·39	·43	Fort Garry.	S. 72 E.	13	·07	·28	Mobile.
53	19.3	·20	·41	Fort Garry.	S. 81 E.	14	·13	·27	Mobile.
54	Feb. 1.1	·19	·65	San Francisco.	East.	18	·00	·95	Fort Sully.
55	1.3	·07	·67	San Francisco.	East.	13	·02	·74	Davenport.
56	9.1	·33	·57	Quebec.	East.	?	·11	·51	Vicksburg.
57	10.1	·08	·50	Fort Garry.	East.	27	·00	·50	Washington.
58	10.2	·08	·43	Escanaba.	East.	36	·06	·41	Savannah.
59	17.3	·10	·38	Omaha.	N. 76 E.	46	·10	·29	Oswego.
60	23.2	·32	·63	Corinne.	?	?	·00	·24	Fort Sully.
61	25.2	·25	·32	Denver.	S. 62 E.	14	·10	·16	Chicago.
62	28.2	·32	·77	Cheyenne.	East.	5	·11	·38	Cleveland.
63	Mar. 5.2	·10	·51	Virginia City.	East.	?	·08	·66	Kingston.
64	5.3	·00	·42	Virginia City.	East.	?	·00	·72	Baltimore.
65	6.1	·03	·45	Fort Benton.	East.	?	·02	·78	Lynchburgh.
66	13.1	·02	·92	Fort Benton.	?	?	·00	·42	Nashville.
67	13.2	·03	·58	Virginia City.	East.	20	·01	·33	Savannah.
68	13.3	·02	·79	Corinne.	East.	20	·00	·40	Savannah.
69	16.3	·04	·68	Santa Fe.	East.	7	·03	·40	Cincinnati.
70	22.2	·10	·64	Omaha.	East.	32	·00	·30	Fort Sully.
71	22.3	·01	·66	Marquette.	East.	32	·00	·47	Fort Sully.
72	27.3	·05	·41	Omaha.	S. 50 E.	42	·00	·36	Norfolk.
73	April 4.1	·08	·31	Yankton.	East.	7	·03	·26	Kingston.
74	4.3	·05	·50	Leavenworth.	East.	5	·01	·36	Kingston.
75	21.2	·08	·45	Leavenworth.	S. 29 E.	29	·00	·26	San Francisco.
76	May 16.1	·09	·58	Santa Fe.	?	?	·07	·16	Duluth.
77	June 20.2	·23	·60	Fort Sully.	?	?	·00	·13	Mobile.
78	July 6.3	·04	·78	Omaha.	East.	5	·00	·12	Denver.
79	12.3	·12	·48	Breckenridge.	S. 50 E.	13	·10	·29	New London.
80	21.3	·17	·39	Fort Garry.	N. 39 E.	9	·02	·19	Lynchburgh.
81	Sept. 11.3	·09	·62	Marquette.	East.	7	·02	·29	Fort Benton.
82	21.1	·30	·76	Fort Garry.	East.	13	·04	·34	Washington.
83	Oct. 2.2	·06	·79	Havannah.	?	?	·01	·27	Marquette.
84	2.3	·06	·83	Havannah.	?	?	·00	·32	Marquette.
85	9.2	·00	·49	Fort Garry.	?	?	·00	·34	Chatham.
86	9.3	·08	·58	Fort Garry.	East.	?	·02	·36	Chatham.
87	10.2	·04	·68	Fort Garry.	?	?	·00	·35	Corinne.
88	10.3	·02	·86	Duluth.	East.	?	·00	·34	Cheyenne.
89	12.3	·23	·51	Fort Garry.	East.	19	·00	·39	Portland, Or.
90	13.3	·15	·87	Alpena.	East.	?	·00	·31	Wilmington.
91	14.2	·11	·66	Yankton.	N. 71 E.	25	·01	·34	Wilmington.
92	14.3	·02	·72	Fort Sully.	N. 71 E.	6	·02	·44	Saugeen.
93	15.3	·03	·95	St. Paul.	East.	20	·00	·52	Cape May.
94	30.1	·30	·71	Duluth.	S. 69 E.	27	·21	·48	Philadelphia.
95	Nov. 9.3	·16	·38	Cape Rozier.	?	?	·02	·36	Corinne.
96	10.1	·02	·48	Farther Point.	?	?	·00	·38	Corinne.
97	10.2	·09	·87	Fort Sully.	?	?	·00	·34	Corinne.
98	13.3	·18	·61	Virginia City.	N. 77 E.	25	·00	·23	Portland, Or.
99	14.1	·17	·43	Fort Garry.	N. 77 E.	25	·00	·36	Portland, Or.
100	14.2	·17	·41	Fort Garry.	N. 77 E.	25	·09	·34	Portland, Or.
101	16.1	·11	·33	Oswego.	S. 79 E.	29	·11	·46	Corinne.

ber of stations was seventy-two, but this number was gradually increased and in November, 1873, amounted to eighty-eight. Column 4th shows the height of the barometer at the nearest center of minimum pressure; column 5th shows the station at which the pressure given in column 4th was observed; column 6th shows the direction in which the low center had moved during the last eight hours, and column 7th shows the velocity with which it moved expressed in miles per hour. Column 8th shows the total amount of rain observed within the area of low barometer; that is, at the stations where the pressure was less than thirty inches. Frequently there was at the same time a second center of low pressure near the borders of the United States, but columns 4–8 refer exclusively to the first center; column 9th shows the height of the barometer at the center of maximum pressure, and column 10th shows the station at which this high pressure was observed. Frequently there was at the same time more than one center of high pressure within the limits of the United States, but columns 9 and 10 refer to that which was regarded as the principal center.

This table shows that barometric minima frequently occur with very little rain. Of the 101 cases here mentioned, more than half showed a pressure less than 29·70; more than one-third were below 29·60, and nearly one-quarter of the cases were below 29·50. The average pressure at the stations of greatest rain-fall mentioned in the table on page 2, was 29·74, and the average pressure at the center of the low barometer attending these remarkable rain-falls was 29·47.

It may be urged that these cases of minimum pressure generally occurred in that region where the stations of observation were widely separated, and that rain may have occurred at intermediate points where there was no observer. There is, however, a considerable number of cases in which the area of low barometer included a large number of stations. In about half of the cases there were at least twenty stations which showed a pressure below thirty inches; in one-third of the cases there were at least thirty stations which showed a pressure below thirty inches; and in several cases there were over fifty stations which showed a pressure below thirty inches. The following table contains the most important examples. Column 1st shows the number of reference from the preceding table and column 2nd shows the number of stations at which the barometer was below thirty inches.

There seems to be no room for doubt that barometric minima sometimes form with little or no rain, and continue without any considerable rain for eight hours, and sometimes for twenty-four hours or longer. These barometric minima seldom continue stationary for eight hours, but almost invariably

Number of stations within the area of low barometer.

No.	Stations	No.	Stations	No.	Stations	No.	Stations	No.	Stations	No.	Stations
75	70	60	47	35	43	74	39	16	32	59	30
101	67	39	45	7	43	100	39	24	31	61	30
77	58	70	45	17	42	58	35	36	31	90	30
19	53	53	44	18	42	73	34	11	30		
76	51	34	44	10	41	39	34	27	30		
20	48	52	43	71	39	6	33	29	30		

travel to the eastward. In several cases the center of least pressure was beyond the limits of the United States so that it is impossible to assign satisfactorily either the direction of their progress or their rate of motion. The table on pages 14 and 15 shows the best results I have been able to deduce from the observations. The average of all these directions is a little north of east, and the average velocity is 20·7 miles per hour. This direction is not quite as northerly as that given in my third paper for barometric minima generally, and the velocity is twenty per cent less.

In order to show more clearly the movement of the barometer during these periods of small rain-fall, I have represented upon Chart III the iso-baric curves for one of these periods, viz: October 19–21, 1872. The most western oval represents the isobar 29·8 for October 19th; the next curve represents the isobar 29·6 for October 20th; and the most eastern curve represents the isobar of 29·8 for October 21st; each of the curves corresponds to the 4.35 P. M. observation. It will be seen that during the first twenty-four hours, the center of least pressure moved only about five miles per hour; but during the next twenty-four hours the average motion was twenty-two miles per hour. During these forty-eight hours not a drop of rain was recorded at any station within the area of a pressure less than thirty inches, although on the 20th of October this area had a diameter of 1,500 miles.

The observations on the amount of cloudiness at the different stations confirm the observations of rain-fall. The following table presents a summary of these observations. Column 2d shows the number of stations within the area of low barometer (i. e., less than thirty inches pressure) at which the sky was reported to be entirely clear at the dates given in column 1st, except that the air was very generally reported to be *smoky* or *hazy*; column 3d shows the number of stations at which the sky was partly cloudy; and column 4th shows the number of stations at which the sky was entirely overcast.

The following are the stations at which the sky was reported to be overcast, viz: October 19.2, Virginia City and Duluth; 20.2, Corinne, Cheyenne and Duluth; 20.3, Denver, Cheyenne

	No clouds.	Partly cloudy.	Entirely overcast.
Oct. 19.2	5 stations.	2 stations.	2 stations.
19.3	8 "	2 "	none.
20.1	9 "	5 "	none.
20.2	13 "	7 "	3 stations.
20.3	15 "	3 "	3 "
21.1	5 "	7 "	3 "
21.2	4 "	9 "	5 "

and Duluth; 21.1, St. Paul, Duluth and Escanaba; 21.2, Santa Fe, Duluth, La Crosse, Keokuk and Toronto. Six of these cases occurred in the neighborhood of the Rocky Mountains, so remote from the center of least pressure that if there had been a rain-fall in that vicinity, it could not be supposed to be the cause of the barometric minimum under discussion. The long continuance of clouds at Duluth, and the extension of this cloud area on the 21st indicates an upward movement of the atmosphere attended with a slight precipitation of vapor, and there may have been rain-fall at places further north. But when we consider that in the Southern States a heavy rain-fall covering an area several hundred miles in diameter exerts scarcely any appreciable influence on the barometer, we cannot suppose that the very limited rain-fall which may possibly have occurred from October 19th to the 21st had any sensible influence in the production of the barometric minimum, or in causing its eastern progress, so that it seems safe to conclude that *rain-fall is not essential to the formation of areas of low barometer, and is not the principal cause of their formation or of their progressive motion.*

The barometric minimum October 19th, appears to have resulted from an area of high barometer (30·35) in the neighborhood of the Ohio valley combined with an area of high barometer (30·29) in Oregon. This excess of barometric pressure on opposite sides caused a general movement of the intermediate atmosphere towards the valley of the upper Missouri, and each of these currents being deflected to the right by the earth's rotation the result was a diminution of pressure over the region between the Rocky Mountains and Lake Superior. These two areas of high barometer on opposite sides of the low area were remarkably persistent from October 19th to 21st, but advanced eastward at about the same rate as the barometric minimum. Plate III, shows the direction of the winds October 20th, 4.35 P. M. They indicate a decided inward movement of the air and a circulation about the center of low pressure. At several of the stations the winds were uncommonly strong. The following table shows the direction and force of the wind where the velocity was greatest.

	Direction.	Velocity.		Direction.	Velocity.
Fort Sully	N.W.	36 miles.	Davenport	S.W.	18 miles.
Duluth	N.E.	28 "	Leavenworth	S.	18 "
Chicago	S.	23 "	Escanaba	S.E.	16 "
Grand Haven	S.	19 "	Omaha	S.	16 "

The distribution of the cases of small rain-fall mentioned in the table on pages 14 and 15, according to the seasons of the year, is as follows:

Spring, 14 cases. Summer, 4 cases.
Autumn, 39 and 21 cases. Winter, 23 cases.

We see that these cases occur most frequently in the autumn and especially in the month of October. They are generally accompanied by a hazy or smoky condition of the atmosphere, and this is the phenomenon which is generally known under the name of *Indian Summer.* It appears to be due to an uncommonly tranquil condition of the atmosphere extending entirely across the continent; and similar cases frequently occur in each month of the year from September to March, but are most common in October.

A comparison of all the facts which have been presented in this paper, together with my six former papers, appears to warrant the following generalizations.

1. Areas of low barometer result from a general movement of the atmosphere towards a central area, and this movement is accompanied by a deflection of the wind to the right, which causes a tendency to circulate around the center with a motion spirally inward.

2. This deflection to the right, which results from the earth's rotation, causes a diminished pressure within the area of this inward movement, and the pressure is still further diminished by the centrifugal force resulting from the circulation about a center.

3. The amount of the barometric depression depends upon the force of the wind, and the geographical extent of the revolving atmosphere. The effect of centrifugal force is not considerable except when the velocity of the wind approaches that of a hurricane. With a velocity of 100 miles per hour, the depression due to centrifugal force may amount to about two inches; but in the winter storms of the middle latitudes with a velocity not exceeding forty miles per hour, the depression due to centrifugal force seldom exceeds one or two-tenths of an inch. In these storms, three-quarters of the observed depression of the barometer is usually the effect of the earth's rotation; but in order that the depression at the center may amount to as much as one inch, it is generally necessary that this system of circulating winds should prevail over an area nearly 2,000 miles in diameter.

4. In North America, south of latitude 35°, areas of low pressure are less frequent and generally exhibit a less depression than near latitude 45°, because the area over which a cyclonic movement of the winds prevails is small; and this area is small because if a cyclonic area could be formed having a radius of 1,000 miles with its center in latitude 30°, its circumference must extend southward to latitude 16°, where the trade winds are steady and seldom interrupted. Such a diversion of the winds toward the north, even if it could be produced, could not be long maintained; so that a large cyclonic area with its center in latitude 30° is well nigh impossible; and it is impossible that there should be a great depression of the barometer in latitude 30°, except with a wind having a hurricane velocity. This is believed to be the reason why in North America the centers of great storms are generally found north of latitude 40°.

5. The causes which may produce a general movement of the atmosphere toward a central area are (A) unequal pressure as shown by the barometer; (B) unequal temperature; and (C) unequal amount of aqueous vapor. Of these three causes the effect of the first is generally so decided that the influence of the other two causes can only be detected by careful observation; but when the pressure of the air is nearly uniform over a large extent of country, the influence of the other two causes is sometimes very palpable, and their influence is generally seen in a slight deflection of the winds from the direction they would have if wholly controlled by the first cause. I have made a considerable collection of facts illustrating the influence of temperature upon the direction of the winds, which I intend to publish hereafter.

6. A cyclonic movement of a large mass of air is generally attended by an upward motion in certain localities, chiefly on the eastern side of the center of low pressure, and this upward movement results in rain-fall. The rain-fall is then not generally the original cause of the barometric depression, but rather an incident of the cycloidal movement of the atmosphere. The fall of the barometer during a rain storm cannot be ascribed to the simple condensation of the vapor of the atmosphere, as some have supposed, since a rain-fall of one or two inches prevailing over an area 300 miles in diameter near latitude 30° produces scarcely an appreciable effect upon the barometer. See tables on pages 2 and 3.

7. The progress of areas of low barometer in all latitudes is determined mainly by the same causes which determine the general system of circulation of the atmosphere; and their normal direction is changed by whatever causes may change the direction of the winds.

8. The heat which is liberated in the condensation of a large amount of aqueous vapor must exert an influence upon the movements of the air, so that while the rain is generally to be regarded not as the original cause but rather as one of the incidents of extensive cycloidal movement, if the rain-area has great geographical extent, it may have a decided influence upon the amount of the barometric depression and upon the velocity with which the storm advances; sometimes accelerating its motion, sometimes retarding it, and sometimes holding it nearly stationary in position for two or three days. In my former papers I have presented some facts which seem to authorize these statements, and I am collecting additional facts bearing upon the same question.

It may be thought that these generalizations present nothing original or novel, but several of them are disputed by meteorologists who have given no little attention to the subject.

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

ART. II.—*The Germination of the genus* MEGARRHIZA, TORR.; by ASA GRAY.

THE object of this brief communication is to describe a peculiar structure which *Megarrhiza Californica* exhibits in germination, and to call for observations upon other species, at the time of germination, in the hope of thereby extending our present imperfect knowledge of this genus of big-rooted *Cucurbitaceæ* of our Pacific coast. For the extraordinary peculiarity in question, being one which, in other cases, is known to exhibit itself in certain species of a genus (as in *Anemone* and *Delphinium*), and not in others, so it may in the present genus give aid in distinguishing the five species which have been characterized upon more or less incomplete or scanty materials.

The first species known was from Oregon; the specimens, being in flower only, were referred in Hooker's Flora Borealis Americana, i, 220, to *Sicyos angulatus*, but were separated in Torrey and Gray's Flora of North America, i, 542, under the name of *Sicyos Oreganus.* In the course of time it was found that there was a similar if not identical species in California, and apparently more than one, that they were perennial from very large and fleshy roots, that, while the flowers much resemble those of *Echinocystis*, the seeds were turgid, marginless, and with thick and fleshy cotyledons. Dr. Torrey, upon whom the examination of these plants devolved, many (about thirty) years ago proposed for them the generic name of *Megarrhiza;* but he refrained from publishing it, even omitted all mention of it in his account of Dr. Bigelow's excellent collection made in Whipple's Expedition (Pacif. R. Rep. iv, 1857), although good materials of that and other collections were in his hands, because he could not make up his mind whether he had to do with one variable species or with two or three. But in the sixth volume of the Pacif. Railroad Rep., which bears the same date of 1857, in Dr. Newberry's list of plants collected in Williamson's Expedition (p. 74), two species are enumerated, thus:

"*Megarrhiza Californica,* Torrey. Petaluma and Sonoma, California; April, in flower."

"*Megarrhiza Oregana,* Torrey. On the shores of Klamath Lake and banks of Willamette River, O. T.; August and September, in fruit."

Before this, however, viz: in March, 1855, Dr. Kellogg, of San Francisco, communicated to the California Academy of Natural Sciences (Proc. Calif. Acad., i, 38), an account of one of these species, apparently the second, under the name of *Marah muricatus.*

A few years later, some plants having been raised in France from Californian seeds, M. Naudin (in Ann. Sci. Nat., ser. 4, xii, 154, t. 9, under date of 1859, but, as the letter-press shows, not printed until 1860 or 1861), published the plant which Dr. Torrey had called *M. Californica* under the name of *Echinocystis fabacea.* This extension of *Echinocystis* was adopted by Bentham and Hooker in their Genera Plantarum. It was, moreover, anticipated by Dr. Kellogg, who, in a second communication to the Californian Academy, under date of June 4, 1855, re-describes his former *Marah muricatus,* states that it "legitimately belongs to *Echinocystis,*" and gives it the name of *E. muricatus.* When, shortly after Dr. Torrey's death, I superintended the printing of his account of the plants collected on our Pacific coast in Wilkes' Expedition, I found that he had left the article on this genus unwritten, and apparently had not determined either upon the number of the species or upon the distinctness of his proposed genus.

When in the recent preparation of the Botany of California the subject came to be studied anew by Mr. Watson, with the aid of more extensive materials, and when these materials were found to exhibit such diversities that at least five species had to be recognized (Bot. California, i, 240), with notable differences in ovary, fruit, seeds, etc., but no approximation to the eastern *Echinocystis,* it could hardly be doubted that Torrey's genus ought to be reinstated; and this was accordingly done.

The *M. Californica* had been raised in the Botanic Garden of Harvard University many years ago, but I had not seen the germination; and we were never able to bring the plant into blossom, as it invariably died down to the ground soon after making a moderate growth. On germinating some fresh seeds early this spring, I was somewhat surprised to find that they came up in the manner of beans. Instead of remaining hypogæous, as from the great thickness of the cotyledons would have been expected, the body of the seed in its shell was raised well out of the soil upon what seemed to be a well developed radicle, like that of *Echinocystis*. If the cotyledons had expanded, though remaining fleshy, in the manner of *Phaseolus*, the difference between this and *Echinocystis*, with cotyledons truly foliaceous in germination, would be much less than had been supposed. I waited long to see if this would occur; I also waited in vain for the expected development of the plumule from between the bases of the fleshy cotyledons. After the lapse of about a fortnight, the plumule in all three of my germinating plantlets came separately out of the soil of the pot; and, on exposing the whole to view, the state of things represented in fig. 1 came to view. That is, the plumule came forth from the base of what appeared to be an elongated radicle (of two or three inches in length); and below this the thickening of the root, which acquires enormous dimensions in old plants, had already commenced. A large amount of the nourishing matter stored in the cotyledons had been carried down to the root and used in its growth as well as that of the plumule. The latter came from a cleft at the very base of the seeming radicle, which otherwise appeared to be solid. But on cutting it across toward the base this was found to be tubular, as shown at the bottom of fig. 2; and later, when more spent and beginning to wither, this stalk was separable from above downward into two, as shown in the upper part of the same figure.

1.

This, therefore, is a case in which long petioles to the cotyledons (of which there is no appearance in the seed), connate into one body, are developed and greatly lengthened in place of the radicle, which is thus simulated. It is the same as in *Delphinium nudicaule* of California, and some other species; only in that genus the cotyledons expand and become foliaceous. In the horse-chestnut petioles are also developed to the cotyledons to a moderate extent, but without union, (see Gray's First Lessons, fig. 24), thus pushing the radicle and plumule well out of the firm seed-coat, in which the very heavy and fleshy cotyledons remain; and the radicle itself, as in the pea, does not further lengthen. In *Ipomœa leptophylla* the radicle remains in like manner short, while petioles to the (here foliaceous) cotyledons develope to a great length, bringing these separately out of the ground, and the plumule between follows later.

2.

Botanists on the Pacific coast are earnestly requested to examine the germination of all the species of *Megarrhiza*, and to compare them with the figures and description here given. At least three species should be met with near San Francisco, and in neighboring parts of California. According to the characters assigned by Mr. Watson in the Botany of California, *M. Californica* should be known by its obovoid seeds, of less than an inch in length, with a small hilum at the narrow base: *M. Marah*, by its more numerous seeds horizontally imposed in a large fruit (of four inches in length), each seed roundish and depressed, flattened, an inch in diameter and about half as thick, with a prominent lateral hilum. *M. muricata*, by a nearly naked fruit only an inch in diameter, containing only two globose seeds of half an inch in diameter. *M. Oregana*, which is known to occur from the Columbia River to the north of California, appears to have seeds resembling those of *M. Marah*, but rather smaller; but they are not well known. The remaining one, *M. Guadalupensis*, of Guadalupe Island, off Lower California, is much out of ordinary reach, unless it should be found in the southern part of the State.

Mature fruits and seeds of all the species are much desired.

Fig. 1 represents a germinating plantlet of *Megarrhiza Californica*, of natural size, complete except the lower part of the root. Fig. 2 represents the cotyledons at a later period, with their united petioles separated from above, still united into a tube below, the lower end of which is cut away.

ART. III.—*On the absorption of Bases by the Soil;* by H. P. ARMSBY.

THE question of the nature of the absorptive power of the soil for bases may be regarded as still to a certain extent an open one. Although the researches of Henneberg & Stohmann, Peters, Weinhold and others have shown conclusively that the absorption is accompanied by a chemical reaction between the salt whose base is absorbed and the soil, an equivalent quantity of other bases being dissolved; and though the investigations of Way, Eichhorn, Rantenberg, Heiden, Knop and Mulder have as conclusively connected this reaction with the presence in the soil of certain zeolitic silicates which appear to be the agents of absorption; it has been the opinion of many distinguished authorities, e. g., Liebig, Brustlein, Henneberg & Stohmann, that the prime cause of absorption is physical in its nature.

The fact which more than any other has served to sustain this view is the peculiar effect of the concentration and volume of the solution upon the amount of absorption. As is well known a given weight of soil absorbs a greater amount of a base from a concentrated than from a dilute solution, and more from a large than a small bulk of the same solution, though the variation is in neither case proportional. This, it is considered, is proof that absorption is at least in part due to physical and not chemical force.

This force seems generally to have been assumed to be analogous to the surface-attraction exhibited by charcoal and other porous bodies. Peters and others hold that the physical force is the prime cause, and that the chemical phenomena are only secondary, while others believe that chemical action is the prime cause and is modified by physical force. Knop advances the theory (Bonitirung der Ackererde, pp. 39 and 152, Fres. Zeit., xiv, 246) that the soil has the power of *dissociating* salts in the presence of some substance like calcium carbonate which can unite with the acid, and that then the chemical union of the base follows.

Pillitz (Fres. Zeit., xiv, 55 and 282) has indeed found that, if a large volume of solution be filtered through a soil until no further absorption takes place, the absorption is proportional to the amount of soil, and that at a certain concentration of the solution the absorption reaches a maximum above which it cannot be raised. He concludes from this that the objections to the chemical view based on the variability of absorption are removed, since in his experiments the absorption was constant.

But these facts, however interesting and important, neither do away with the variability of absorption as ordinarily determined nor rob that variability of its force as an argument for the physical nature of absorption, since as Pillitz himself says even the most dilute solution is not exhausted, which must be the case were the variations due simply to a lack of sufficient material to saturate the soil.

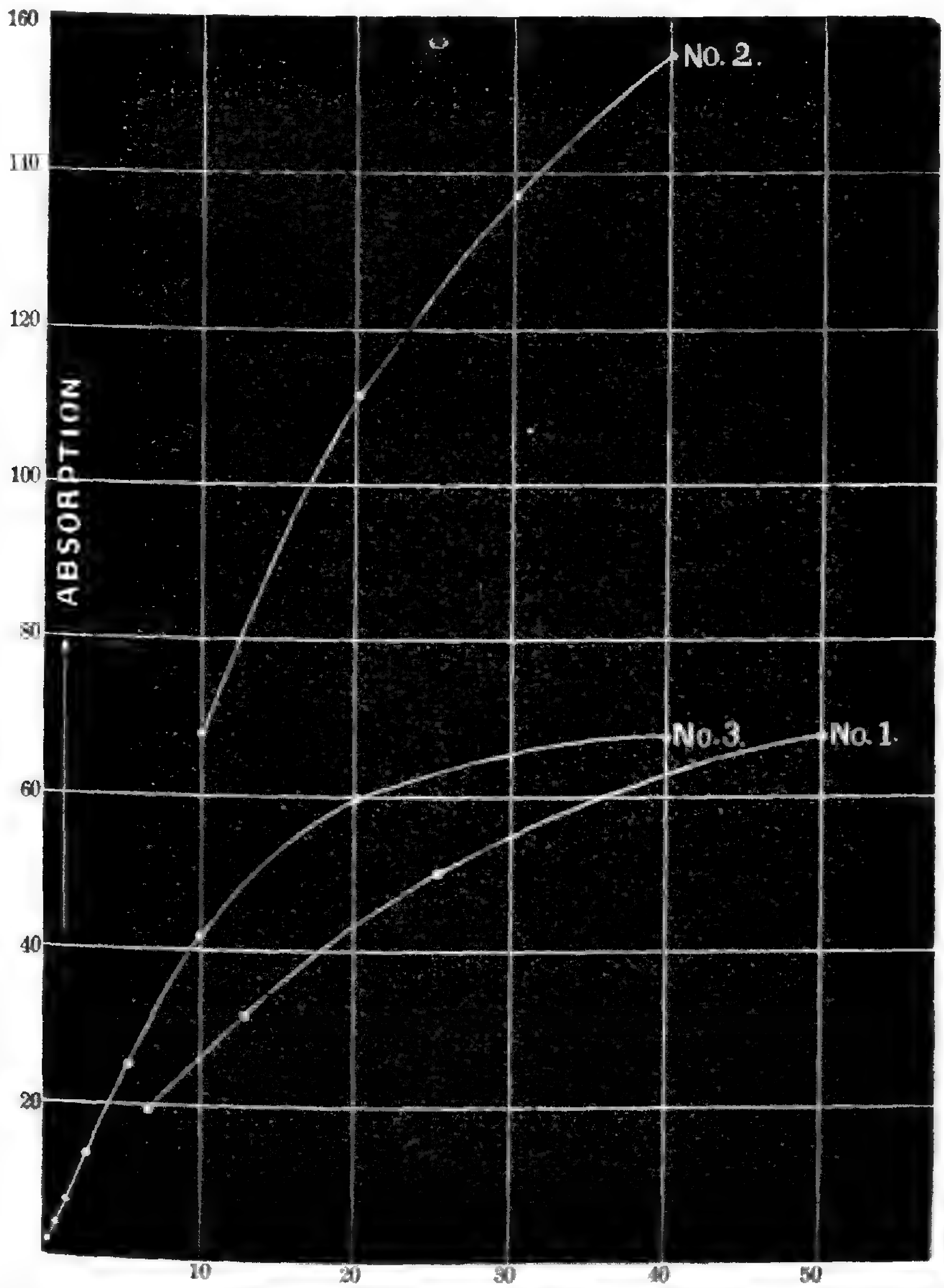
In view of the interest attaching to this question it seemed to me desirable to compare the behavior of the soil in this respect with that of pure hydrous silicates. If it should be found that the exchange of bases between these compounds and neutral salts showed the same variations as soil-absorption, then, whatever view might be held as to the cause of these variations, all possible objections to the theory which considers soil-absorption to be such an exchange of bases between the salt and the hydrous silicates known to exist in the soil would seem to be removed.

As illustrating the variations of soil-absorption the following determinations made in the laboratory of Prof. Knop in Leipzig may be adduced. Two soils were used: No. 1, Deposit of the Nile. No. 2, A loamy soil from the vicinity of Leipzig.

The absorptive power of these soils for ammonia was determined by Knop's method (Bonitirung der Ackererde, 49) by digesting the soil in the cold with a solution of NH_4Cl of known strength for forty-eight hours and determining the ammonia remaining in the fluid by means of the azotometer. The results denote the c. c. of nitrogen at 0° C. and 760 m.m. pressure contained in the ammonia absorbed, and the concentration of the solution employed is stated in the same way. It was found more convenient to vary the amount of the soil than of the solution.

				Absorption.	
	Nos.	N in 1 c. c. of Sol.	Wt. of Soil.	Soil No. 1.	Soil No. 2.
I.	1.	1·079 c. c.	50 grms.	67·7 c. c.	45·2 c. c.
	2.	----	25 "	49·6 "	28·4 "
	3.	----	12·5 "	31·5 "	16·2 "
	4.	----	6·25 "	18·4 "	9·3 "
II.	1.	2·158 "	50 "	111·9 "	67·3 "
	2.	----	25 "	77·7 "	38·2 "
	3.	----	12·5 "	52·2 "	20·3 "
	4.	----	6·25 "	33·1 "	12·7 "
III.	1.	3·237 "	50 "	137·8 "	
	2.	----	25 "	85·0 "	
	3.	----	12·5 "	48·8 "	
	4.	----	6·25 "	32·1 "	
IV.	1.	4·316 "	50 "	155·7 "	88·1 "
	2.	----	25 "	94·0 "	55·1 "
	3.	----	12·5 "	54·6 "	36·3 "
	4.	----	6·25 "	33·1 "	24·9 "

Representing graphically the results of the first series (I) we obtain the curve No. 1 in the figure, showing the influence of the relative volume of the solution on the absorption by soil No. 1. The other three series give exactly similar curves, and the influence of the concentration of the solution is seen in curve No. 2, which represents the absorption by fifty grams of soil No. 1 from solutions of increasing concentration.



But not only these experiments, but all others on the subject accessible to me show essentially the same result. With the exception of a single experiment by Laskowsky (Knop, Boni., etc., p. 150) the absorption never increases proportionally to the soil, nor is it, as is sometimes stated, independent of its amount.

In order to study the absorption of bases by hydrous silicates an artificial silicate was prepared in the method described by Way (Jour. Roy. Agr. Soc. of Eng., xi, 313).

Eighty grams of air dry aluminum hydrate were dissolved in a strong solution of soda (containing about 200 grams NaOH), the solution was diluted largely, and to it were added about 310 c. c. of commercial water-glass, containing 91 grms. SiO_2. A bulky, flocculent precipitate resulted which subsided readily and could be washed by decantation without much difficulty. The washing was continued till the washings showed no alkaline reaction, the precipitate collected on a filter and dried at 100° C. till it seemed dry to the touch. It was then pulverized, brought upon a filter, washed till the filtrate gave no precipitate with the solution of calcium chloride used in the experiments, and again partly dried at 100° C.

An analysis gave :—

Loss at 100° C	39·94
Dry substance	60·06
	100·00

The dry substance contains :—

SiO_2	48·42
Al_2O_3	23·16
Na_2O	14·20
H_2O	14·13
	99·91

A neutral solution of calcium chloride was also prepared by dissolving fused $CaCl_2$ in water, acidifying with HCl, and neutralizing with $CaCO_3$. 1 c. c. contained the equivalent of 0·01683 grams CaO.

Varying portions of the air-dry silicate were digested in closed flasks with the above solution diluted to five, ten, or twenty times its volume exactly as in the experiments with soil. The mixtures stood three days at ordinary temperature with frequent shaking, and then in 50 c. c. of the liquid the lime was precipitated as oxalate in the usual way, and weighed as oxide. The result calculated on the whole quantity of the solution and subtracted from the amount of lime originally present gave the absorption. The results in every case are expressed as CaO, as is also the strength of the solution employed. The following are the results.

	Nos.	CaO in 1 c. c. of sol.	Wt. of silicate.	Vol. of solution.	Absorption.
V.	1.	0·003366 grms.	40 grms.	200 c. c.	*[0·6732 grms.]
	2.	------	20 "	---	0·5952 "
	3.	------	10 "	---	0·4172 "
	4.	------	5 "	---	0·2432 "
	5.	------	2·5 "	---	0·1324 "
	6.	------	1·25 "	---	0·0680 "
	7.	------	0·625 "	---	0·0328 "
	8.	------	0·3125 "	---	0·0164 "

* Only traces of lime were left in the solution.

Nos.		CaO in 1 c. c. of sol.	Wt. of silicate.	Vol. of solution.	Absorption.
VI.	3.	0·001683 grms.	10 grms.	200 c. c.	0·2996 grms.
	4.	------	5 "	---	0·2084 "
	5.	------	2·5 "	---	0·1217 "
	6.	------	1·25 "	---	0·0673 "
	7.	------	0·625 "	---	0·0338 "
	8.	------	0·3125 "	---	0·0198 "
VII.	5.	0·000841 grms.	2·5 grms.	200 c. c.	0·1151 grms.
	6.	------	1·25 "	---	0·0663 "
	7.	------	0·625 "	---	0·0359 "
	8.	------	0·3125 "	---	0·0187 "

It will be seen that the same variations occur here as in soil-absorption. Representing the results of (V) graphically, and expressing the absorption in centigrams for convenience, we obtain the curve No. 3, similar in character to No. 1.

Further these results seem to correspond with those of Pillitz already mentioned. The existence of a "point of saturation" is simply due to the fact that there is a limit to the amount of replaceable bases in the soil. A similar limit seems to have been reached in some of these experiments. In experiment VII, 8, about two-thirds of the soda of the silicate has been replaced by lime, and an increase of concentration seems unable to carry the replacement further. The same is seen in VII, 7, and the corresponding ones of the other series, while in those experiments where this limit is not reached the absorption increases with the concentration in the same way as in soil-absorption. For the same reason, apparently, the absorption in the last four experiments of (V) and the last three of VI, decreases proportionally to the soil, seemingly unable to pass this limit of two-thirds. That the rest of the soda *cannot* be displaced is not probable, but it is evidently more difficultly replaceable. The high absorption of (VI, 8) is perhaps an error of experiment.

Since, now, it has been shown that the absorption of bases by hydrous silicates resembles in all essential particulars soil-absorption there would seem to be no reason why the latter should not be considered to be due chiefly to these silicates in the soil. That other agents may also be concerned to some extent, especially in the absorption of free bases, is doubtless true, but that any form of surface-attraction can decompose simple salts is yet to be proved.

In regard to the chemical or physical nature of absorption it will hardly be denied, in view of the results of Way, Eichhorn and Heiden, that the reaction between the hydrous silicates and a salt is essentially a *chemical* process consisting in a partial exchange of bases. The reason why the exchange is not complete would seem to be the same as the reason why, e. g., HCl and O when heated together are not completely converted into H_2O and Cl, or the reverse; or why, when two salts are mixed in solution, a partial decomposition takes place, as has been shown by Gladstone (Phil. Trans., 1855, p. 179) and others; viz: the so-called *action of mass*, or the tendency of the resulting new compounds to react on each other and re-produce the the original bodies. This tendency is specially marked when the total solubility of the system is nearly the same after and before the reaction, as where all the possible products are soluble or where one insoluble body gives rise to another.

The latter is exactly what occurs in soil-absorption, or the absorption of bases by pure silicates, and hence we may safely say that the variations caused by the volume and concentration are due to the influence of mass on a primarily chemical process.

This view has already been suggested by Ad. Mayer (Lehrbuch der Agricultur-chemie, ii, p. 93). It receives confirmation from the researches of Gladstone already alluded to. He added to a solution of ferric nitrate increasing portions of potassium sulpho-cyanate and found that each successive addition produced less and less ferric sulpho-cyanate, but that the ferric nitrate was never completely decomposed. His results represented graphically give a curve essentially like those for absorption already described.

According to this view it is the accumulation of sodium chloride in the solution which prevents the further absorption of lime by the silicate. If then sodium chloride were added to the solution in the first place, we should expect the absorption to be less. To test this (VII) was repeated with the addition of 0·1700 grms. NaCl (about equivalent to the $CaCl_2$ present) to each experiment. The following results were obtained.

Silicate.	Abs. without NaCl.	Abs. with NaCl.
2·5 grms.	0·1151 grms.	0·1039 grms.
1·25 "	0·0663 "	0·0595 "
0·625 "	0·0359 "	0·0303 "
0·3125 "	0·0187 "	0·0143 "

In every case the absorption has been decreased by the addition of the sodium chloride, as required by the theory.

We are then, I believe, justified in the following conclusions.

The absorption of combined bases by the soil consists in an exchange of bases between the salt and the hydrous silicates of the soil.

This exchange, which is primarily chemical, is only partial, its extent varying:

1st. With the concentration of the solution.

2d. With the ratio between the volume of the solution and the quantity of soil used.

The cause of these variations is probably the "action of mass," or the tendency of the resulting compounds to re-form the original bodies, the absorption actually found in any case marking the point where the two forces are in equilibrium.

Laboratory of Rutgers College, May, 1877.

ART. IV.—*Double-Star Discoveries with the* 18½-*inch Chicago Refractor;* by S. W. BURNHAM.

THE new double stars described below were discovered with the 18½-inch Clark refractor of the Dearborn Observatory, on the nights of October 1, 2, 4, 7, 10, 11, 15, 16, and 17, 1876, and are some of the results obtained in the use of that instrument during a period of three or four weeks, the only opportunity the writer has had of using it. The observations here given are not as complete as could be desired; some of the new pairs being only partially measured, and others not at all. A number of other new and interesting pairs were found, but the approximate readings of the circles, roughly noted at the time of finding them, are not sufficient to positively identify them in the star catalogues and thus fix their absolute places; and these with other suspected pairs, and new companions to prominent pairs and binary systems, are necessarily not included in the following list. The intention was to measure, during the course of the work, all new pairs on at least three different nights, in order to give, as accurately as possible, reliable micrometrical results with which future observations might be compared for determining the question of physical relation between members of the systems. This seemed to be the more important from the fact that many of these pairs are too difficult for ordinary apertures, and are practically beyond the reach of most of the well-known double-star observers in Europe; and a considerable time might elapse before the objects would be re-observed elsewhere. It is necessary to state, in explanation of its manifest incompleteness, that the work was unexpectedly, and without notice, terminated by the action of the officers of the Chicago Astronomical Society which has control of the instrument, and no opportunity has been afforded to complete the projected series of observations which was but just commenced. Enough is given, however, to show the value and effectiveness of the telescope in this important branch of astronomical research; and how much might be accomplished for science, if it were used for any other purpose than exhibition to visitors.

The reference numbers attached to these stars are the numbers in my double-star catalogues, seven of which lists, with the stars numbered consecutively, have appeared in the Monthly Notices of the Royal Astronomical Society, Astronomische Nachrichten, and in this Journal.

No. 437=L 4291.

R. A.=$2^h\ 12^m\ 26^s$ }
Decl.=$+3°\ 39'$ }

Not measured, but angle and distance estimated as follows:

P=45°± D=5″±

The principal star is about 7½ magnitude, and the companion not brighter than 11 of Struve's scale. The pair of small stars in the field, *sp* is Σ 247 *rej.*

No. 438=Σ 2538

R. A.=19^h 27^m 3^s
Decl.=+36°27′

A and B	P=43°·5	D=6″·32	(1876·8)
A and C	245·2	53·04	(1830·8)
C and D	52·5	6·07	(1830·8)

The three large stars, A, C and D, constitute the double star Σ 2538(=S 719), but the small companion near the principal star is now recorded for the first time, and is probably too minute for ordinary telescopes. The measures given above of C and D are by Struve. These stars seem, by a comparison of Struve's results with those obtained later by Mädler, Secchi and Otto Struve, to be relatively fixed, but some of the measures are not very accordant. By a single observation I found these angles respectively, 237°·1 and 51°·9, but there may be an error of 10° in reading micrometer of the first. There is still another new member of this group, in an exceedingly faint star almost exactly midway between A and C. No opportunity occurred to measure this. Struve gives the magnitudes of A, C and D as 8·2, 8·3 and 8·7 respectively.

No. 439=Arg. (29°) 3845

R. A.=19^h 55^m 56^s
Decl.=+29° 30′

The principal star is about the eighth magnitude (Argelander, 8·1), with a small companion. The measures of one night give:

P=249°·7 D=2″·70 (1876·8)

No. 440=L 38520

R. A=20^h 1^m 27^s
Decl.=+35° 27′

A and B	P=61°·3	D=6″·47	Mags. 7·0 . . 12+	(1876·8)
A and C	25·8	7·75	11·0	(1876·7)
A and D	296·0	11·27	9·5	(1783·7)
A and E	106·8	28·15	11·5	(1876·7)
A and F	32·8	29·45	7·5	(1783·7)
F and G	113·0	10·12	12·	(1876·8)

The large stars (A, D, F), of this interesting group have long been known, and constitute the double star ♅ III. 113 (=Sh 314=Σ 2630 *rej*). The small attendants, C and E, I found with the 6-in. refractor in 1875. The faint star, G, was discovered by Mr. I. M. Ward of Belfast, widely known for his remarkable acuteness of vision, with an aperture of only 4·2-in. The very minute companion, B, was added with the 18½-in., the whole forming one of the finest multiple systems known. Of the measures given above, D and F are by Sir William Herschel; C and E by Baron Dembowski; and B and G my own results on the occasion last referred to. The relative situation of the stars known to the early observers appears to be substantially unchanged. For A and D Dembowski finds:

P=300°·7 D=11″·12 (1876·7)

By comparing the measures of Sir John Herschel and Sir James South, with the recent observations of Baron Dembowski, there seems to be an error in Herschel's distance of A F;—

P=28·2	D=36·″52	(1823·6)
28·2	35·98	(1876·7)

The relation of the closer stars can be determined only after a series of carefully repeated measures, but it is at least probable that they will be found to have some physical connection.

No. 441=L 39013

R. A.=20h 12m 37s
Decl.=+28° 46′

This is a 7·5 m. star with very small satellite, measured on one night as follows:

P=65·°4 D=5″·87 (1876·8)

No. 442=Weisse xx. 456

R. A.=20h 13m 3s
Decl.=+37° 11′

A fine group consisting of three large stars, each about 8·5 m. with closer minute companions. The following measures were made on this occasion:

A and B	P=104°·1	D=18″·47
A and a	157·5	4·40
A and b	157·±	7·±
A and c	332·5	19·55
B and d	164·3	8·12
B and C	48·6	17·69

There are several other small stars near not measured.

No. 443=L 39293

R. A.=20h 19m 12s
Decl.=+28° 37′

Angle and distance estimated only:

P=120°± D=10″± Mags. 7·5 . . . 11·5

There is a third star following, about 30″ distant.

No. 445=Cygni 287

R. A.=20^h 58^m 23^s }
Decl.=+28° 37′ }

Very unequal pair; the principal star 7 m. in Lalande.

P=90°± D=4″±.

This is L 40821.

No. 446=Weisse xxi. 344

R. A.=21^h 15^m 44^s }
Decl.=+32° 56′ }

A pair of small stars, the larger 9 m. near and south following a bright star.

P=261°·7 D=2″·30

No. 447=Vulpeculae 129.

R. A.=21^h 18^m 45^s }
Decl.=+24° 48′ }

This is a bright star, about 6 m. with a difficult companion in the direction of 340°. Distance not noted, but probably under 5″. No opportunity was afforded to measure or examine it a second time.

No. 448=L 41874

R. A.=21^h 24^m 35^s }
Decl.=+44° 24′ }

There is some uncertainty about the place of this pair. It is assumed to be the above 7 m. star in Lalande, which is nearly in the observed place, but may be a larger star south following. Estimated as follows:

D=2″± Mags. 7·0 . . . 11·0.

A distant companion preceding.

No. 449=Radcliffe 5335.

R. A.=21^h 34^m 42^s }
Decl.=+41° 11′ }

The three larger stars, A, C and E, were discovered by Sir William Herschel (=♅ III. 110), and also entered in the Pulkowa catalogue (=OΣ 447). The new members of the system, B and D, are very minute, and might be easily overlooked with even a large aperture. My measures of these, and Dembowski's of C and E are as follows:

A and B	P=19°·1	D=6″·78	(1876·8)
A and C	170·5	13·71	(1866·6)
A and D	248·2	17·94	(1876·8)
A and E	45·7	29·13	(1866·6)

Dembowski gives the magnitudes of A, C and E as 7·0, 10·8 and 7·7 respectively. A comparison of the measures of these stars with the early observations of Herschel, would seem to indicate considerable change, but this is not confirmed by the intermediate measures of Otto Struve.

Herschel	A and C	P=157°·6	D=13″·90	(1783·8)
O. Struve	A and C	169·4	13·86	(1848·3)
Herschel	A and E	49·4	25·97	(1783·8)
O. Struve	A and E	45·3	29·00	(1848·3)

The close agreement between the measures of O. Struve and Dembowski accords with my own results on the occasion of observing the new companions, when the angles came out 170°·5, and 44°·9, respectively.

No. 450=B. A. C. 7931

R. A.=22h 38m 40s
Decl.=+38° 50′

As a double, this beautiful object is found in the catalogues of both Struves, and Herschel (=Σ 2942=*O*Σ 478=*H* 1802). Struve's magnitudes are 7·0 and 9·2. The colors are very striking, the larger being, according to Struve, reddish gold, and the smaller, ash-color. A third much smaller star was discovered with the 18½ in., and measured once as below:

A and B	P=282°·4	D=2″·66	(1831·6)
A and C	232·0	10·23	(1876·8)

Measures of A and B by Struve. Dembowski gives, P=280°·6; D=2″·80 (1866·6), from which it is safe to infer there is no substantial change in the relation of these stars, and this view is supported by the measures of Otto Struve, Mädler, Dawes, and others. The small star is not a difficult object with the 18½ in., and can perhaps be measured with a smaller aperture.

No. 451=15 Lacertae.

R. A.=22h 46m 37s
Decl.=+42° 40′

This star was seen with a minute attendant, roughly estimated from memory as about 20″ distant. The angle was not noted, and no opportunity occurred to re-examine and measure subsequently.

No. 452=L 44915

R. A.=22h 51m 37s
Decl.=+42° 22′

A fine pair observed about the same time as the preceding, and like that only estimated for the purpose of certain identification:

P=270°± D=6″±

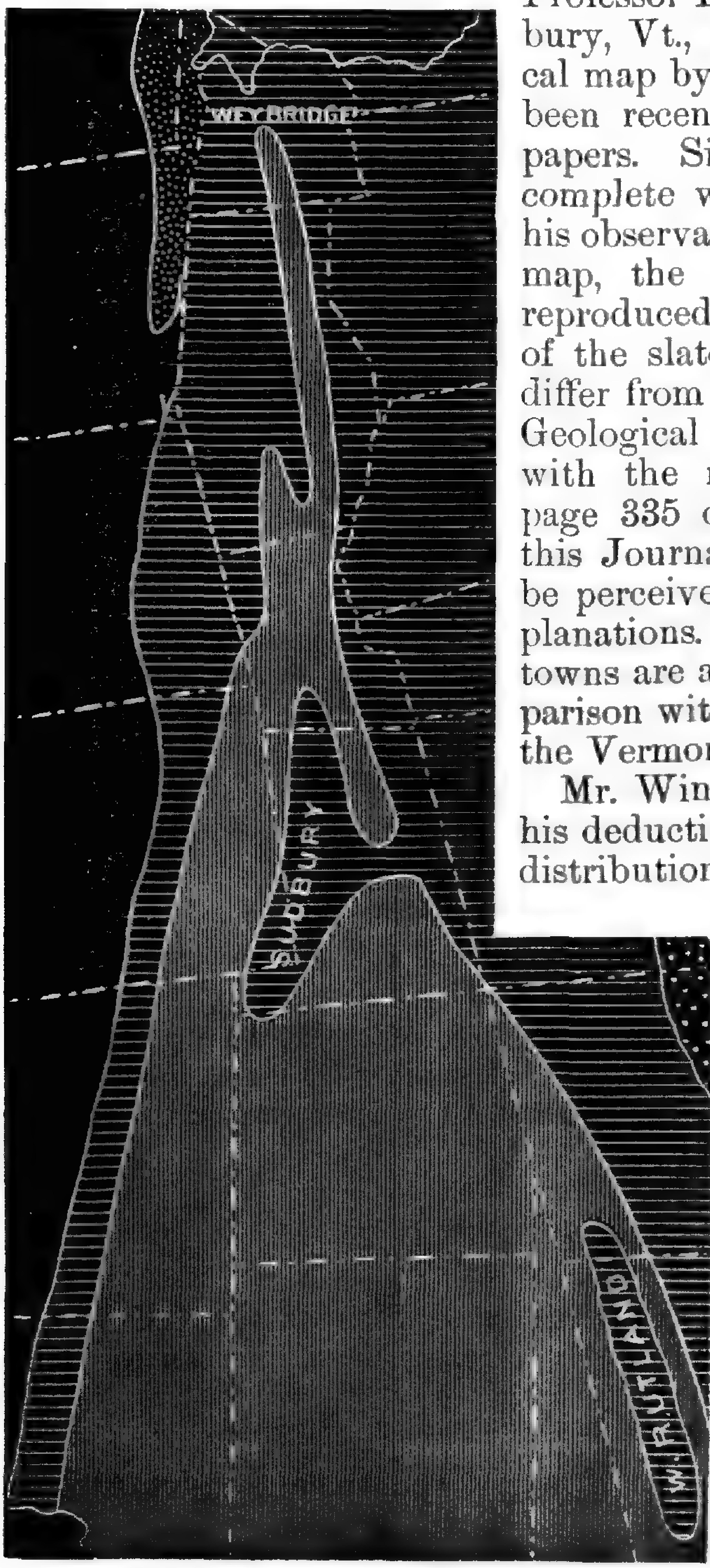
The large star is 6½ or 7 magnitude, and the companion below 12 of Struve's scale.

Chicago, May 5, 1877.

ART. V.—*Supplement to the Account of the Discoveries in Vermont Geology of the Rev. Augustus Wing;* by JAMES D. DANA.

SINCE the publication of the preceding number of this Journal, containing the concluding part of the account of Mr. Wing's discoveries, I have received from Professor H. M. Seely, of Middlebury, Vt., a manuscript geological map by Mr. Wing, which had been recently found among his papers. Since the account is not complete without the results of his observations contained in this map, the portion of it is here reproduced in which his outlines of the slate and limestone areas differ from those of the Vermont Geological Map. By comparing with the map and remarks on page 335 of the last volume of this Journal, the differences will be perceived without special explanations. The outlines of the towns are added to aid the comparison with the colored map in the Vermont Report.

26.



Mr. Wing's map contains also his deductions with regard to the distribution of the formations—part of which are not yet established. The West Rutland and Sudbury areas are both made Chazy along the center and Trenton along the east and west borders, which may be true, although only Chazy fossils have been distinguished in the former, and Trenton in the latter. Along either side of the central slate belt, which is Hudson River (Cincinnati) in age, a belt of color indicating Trenton extends; then others, more remote, for Chazy, Calciferous and Potsdam; and the Chazy east of the slate-belt extends two-thirds of the way to the quartzyte. These points in the map rest mainly on fossils, except the eastern boundary of the Chazy, and the periods assigned to the part of the limestone still farther east.

Art. VI.—*On the relations of the Geology of Vermont to that of Berkshire;* by James D. Dana.

In my memoir on the Quartzyte, Limestone, and associated rocks of Great Barrington, Berkshire Co., Massachusetts, published in this Journal in 1872 and 1873,* I based the conclusion there presented with regard to the age of the Berkshire rocks largely on the single discovery of Mr. A. Wing, of Chazy fossils in the West Rutland limestone, the only one of his that had then been made public. The wider knowledge of his discoveries which we now have, through his notes and letters, gives a better basis for a decision, and I propose to consider the bearing of the facts as now understood.

We have first to enquire what reasons there are for making the geology of Vermont a key to that of Berkshire. These are afforded both by the geographical and the stratigraphical arrangement of the rocks. The facts given beyond are in part contained in my former memoir. Others are added from my more recent observations.

1. The Geographical Arrangement of the Rocks.

Whatever be true of the whole Green Mountain region, the *western half* of it, including the "Eolian limestone" and its associated rocks, is eminently a natural area, both as regards its topography and its rocks. This north-and-south area is divided among four States—three of Western New England, and the State of New York. But the boundaries of Vermont, the northern of the series, are of political authority, not geological; and so are those of Massachusetts, Connecticut, and New York.

(1.) *The Limestone formation.*—The great limestone belt of Vermont stretches southward, without interruption or diminished width, into Berkshire Co., Massachusetts; through Berkshire, into Western Connecticut; and, continuing its south-by-west trend over Canaan and Salisbury, it passes out of Connecticut, still as wide as in any more northern part, into eastern New York, over the towns of Amenia and Dover, to Pawling. Thence it still stretches southward for seven or eight miles, but

* Vol. iv, 362, 450, (504); v, 47, 84; vi, 257.

with narrowing limits, and finally ends in a narrow strip among the flexures of hard gneiss rocks. It is one of the long Green Mountain formations.

(2.) *The Quartzyte series.*—Associated with the limestone belt, and following mainly its eastern border, there is a *quartzyte* series, consisting in Vermont of quartzyte and crystalline slate or schist (hydromica slate, sometimes chlorite slate), and rising at intervals into mountain ridges. This quartzyte formation commences just abreast of the northern limit of the "Eolian limestone" in Vermont; and it follows it southward through Massachusetts, and into Connecticut, being, throughout, its close attendant.

(3.) *The Slate or Schist series.*—Again, along and west of the central portion of the limestone region, and on much of its western border, there are ranges of hydromica slate often chloritic, with some clay-slate. A broad slate belt is a prominent feature of the region in Vermont west of its center. It commences within ten miles of the northern terminus of the limestone, extends south with increasing width and height, rising at intervals into mountain elevations 2,500 feet or more in height, Herrick Mountains, in Ira, having a height of 2,661 feet, and Equinox Mountain, in Manchester, 3,872 feet (Guyot) above tide-level. It continues with unchanged course into Massachusetts, or rather along the connecting borders of Massachusetts and New York, and this part, south of Vermont, has long borne the name of the Taconic Mountains; and here it rises into peaks nearly as high as those of Vermont, Graylock being 3,600 feet in height, and Mount Everett, 2,634 feet. Further, the Taconic Mountains consist chiefly of hydromica slate more or less chloritic, like the southern portion of the same range in Vermont.

Thus there is a marked unity in the area from north to south indicated not merely in the continuity of the limestone formation, but also in the like continuity of the whole series of associated rocks—limestones, quartzyte and schists—of the eastern, middle and western portions of the great north-and-south area. And this unity favors strongly the idea of oneness in age, in origin, and in mountain-making movements.

The lithological identity is not perfect throughout; yet the differences are introduced by very gradual transitions, evident only as the whole area from north to south is surveyed, and hence they are additional proof of the unity. They are differences mainly in *grade of metamorphism.*

The great central slate-belt of Vermont commences to the north, according to the Vermont Report, in a *clay-slate* belt. Thirty miles or so south, hydromica slate, a more crystalline rock, commences on the two borders of the clay-slate area, with the band of the eastern border much the broader—corresponding in this with the general fact of a higher degree of metamorphism on the east. Seventy miles farther south, in the Taconic Mountains, and its eastern spur, Graylock, the hydromica slate is in part of somewhat coarser texture and more chloritic, and this same rock constitutes Mount Washington in southwestern Massachusetts, near the southern termination of the Taconic range. It even becomes in part mica slate.

The distance from the north extremity of the slate belt to Mount Washington, through which this small change occurs, is 150 miles.

The ridges in Berkshire south of Graylock, or over the western third of the limestone region, including the ridges either side of West Stockbridge village, and the Tom Ball ridge farther south, west of Williamsville, consist of the same rocks as Graylock, with scarcely appreciable difference. Some of the beds are garnetiferous.

The ridges along a line a little farther east, near the center of the limestone belt, that is, those next east of Tom Ball, and east and west of Great Barrington, have the hydromica slate replaced by mica schist, and then by mica schist and gneiss, part of it a thick-bedded granitoid gneiss. South of Great Barrington, in Sheffield, the schist of ridges in the midst of the limestone area (which has here great width) is a coarse mica schist containing abundantly garnets and crystals of staurolite; and the same staurolitic mica schist exists under similar circumstances near Falls Village, in Canaan, Connecticut, the next town south of Sheffield, and also, farther south and west, in Salisbury. Thirty miles south-by-west of Canaan, about Pawling, and beyond to the termination of the limestone belt, the associated rock is mica schist or gneiss.

The schists, according to the above facts, become more and more crystalline on passing southward—chloritic hydromica slates giving way to mica schist, garnetiferous and staurolitic mica schist, and gneiss; but only by very gradual transitions. It should be here kept in view that the difference in constitution between hydromica slate and mica schist consists simply in the presence of a few per cent (three to six) of water in the mica of the former, and only one or two or none in that of the latter; and that gneiss has merely the distinction of more feldspar and less mica than mica schist.

A parallel change takes place in the associated limestone formation. To the north, in central Vermont, and especially along the western portion of the limestone region, occur the areas of grayish half-altered or semi-metamorphic limestone, affording distinguishable fossils. Further, the limestone of this northern portion of the Eolian limestone is generally very fine in grain even where of the purest white color. In Pittsford and Brandon are found the best of statuary marbles, looking like the finest loaf-sugar in texture. South of Pittsford, in Rutland, the marble is a little less fine in its grain than it is farther north; in Berkshire, it is mostly much coarser, none answering to statuary marble existing anywhere; and in southern Berkshire and Canaan, Ct., it is still coarser in crystallization, and abounds also in many places in tremolite, white pyroxene, and mica. Thus the fact of intenser metamorphism to the southward is as plainly apparent in the limestones as in the schists.

After this survey of the facts we have to admit that the differences are so distributed geographically as to prove unity of area and rocks, rather than diversity.

Similar differences, depending on degree of crystallization, are found in going *from west to east* in Massachusetts, as in Vermont. The rock of the Taconic Mountains is mainly hydromica slate and chloritic hydromica slate; and of ridges, *farther west*, in Columbia County, New York,—as in Copake at the foot of the mountains,—a finer hydromica slate and clay-slate, with bluish semi-crystalline limestone. But going eastward, in Berkshire, to Stockbridge and Great Barrington, and farther east to Monterey and Tyringham, there are, as illustrated in the facts stated beyond, first a coarser hydromica slate, partly garnetiferous; then fine-grained mica schist and gneiss; and then coarser and harder varieties of the latter rocks; and the crystalline limestone, which is almost free from foreign crystallizations in Stockbridge and West Stockbridge, contains large crystallizations of white pyroxene or tremolite in some places in Lee, Monterey and Tyringham.

2. The Stratigraphical Relations.

In Vermont we have found the following cases of *conformable superposition or interstratification*, as described in the account of Mr. Wing's researches, and illustrated in the figures of sections accompanying.

(1.) The limestone and schists conformable.

(2.) The quartzyte and schists conformable.

(3.) The quartzyte and limestone, and also the quartzyte, schists and limestone, conformable.

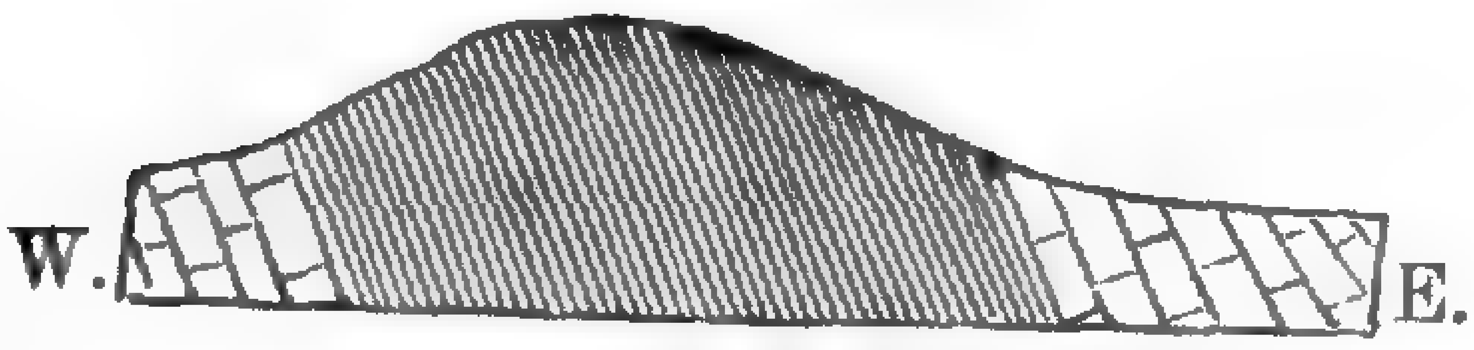
The *first* of these Vermont cases of conformability is illustrated in the sections on pages 338, 340, 344, 346, 347 of the last volume of this Journal; the *second*, in the constitution of the quartzyte formation, as explained on page 411; the *third*, in the sections presented on pages 340 and 412.

The following facts show that wholly similar cases of conformable superposition exist in Berkshire.

(1) *Interstratified limestone and schists.**

Fig. 1 represents a very common case of this first kind. Chloritic hydromica slate, dipping eastward, lies between strata of limestone which have the same dip. Examples occur in the southern third of the ridge called Tom Ball, southwest of Van Deusenville; also in Alvord, west of Tom Ball; in West Stockbridge; along much of the Taconic range, the slates

1.



South end of Tom Ball.

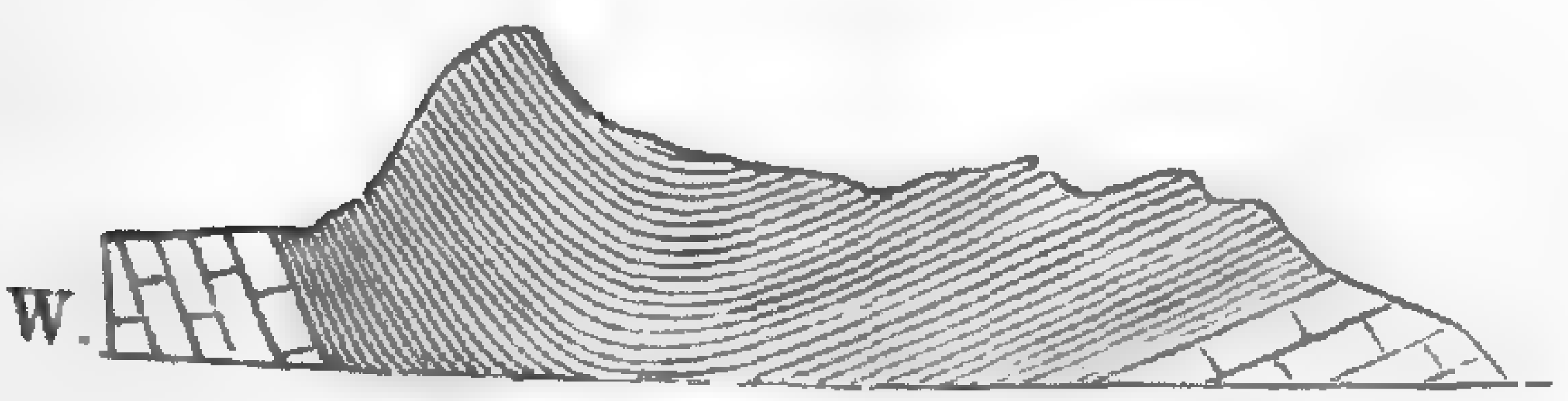
2.

West of Glendale.

having eastward dip between limestone strata of like dip; and in many other places. Two miles east of Tom Ball, in Glendale, the structure is repeated with thin strata of the schist as in fig. 2; moreover, the schist, is here a coarse *mica schist* instead of hydromica slate. West of the village of Great Barrington, there is a ridge of schist between limestone, as in fig. 1, but the schist is mica schist with some gneiss, and a thin bed of quartzyte. A few miles farther south, in Sheffield, in the midst of the limestone area, and not far from its center, the conditions in fig. 1 exist, but with the schist a mica schist containing staurolites and garnets.

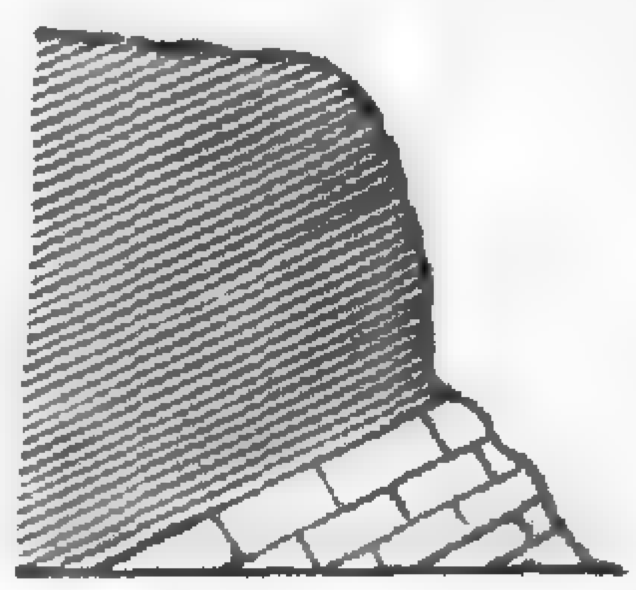
Examples also occur in which the dip is comparatively small. At the north end of Tom Ball the position of the rocks is as represented in fig. 3, in which on the east the limestone

3.



North end of Tom Ball.

4.



West of Glendale.

dips west 18° to 20° under the chloritic hydromica slate, containing in some places many garnets, and passing also into mica slate. The schist overlies the limestone in a synclinal.

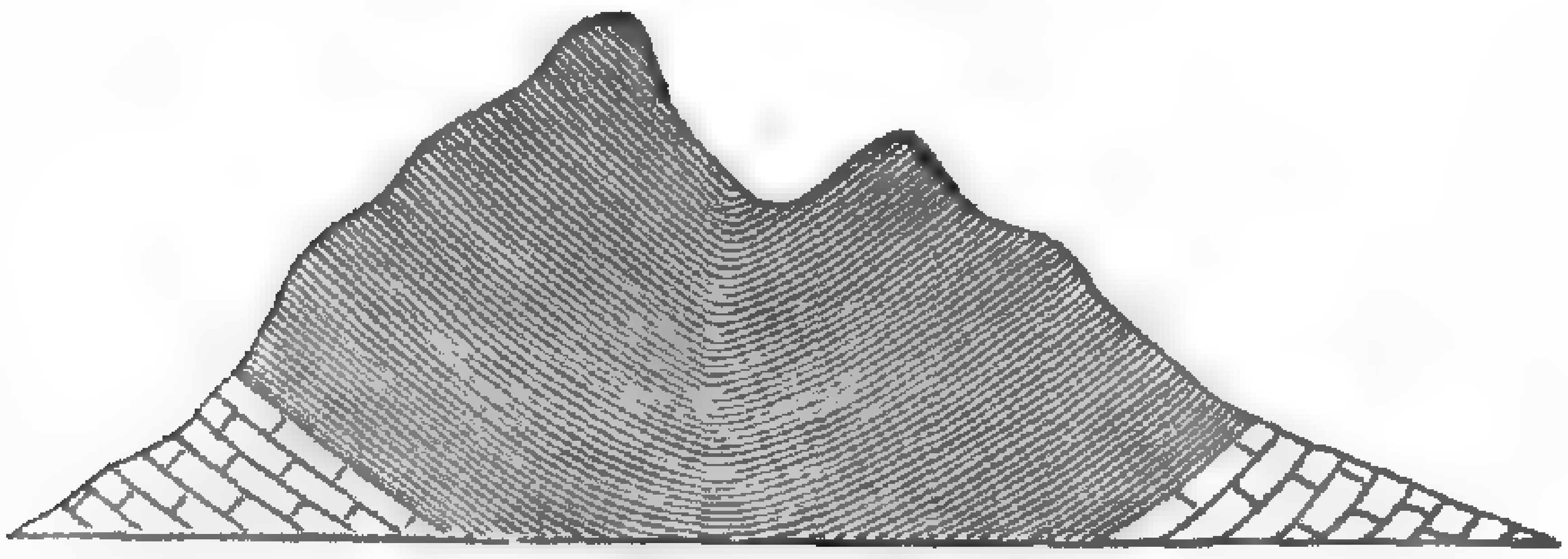
East of the north end of Tom Ball, on the road to Glendale, the limestone dips eastward 25° under a bluff of garnetiferous mica schist (fig. 4).

The facts connected with Graylock, in Northwestern Massachusetts, the highest of the Taconic peaks, point to a synclinal (or a synclinal with subordinate anticlinals and synclinals),

* In all the figures the blocked areas represent limestone; the simply lined, slate or schist; the lined and dotted, quartzyte. Moreover, the right end is the *eastward* end.

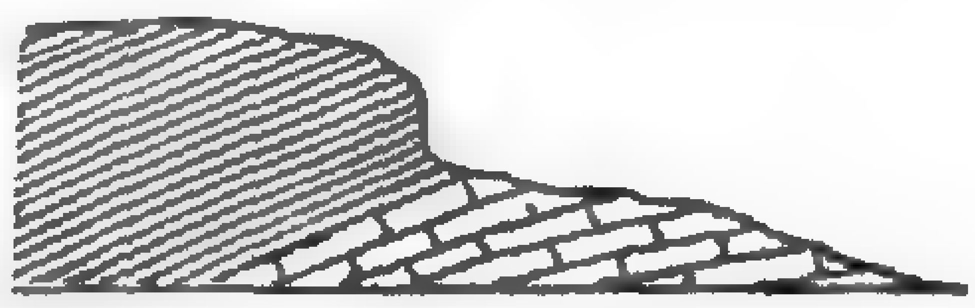
much like that of the north end of Tom Ball, as shown in figure 5, by Emmons, here repeated.* The same structure exists in Mount Washington in Southwestern Massachusetts, the next highest summit of the range. At the *eastern* foot of this mountain the limestone dips *westward* at a small angle, (25° to 30°), beneath the chloritic hydromica slate, as I have described in a former article;† and the more eastern and highest peak of the mountain, called Mt. Everett, partakes of

5.



Graylock.

6.

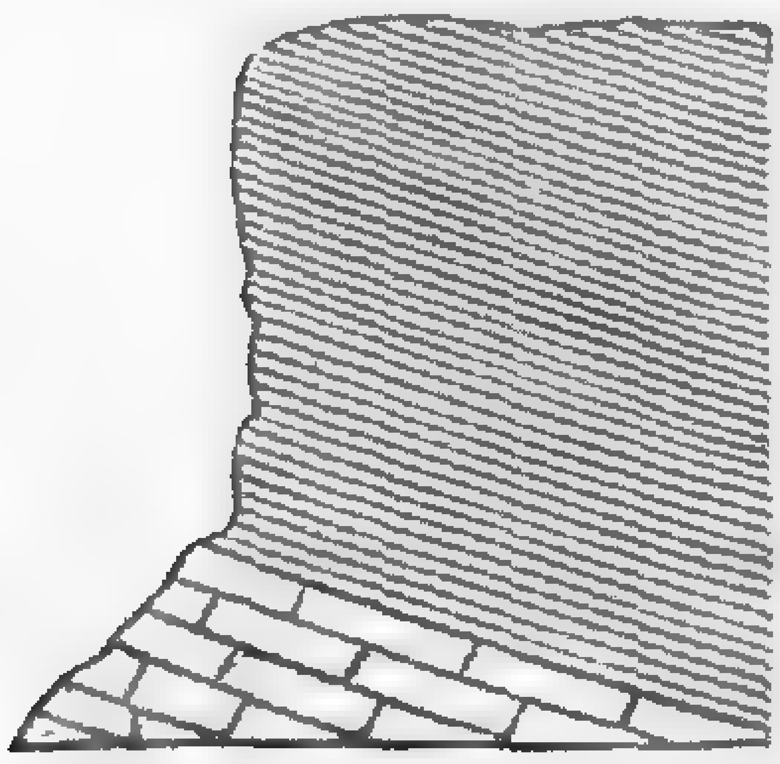


Half mile N. of Housatonic, west of the Old Furnace.

this westward dip; while in Copake, at the *western* foot, where the dip of the slate is eastward, the limestone dips *eastward* conformably to the slate, (the strike N. 20°–25° E., dip 40°–50°). In my examinations in Copake I had the guidance of Mr. William Miles, who had thoroughly explored the limestone localities. Besides the many conformable outcrops over the interior of the valley, there were others of large extent close to the slate of the mountains, and one where the limestone and slate were seen in contact.

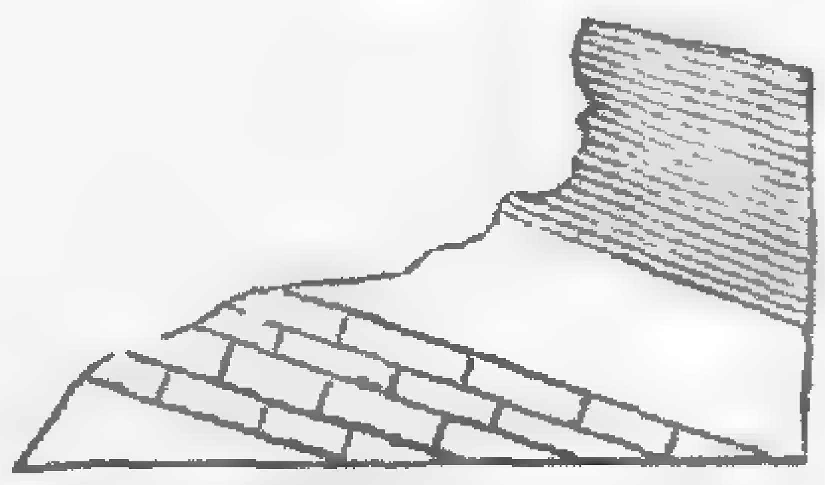
Again, half a mile north of Housatonic, west of the river, the section in fig. 6 is seen in an abandoned quarry. The limestone dips 10° to 25°, and passes beneath mica slate. In

7.



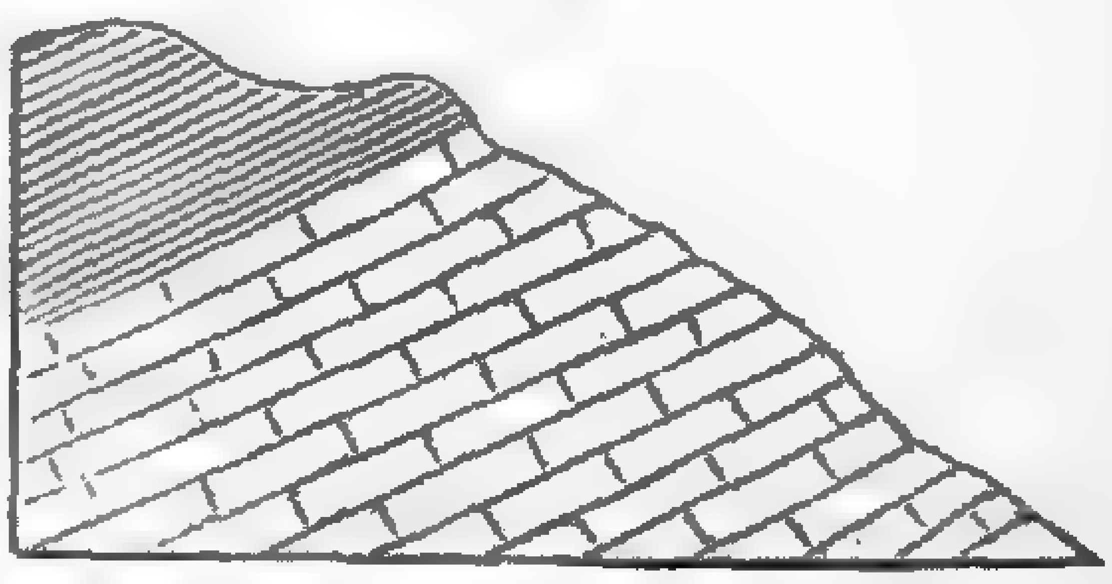
Canaan Mountain. Southwest Front.

8.



Falls Village, Canaan. West side of river.

9.



Hill west of the village of Tyringham.

Canaan Mountain, Connecticut, in the southwest front there are 150 feet of limestone at base, dipping 15° to 20° to the eastward underneath mica schist (fig. 7). In the same town, at Falls Village, west of the Housatonic River, a ridge (fig. 8) consists of limestone below dipping at an angle of 15°–20° under a mica schist containing garnets and staurolites. The mica schist forms the upper part of the hill and the limestone outcrops toward its base.

* See last volume of this Journal, p. 347. † This Journal, III, vi, 266, 1873.

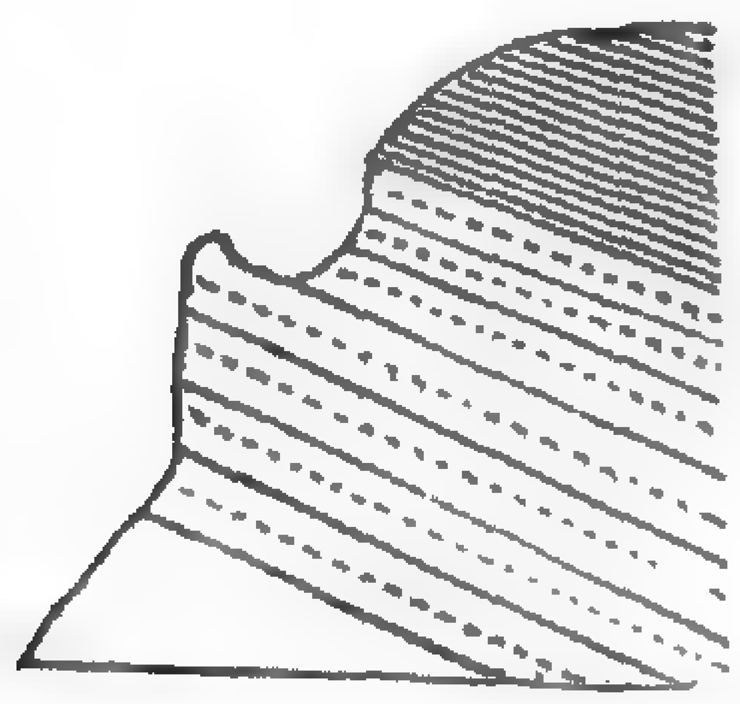
Further, in the most eastern of the limestone areas, in Tyringham, twelve miles east of the Taconic range, a hill, just west of the village, having a height of 450 feet above the bridge near its base, consists of well stratified limestone to within sixty-five feet of the top, (fig. 9); and above this of mica schist (the contact distinct), and very hard whitish thick-bedded gneiss; the whole dipping southeast 20° to 28°, with the strike N. 40°–45° W. Within the limestone stratum, fifty feet below its upper limit, there is a thin layer of mica schist.

These examples are sufficient to illustrate the point in view. Two others are given beyond.

(2.) *Interstratified quartzyte and schists.*

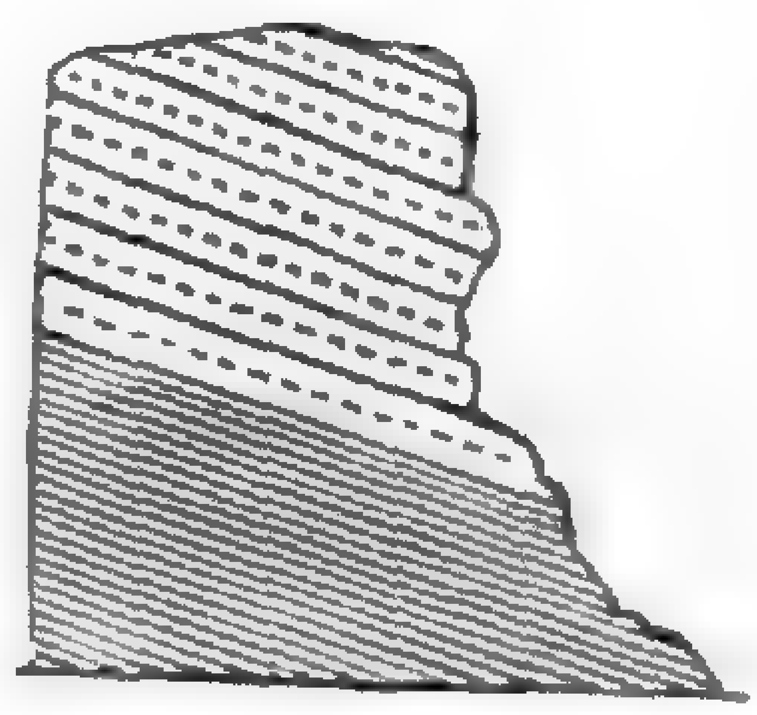
At the east front of Monument Mountain, half way from Stockbridge to Great Barrington, quartzyte overlies mica schist and gneiss (fig. 10), the dip 15° to 25°, to the southeast. The

11.



West end of Monument Mountain.

10.



East front of Monument Mountain.

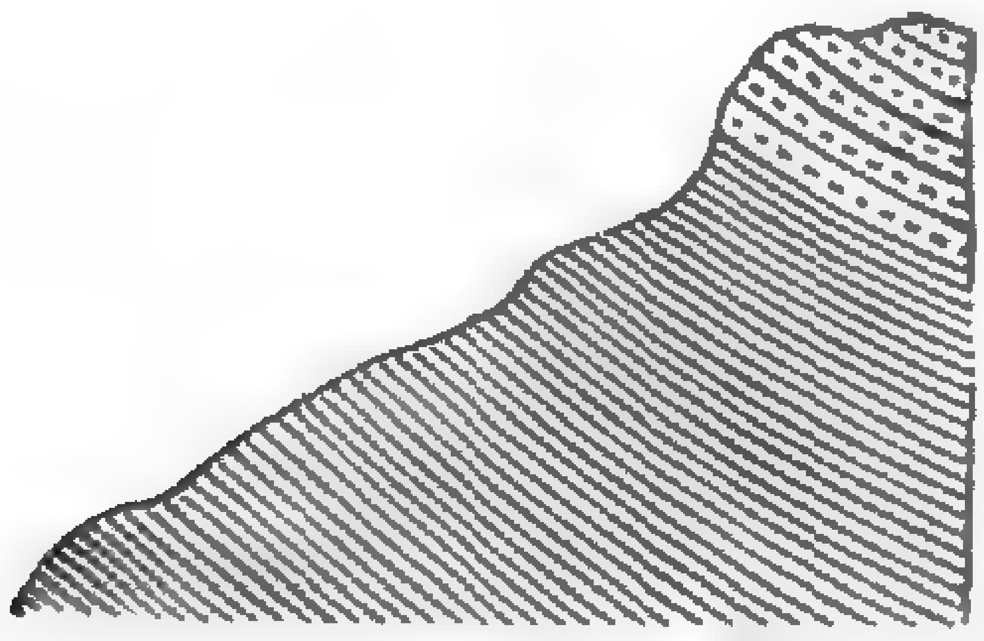
quartzyte is a hard kind without bedding, but vertically jointed. At the western end of the same mountain, opposite the village of Housatonic, the quartzyte, which forms the bold part of the front and rises to its greatest height a little back from the front, is at last capped by mica schist and gneiss (fig. 11), a continuation of the stratum that *underlies* the quartzyte of the eastern front. The quartzyte is here mostly devoid of bedding; but in its upper part, the bedding is distinct and parallel with that of the schist. This stratum of schist is locally a handsome granitoid gneiss half a mile to the eastward, at the top of the western half of Monument Mountain, showing in hand specimens no bedding whatever; but in most parts of the mountain it is rather mica schist than gneiss.*

East Mountain, rising from the Great Barrington Valley half

* This section of the western end of Monument Mountain is not here continued to its base, because the observations of this part were not wholly satisfactory owing to the concealment of the rocks by the soil. The stratum of schist in my former published section was inferred to exist there below the quartzyte, as I state in describing the section, from the great number of blocks over the surface; and that of the underlying limestone from small exposures along a path up the lower slopes of the mountains south of the old furnace, and from some very large masses of limestone on the east bank of the river, above the furnace, which may possibly be transported blocks.

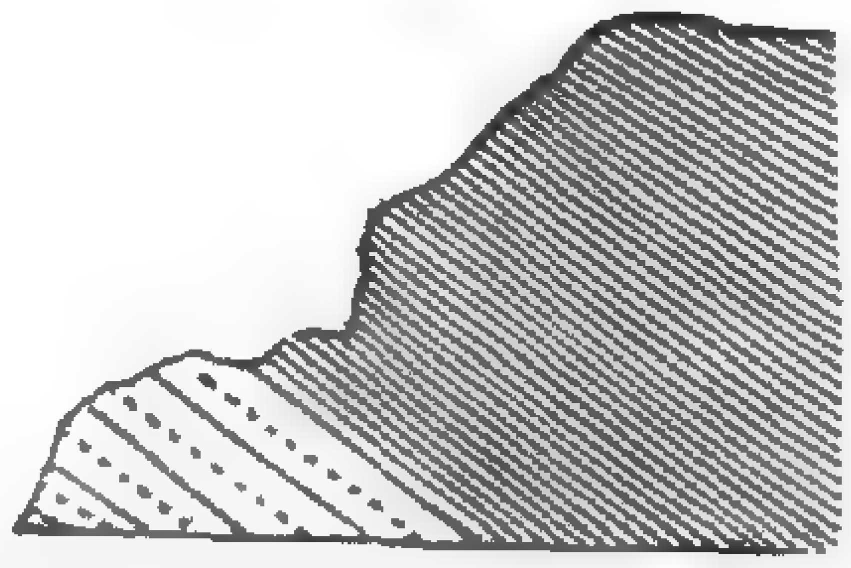
a mile east of the village, consists below of thick-bedded gneiss, similar to part of that of Monument Mountain, but contorted in its bedding and dipping 40° to 50° to the eastward; at top, for the upper 100 feet, it is laminated quartzyte (fig. 12), resembling the laminated quartzyte of many other localities in the limestone region. This quartzyte is gneissoid in many places, or a sandy gneiss, making manifest thereby the close relations of the two rocks.

12.



East Mountain, Great Barrington.

13.



Cobble Hill, South Canaan.

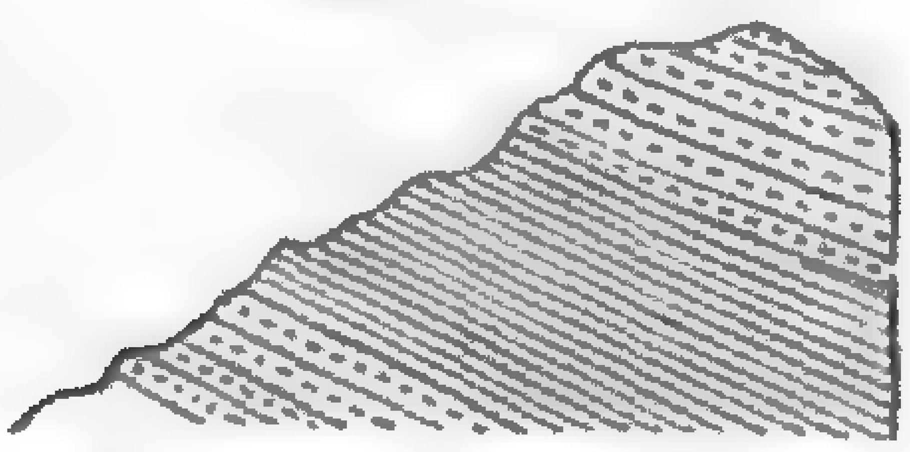
In South Canaan, east of the village, Cobble Hill consists below, to the west, of a soft-bedded quartzyte, dipping southeastward 40° (fig. 13), twenty to twenty-five feet of which are exposed on the road side; next above, a stratum of mica schist and thin-bedded gneiss, containing scales of both black and white mica; and then a whitish, granite-like gneiss. The quartzyte contains at intervals, in its upper part, streaks of black and white mica, and thus exhibits its relations to and passage into the overlying gneiss.

East of the village of Lee, a low ridge consists below of quartzyte; at middle of mica schist; and at top of quartzyte—all dipping eastward 15° to 25° (fig. 14).

(3.) *Interstratifiel quartzyte, limestone, and schists.*

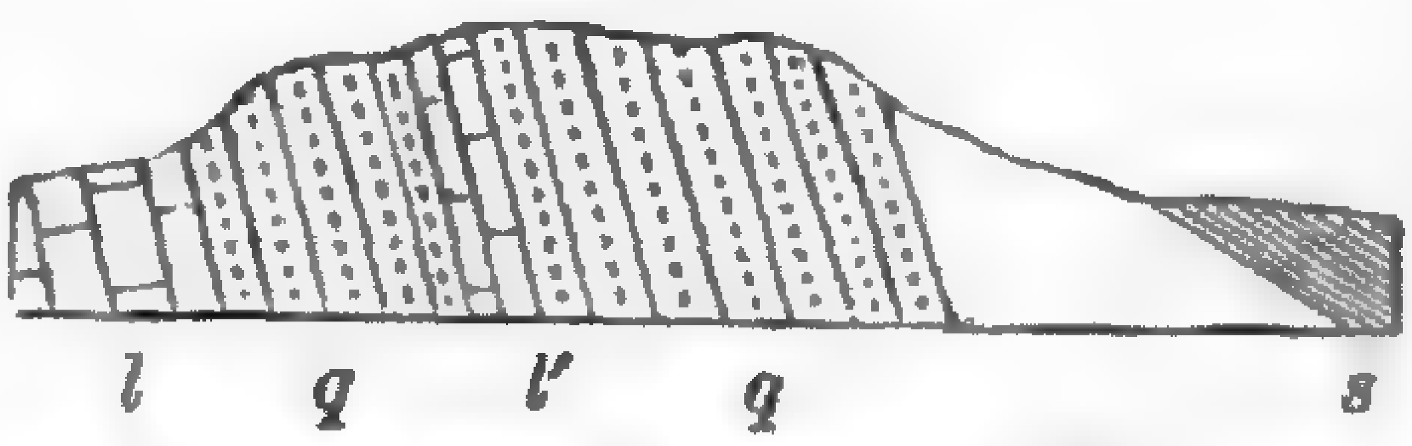
The fact that the quartzyte keeps by the side of the limestone, with small exceptions, from its northern limit southward to Connecticut suggests that there is a close stratigraphical connection between them. Further, seeing that the limestone occurs interstratified with the schists, and also the quartzyte of the same region with the same schists, there would seem to be hardly any ground for questioning the inference that the quartzyte and limestone are parts of the same great series of forma-

14.



East of the village of Lee.

15.



Quartzyte ridge east of south end of Tom Ball.

tions. On these grounds and the occurrence of limestone near by, it would be a reasonable inference that the strata of fig. 14 and the limestone are conformable. But there is also demonstrative evidence of this relation in sections. Fig. 15 represents a section of a ridge east of the southern part of Tom Ball. Limestone, dipping eastward 70° to 80°, adjoins a hard quartzyte; and in the quartzyte there is a stratum of impure limestone (l′) dipping with the other limestone.* This stratum indicates the dip of the quartzyte, which is elsewhere without bedding, and shows the conformability of the two rocks. East of the ridge there is an outcrop of mica schist, thirty rods east of the eastern outcrop of quartzyte, having nearly the same strike though less dip; so that we have all three rocks associated in the same section.

Fig. 17 represents several alternations of quartzyte, schist, and limestone, near Devany's quarry, four miles east of Great Barrington, all with small eastward dip; and here also mica schist and gneiss alternate with the other rocks, and, besides, constitute the upper stratum at the quarry. At this place, the intervals of earthy surface between the outcrops are as follows: between 3 and 4, fifty yards; between 4 and 5 (limestone and overlying quartzyte), hardly a yard; between 5 and 6, a marshy spot of forty yards; between 6 and 7, fifty yards; 7 and 8 (limestone and overlying gneiss) are in contact, and so also are 9 and 10 (quartzyte and overlying gneiss). No. 1 is the eastern border of the limestone of the Konkaput valley. The

16.

Three-mile Ridge, west side of Konkaput Valley.

17.

Devany's Quarry, east side of Konkaput Valley.

thinner lower layers of quartzyte in this section have little lateral extent. Devany's bluff is part of the southwestern foot of Beartown Mountain. The schist at the top of the bluff, (10, fig. 17), continues upward to a height of 800 or 900 feet above the upper quartzyte, being the rock of the mountain; and at this southern extremity of the mountain it has a small dip (10° to 25°) to the northeastward, so that the quartzyte and limestone of the Devany region is overlaid by at least 800 feet of schist. This schist is mostly a whitish and gray gneiss, very tough and hard; but with it there is granulyte, gray and black mica schist, and blackish hornblendic schist.

* This Journal, III, v, 84.

Fig. 16 exhibits the stratification in Three-mile Ridge,—a ridge on the opposite side of Konkaput valley from Devany's bluff, and shows the same succession essentially as on the Devany side—namely, limestone (that of the Konkaput valley) below; next quartzyte; next a great thickness of gneiss—not less than 800 feet. Three-mile Ridge extends southward (S.S.E.), with rather an abrupt front, and shows in a distant view nearly horizontal lines of stratification. The dip is mostly 25° to the northwest; but at base, toward the notch passed through by the road to Great Barrington, it is diminished to 8°. The gneiss (as may be seen three or four hundred yards south of the notch) rests on a stratum of quartzyte. It is hard quartzyte, but has the bedding distinct. It includes, besides some interrupted micaceous lines, a layer a foot thick of gneiss; but this gneiss layer, after a few rods, fades out to the northward and becomes a layer of quartzyte scarcely distinguishable from the rest of the quartzyte. Thus again, the distinction between quartzyte and gneiss in Berkshire proves to be of no more importance than that of quartzyte and hydromica slate in the quartzyte formation of Vermont. The soil conceals at this place the lower part of the quartzyte stratum, and the underlying rock or rocks; but, half a mile southeastward, along a road which runs nearly parallel with the mountain and not far from its base, and also between this road and the mountain, the limestone of the Konkaput valley outcrops with a small northwestward dip (15°–20°), conformable to the schist of the mountain; and these outcrops continue numerous for more than a mile. In one knoll, toward the mountain, the beds were found to dip eastward, but this was an exceptional case. Elsewhere the dip was northwestward, and at one spot the limestone was seen directly overlaid conformably by the schist.

I have above given the facts of my own observation. The same general conclusion with regard to the interstratification of these formations was long ago reached by Professor Edward Hitchcock, and announced in his Report on the Geology of Massachusetts. Speaking of the quartzyte, he says (Report of 1841, p. 590): "it alternates with and passes imperceptibly into gneiss and mica slate; and in fact it might very properly be regarded as a member of the gneiss and mica slate formations;" in Berkshire "it is frequently interstratified with gneiss and mica slate, especially along the eastern side of the valleys, as in Tyringham, Great Barrington and Sheffield."

He also states (p. 573 and beyond) that in Berkshire, the limestone occurs interstratified with the gneiss, mica slate, talcose slate and quartz rock of the region; that in New Malborough and Tyringham it is found in beds between the strata of gneiss, as at Hadsell's lime quarry; and that its interstratification with mica slate may be seen in numerous places in all parts of the county. He adds that he had not "met with a spot where the limestone is in direct contact with quartz rock; but as this rock frequently alternates with gneiss and mica slate, and the latter with the limestone, they must all be regarded as interstratified with one another."

Before Professor Hitchcock's observations were made, Professor Dewey announced in this Journal, in 1819, that the Berkshire limestone at the *Cave* or *Falls* in Adams, east of Williamstown, and also west of the Hoosac, *rests on mica slate.* Further, Professor Silliman, in the second volume, 1821, gives an account of the interstratification of the limestone and mica slate in Salisbury, Ct., west of the Housatonic, saying that "in the course of five or six miles there are as many alternations and successions of these two rocks," and "their junction in some places is exactly defined."

Abrupt transitions in dip or strike occur in some places which suggest that there is unconformability. But the above-explained actual sections prove them to be exceptional; and this is sustained by other facts. They are common over the broad areas of crystalline limestone moderate in dip, and of rare occurrence over the regions of schist, and also in the limestone areas close adjoining the schist. When making my first section of Western Connecticut, I passed from the schists, which had given regular dips and strikes, to the wide limestone area of Canaan; and expected to find in it essentially the system and regularity of position met with in the other rocks. But the observations of dip and strike were soon found to be of little value except as regards questions of local interest; they could not be used to determine either the direction of the uplifting force, or that of conformability in the formations, because of the abrupt local changes, which sometimes amounted to 50 or 60 degrees in dip and strike in a few rods. The same irregularities occur over all the other limestone areas of the Green Mountain region except where the beds dip at a high angle. Examples occur in the broad valley east of Monument Mountain, at a quarry half a mile distant from the bold front of the mountain, where the beds are vertical; in the valley west of Devany's quarry, just west of the place where the section represented in fig. 14 was obtained; in the Housatonic Valley between Housatonic village and the old furnace; in the vicinity of Glendale and Stockbridge; in the valley of West Stockbridge, and in other places. In sections observed close by the intervening ridges of schist, the irregularities are with a rare exception absent and the conformability to the schist is placed beyond doubt.

An unconformable limestone ledge is alluded to above as existing in the valley near the Devany bluff. The *conformable* limestone-outcrops extend along the side of the valley for a fourth of a mile. But toward the west end of the series, in front of the conformable outcrops, that is, a little nearer the middle of the valley, there is a ledge with a dip of 80° to 85°, instead of 25° or 30°. Its little extent shows that it is one of the local exceptions. And this is made more manifest, and its existence partly explained, by the fact that in the same transverse line across the flat valley, and just beyond its middle, there is a hill of schist whose beds dip 50° to the westward, instead of the usual 25° or less. The schist in the mountains forming the sides of the valley has little variation in dip for several miles.

The reason for these irregularities is to be found in the inflexibility of uncrystalline limestone as compared with other uncrystalline rocks (shales and sandstones) and its tendency, therefore, to break and become irregularly shoved up under uplifting or flexing action. Moreover, the limestone areas appear generally to be regions of anticlinals, and the schist areas those of synclinals; and the former, whatever the rock, are usually the places of greatest surface fractures, and the latter, of least. In the synclinal, the limestone beds are kept in place beneath the overlying strata; and therefore, the irregularities in the limestone should not appear close to the schist.

In such a region of extensive upturning and mountain-making as that of the Green Mountains there must be many lines of great fractures and faults. Yet the only case of non-conformity in dip adjoining a ridge of schist which I have observed occurs near the middle of the limestone region within half a mile east of Great Barrington village at the foot of the section represented in fig. 12. The limestone dips 80° to 85° to the westward; and the schist, at its nearest outcrop—10 yards—dips 50° to 60° to the eastward, the strike being N. 10° E. The schist is mostly a thick-bedded gneiss; and its antique look and massiveness, with its contorted texture, led me, in view of the non-conformity of dip, to suspect actual unconformability, and also difference in age and system of uplift. But this idea was soon set aside by the discovery that the top of the ridge was made partly of quartzyte, like that of Monument Mountain three miles north, and by other facts showing that both the schist and quartzyte were part of the limestone series.

The facts here brought forward fully establish the conclusion that the limestone, quartzyte, and schists under consideration have the same stratigraphical relations in Berkshire that they have in Vermont. They therefore sustain the view that these formations constitute together a conformable series; and, also, that the area they cover is geologically one.

[To be continued.]

ART. VII.—*On certain new and powerful means of rendering visible the Latent Photographic Image;* by M. CAREY LEA.

THE development of the latent or invisible photographic image produced by the action of light is beyond all question the most remarkable and the most interesting fact with which photo-chemistry has made us acquainted. Our knowledge, however, of the substances capable of exhibiting this power, has increased with singular slowness. It commenced with the discovery, by the late Rev. Mr. J. B. Reade, in the year 1836, of the existence of this power in *gallic acid*, and not long after *pyrogallol* was found to possess the same property in a more energetic degree. Mr. Robert Hunt discovered that *ferrous sulphate* acted somewhat more powerfully than pyrogallol, provided that a soluble salt of silver was present. This was more than twenty years ago. Since then, no useful addition has been made to this list of so-called "developers," though several of simply scientific interest. I was enabled to add to it *hæmatoxyline* about ten years since. *Morphia* has been found to have limited developing powers. When pyrogallol or gallic acid was employed in the absence of a soluble salt of silver, it was found that the activity of these bodies could be greatly increased by the presence of an alkali (alkaline development), for which purpose ammonium carbonate has been generally employed. It has been recently affirmed that in the ammonia-pyrogallol process, pyrogallol could be replaced (though with less energetic action, and therefore not advantageously) by a decoction of coffee berries, probably by reason of the quinic and caffetannic acids contained; and possibly by one or two other substances. This I believe represents the information acquired up to the present time.

In the following investigation I propose to show:

1. That the number of bodies endowed with the power of developing the latent image, so far from being very limited, as hitherto supposed, is, on the contrary, very large.

2. That contrary to what has been generally held, *potash* acts more powerfully in aiding development than ammonia; that there exist substances which develop with more or less energy in the presence of potash (e. g., mannite), but which have no such power in the presence of ammonia,* or alone.

3. It has been generally thought that the most energetic form of development, when no soluble salt of silver is present, is that which depends on the use of free alkali. I propose to show that there exists a form of development which under

* Unless possibly after greatly prolonged exposure.

appropriate conditions is more powerful than any yet known, in which there is *no free alkali present.*

4. It has been held that ferrous salts act only in the presence of a soluble salt of silver, and scarcely attack the silver haloid in the film, to produce an image in the absence of silver nitrate or other soluble silver salt. This also I think can be disproved.

As the development of the latent image depends (in the class of cases which I shall here consider,) upon a reduction of the portions of the sensitive substance which have been acted upon by light, it is evident that it is amongst reducing agents that we must look for bodies possessing this power. But here we are at once met by the fact that it is not the reducing power alone that is involved. We find that many substances which reduce silver salts energetically, have no power to evoke the latent image, and also that the developing power, where it exists, stands in no sort of relation to the energy of the reducing power. It is an *elective* power that is required, a tendency to reduce, not the whole surface, but only those parts that have been acted upon by light, and to spare the others. For example, it is easy to prepare alkaline solutions of ferrous salts, by having present a sufficient quantity of neutral potassium tartrate. But such solutions, applied to a sensitive surface that has received sufficient exposure under a negative, or in the camera, for ordinary development, seem to attack equally those parts that have been acted upon by light and those that have not. So that the sensitive surface darkens uniformly without showing the vestige of an image. Other similar cases will appear farther on.

In the following series of investigations a pure photographic paper was selected as the material for containing the sensitive substances. In the selection of the sensitive material itself, the object was to obtain the most highly sensitive possible. Silver iodide and bromide together are more sensitive to light than either separately, but also are more subject to irregular reduction. The best means of removing this difficulty without impairing the sensitiveness, I found to be the addition of silver chloride, which previous investigations had shown me to possess this power in a very remarkable way. Accordingly the present investigation was conducted upon surfaces containing these three substances together. The proportions used were those resulting from a solution containing eight grains potassium bromide, two of potassium iodide, and one and a third ammonium chloride, to the ounce. This proportion was that which gave the best results and was maintained in the experiments throughout. Facility of development is always increased by the presence in the sensitive film of some suitable organic substance. In these investigations a decoction of *cocculus indicus* was employed: this was applied together with the haloids, first; after drying, the silver solution. Finally the sheets were very thoroughly washed out, to remove every trace of excess of silver nitrate and of all other soluble matter. To this careful washing much importance attaches. If any cocculus were left in the paper, it might, by dissolving out in the developing solution, confuse the result, inasmuch as cocculus with potash exhibits some developing powers. Every trace of it was therefore removed by the most careful washing, and as an additional precaution, the most important results were repeated on paper prepared with haloids only, in order to control the conclusions with exactness.

RESULTS.—A. *Sugars.*

Several sugars when heated with dilute aqueous solution of potash exhibit power of development. *Glucose* and *cane sugar* very slightly. *Milk sugar* produces a light metallic looking image on a dark ground. *Glycocine* was without effect. *Manna* acts very powerfully, producing an image perhaps as bold and strong as any substance hitherto known. The contrast between this strong action of mannite and the very weak action or entire inactivity of the other sugars named seemed very singular. It was thought that it might possibly arise from the fact of mannite not being a carbohydrate like the others mentioned but containing more hydrogen than sufficient to convert the oxygen into water. Therefore another sugar of the same class, *quercite*, was tried, but was found to possess no developing power whatever. The remarkably energetic action of mannite remains therefore without explanation. This substance and milk sugar, offer a good illustration of what has just been said of developing power being not necessarily proportional to reducing power. Milk sugar in conjunction with potash energetically reduces the silver haloids, but shows little developing power, while the converse is the case with mannite.

The image produced by mannite is of a redder shade than that resulting from any other developing agent.

B. *Glucosides.*

Daphnin gave a moderately strong image; its derivative, *Daphnetin*, a bolder and fuller. *Phloridzin* and *glycyrrhizin* gave no images. So-called *flavin* gave no image when simply heated with potash, but when boiled with potash and zinc turnings gave a moderately strong one, doubtless by the conversion of quercetin into *quercitrin*. Accordingly an infusion of *white oak bark* was found to give a good image. *Solanin* gave a moderately strong image, as also did *thujine*. *Colocynthine* (decoction of colocynth was used) gave little or no result. *Æsculin*, a fair image. In all cases the substance was heated with dilute aqueous potash before use.

C. *Acids.*

Of a number of organic acids tried with excess of potash, one only, *cevadic acid*, exhibited tolerable developing power. *Phenol*, and *glyceric*, and *gentianic* acids powerfully reduced the silver haloids, but with little or none of the elective power necessary to produce an image. One, *oleic*, produced an image lighter than the ground. *Santonic*, *sinapic*, *gummic*, *malic*, and *hippuric* acids produced either faint traces of an image or none at all. *Vanadous acid* (potassium vanadite with excess of potash) failed to exhibit any developing power.

D. *Resins.*

Resinous substances for the most part dissolve easily in dilute aqueous potash, and exhibit more or less developing power. Foremost among them is *guaiacum* which gives a very vigorous image, not far short of what may be obtained with pyrogallol. *Balsam of tolu* and ordinary *resin* both have moderate developing power. Resin scarcely attacks the parts that have not been acted upon by light, whereas tolu does so. Resin of *podophyllin* gives a strong image.

E. *Essential Oils.*

When *oil of cloves* is boiled for a few moments with dilute aqueous potash, and the mixture is then much diluted with water, it acts slowly on the image, but as the action is sustained and clear, there results at the end of about an hour, a vigorous and very clear image. *Oil of Roman chamomile* acts somewhat similarly, but more feebly. *Oil of peppermint* produces an image of a gold color, and at the same time darkens the parts not acted upon by light, thus producing an image on a darker ground. Something similar has been already mentioned in the case of oleic acid. In these cases, where the light acts, the developing agent seems to reduce metallic silver, elsewhere, a dark basic salt, perhaps with organic matter in combination, is formed.

F. *Bases.*

Daturin (atropin?) gives a weak image. *Codein*, none. As a general thing the organic bases exhibit little tendency to evoke the latent image.

G. *Pyrogallol.*

In the course of this investigation, some interesting and new observations were made in connection with this well known agent, that deserve mention here.

Pyrogallol is well known to have, when employed by itself, considerable developing power, which however, is greatly increased by the presence of caustic or carbonated alkalies. It appears that these alkalies can be replaced with sodium *metaphosphate*, with about equal results. With sodium *hypophosphite*, the effect is fair but inferior. But with potassium *formate*, a more energetic result is obtained than by any other method of using pyrogallol: a stronger development than by any of the methods now in use.

H. *Various.*

Trials were made with a considerable number of substances of vegetable origin whose constitution or properties seemed to indicate that they might exhibit power of development. In all cases they were boiled a few moments with dilute aqueous potash, as it was found that in that way their characteristic actions were most fully brought out. *Aloes, uva ursi leaves, areca nuts*, the bark of the *berberin tree, morus tinctoria*, exhibited very considerable developing power. *Gratiola, ipecacuanha, pimento nuts*, well marked power, but less than the foregoing. A decoction of *Iceland moss* exhibited the properties already described in the case of oleic acid and essential oil of peppermint. Many other substances were examined, and showed either faint traces only or absence of power, e. g., *litmus, carthamus, rutin, bryony, stavesacre, colchicum, turmeric, nux vomica, caffein, berberin*, etc.

Acetone, in conjunction with aqueous potash, is a powerful developer and gives a bold and vigorous image.

Aldehyde, with potash, gives no image, a result that seems somewhat remarkable.

I. *Cuprous oxide dissolved in Ammonia.*

A colorless solution of cuprous oxide in ammonia develops a strong image, and is interesting as being one of the very few entirely inorganic developers discoverable. As might be expected, its action is heightened by the presence of many organic matters.

When to a solution of cuprous oxide in ammonia, *formic acid* is added in quantity not quite sufficient to neutralize the bases, and this solution is applied to the latent image, a powerful development is obtained, resulting in a pure black image. *Lactic acid* exhibits a similar reaction, but less perfectly, and no doubt a large number of other organic acids share the same properties.

Various substances that develop in presence of potash, especially *gum guaiacum, gallotannic acid* and *manna*, heighten the action of the cupro-ammonia solution. Others do not, of which *picrotoxin* (*cocculus indicus*) is an example. Of all the substances named, guaiacum appeared to have the most power, and next to it, perhaps formic acid.

J. *Ferrous Salts.*

The salts of ferrous oxide have proved to be the most interesting and remarkable of all the bodies examined, in their action on the image. When a salt of silver is present in solution, to suffer reduction and to furnish silver for building up the image to be developed, as in the case of the so-called "wet process," ferrous sulphate is the most powerful developing agent known, and is accordingly, always employed. But in the absence of silver in actual solution it is powerless. It is in connection with such sensitive surfaces (i. e., those from which silver nitrate or other soluble silver salt has been removed by washing), that the present investigation is made, and I have verified this fact, already established, very carefully. A surface of sensitive paper, from which all silver compounds have been removed, may, after receiving a latent image, be left long in contact with ferrous sulphate without an image being developed.

Desirous of finding a means of applying ferrous salts to these developments, my first efforts were directed to the formation of alkaline solutions containing ferrous oxide in solution, but they did not appear to possess any power of development. I then tried ferrous oxide in combination with organic acids, and here at once most interesting results followed. Several organic salts furnished beautiful developments, among which may be especially mentioned *ferrous succinate, lactate* and *salicylate.* The succinate is best used by forming a slightly acid solution of ammonium succinate, and adding to it a solution of ferrous sulphate in quantity not quite sufficient to form a precipitate. Many other ferrous salts, among which may be mentioned *citrate, formate* and *tartrate,* give images, but much inferior to those already mentioned. The succinate and lactate develop so well that they might pass into use, were they not, as well as all other developing agents, so much exceeded by the oxalate.

Ferrous oxalate, when applied to paper sensitized in the manner already described, exhibits developing powers of a very remarkable kind. A piece of sensitized paper exposed for a very brief period to diffuse light under a negative, and then cut into two pieces and tried, the one with this development, the other with the ordinary alkaline pyrogallic development, exhibits the following differences:

The same exposure which with the alkaline pyrogallol gives a weak and sunk-in image after a protracted development, gives with ferrous oxalate a bright, bold image, and this in a much less time. The development is particularly clear and clean. The unexposed parts are not attacked: the developer possesses a great deal of that elective power previously spoken of, which causes it to react strongly on those parts which have received the influence of light, and spare those which have not.

Ferrous oxalate is easily obtained by adding a strong warm solution of oxalic acid to one of ferrous sulphate. A bright yellow precipitate falls, which continues to increase for some time, and which may easily be washed by decantation. The method of employing it is by dissolving it in an aqueous solution of neutral potassic oxalate. The latter substance is to be dissolved in about three times its weight of hot water, and the precipitated and washed ferrous oxalate is dissolved in it to saturation. A deep red solution is obtained, which for use needs only to be diluted with from five or six up to twenty or thirty times its bulk of water, according to the energy of effect desired.

An active solution of ferrous oxalate may be obtained by simply adding a solution of ferrous sulphate to one of neutral potassic oxalate, in quantity just sufficient to avoid forming a permanent precipitate. But the first described method gives the best results.

Philadelphia, May 8, 1877.

Art. VIII.—*On the possibility of Transit Observation without Personal Error*; by S. P. Langley.

The different modes of dealing with personal equation may be divided into two broad classes: (1) those which attempt to diminish or eliminate it during the act of observation, (2) those which aim to find its amount, and to apply a subsequent correction. Redier, Braun, A. S. Herschel, Wheatstone and many others, have proposed devices falling in the first category; all of which involve the use of a movable reticule, which, theoretically, should travel at the same apparent rate as the star. The mechanical difficulties of doing this accurately (considering that every star has a different apparent rate) are extreme, and they almost necessarily involve the use of delicate apparatus forming a part of the telescope. These difficulties have never been overcome,—scarcely attacked, and were they vanquished, others would remain. This method then, though perhaps still susceptible of success with skillful treatment, has not yet proved of any practical utility. A very different proposition, originally due I think to M. Faye, and made as long since as 1858, is that for the use of photography in transits. This evidently, if practicable, does away with personal error, and if the exposure be reduced to a very brief time—let us say to $0^s{\cdot}01$—it is clear that the motion of the star is immaterial, for we have its position photographed relatively to the wires, as it was at a given instant. This method has been little used, except for the sun, owing to defective light, but though not yet practicable save in limited cases, it is perhaps not too much to say that it will probably be the method of the future.

Under the second class come the ordinary procedures for the determination of relative error, or the personal equation between two observers; such as their interchange of stations, or their observing the same stars with adjacent instruments, or with the same instrument jointly, etc. These comparisons are liable to error themselves, are commonly tedious, and often compel long journeys. When successful, they give, not the absolute error, but the error as compared with another error, itself subject to an unknown variation. Unsatisfactory as all this is, however, such methods are in common use, and will remain common till better are provided. An effort in this direction has stimulated the invention of a great number of devices to enable the observer to determine his equation by comparison with the transit of an artificial star, itself, self-recording. This suggestion (said to have been first made by Prazmowski in 1854), has been the parent of many attempts, among which those of M.M. Hirsch and Plantamour; and that of M. Wolf of the Paris Observatory, particularly deserve attention; and of subsequent ones too numerous for description, though the apparatus of Professor Eastman, U. S. N., and of Professor Rogers of Harvard College Observatory, mav be cited as favorable examples. It may be observed that the use of such apparatus, however ingenious, can only determine the personal error then and there, and can give no guarantee against its variability, which is, after all, the most formidable difficulty. Were this a history of devices for correcting or eliminating personal equation, a volume might be easily filled with an account of proposals coming under one or the other of these two heads, for the literature of the subject is fuller than most are aware.

To propose to offer anything new at this day on such a subject may seem to be hardy. I venture however to ask attention to a method for eliminating the equation on the star itself, which has worked well on trial.

Before stating it, let us observe that we restrict the words "personal equation" here, to the correction for the error committed by the observer in noting the time of transit of a star owing to the motion of the latter, and that for brevity we leave untouched the effect of certain minute irregularities familiar to the observer, such as the actual inequality of wire intervals which should be equal, or the apparent irregularity in the motion of the star due to atmospheric tremor. A particular interest in the subject has long led me with others, to try to remove the error from the observation, in the act of observation itself. One mode which presented itself many years since, and which has been tried in numerous subsequent plans I have made, was to view the star only for a brief time through a narrow linear aperture in a moving screen, thus exhibiting its position in the field for a moment only, though the use of a flash of light which for an instant illuminates the wires has seemed better. In any case the essential idea was to treat the eye as it has been proposed to use the photographic plate, and to impress upon it by instantaneous vision an image of the position of the star independent of personal error (in one sense,) since the star was to have sensibly no time to move, while the view lasted, while yet the effect then seen would remain (owing to persistence of vision,) quite long enough for cognizance. After a great number of forms of the movable screen were considered, they were set aside for the flash of light from the electric spark.

To make the present plan plain, let us recur to the use of photography as an illustration, and first suppose that the transit wires are twenty-five in number and so near that a star occupies one second in passing from one to another. In the place of a transit lamp, let a wire, attached to a repeater in the clock circuit, dip in a mercury cup, and the circuit being broken every second by the clock, recording simultaneously on the chronograph; the otherwise dark field will be illuminated by a brilliant instantaneous flash, by whose light the wires are projected with the crossing star on the sensitive plate of the camera. If this plate be renewed or moved downward at each flash, we obtain twenty-four successive pictures while the star is crossing, each showing it at the extremity of its luminous traces in precisely the same relation to the adjacent wires, since the wire interval in time, and the flash interval, are identical. If then the star is caught by the first flash, one-third of the way from the first to the second wire, it will be exhibited by the next flash one-third the way from the second to the third, and so on. Any one of these photographic pictures would on being measured, and compared with the chronographic record give the time of transit free of personal error, but this method, applicable if at all, at present, only to the brighter stars, is here used only in illustration. Even were it practicable we do not always have a photographer or photographic material at command, but we have the eye at all times, and I hope to show how we may obtain from it, results of the same order of accuracy as those we could expect from the photograph, and equally exempt from personal error, in the sense in which we have defined it.

First as to the difficulties to overcome. In the case of the photograph, there is an opportunity for subsequently measuring the distance of the star from the wire, which we have not with the eye. There is one particular case however, where the result is the same for both, that, namely, when the flash comes, the star is on the wire and bisected by it; in this case we know its position as accurately by the eye, as if we bisected its image on the plate by the wire of our measuring micrometer, with the same magnifying power. If we suppose, then, that the star observed was in the equator, and that, by a happy accident, the first flash came just as it was crossing the first wire, this wire would be sharply defined on the disc of the star and bisecting it, and the simultaneous record on the chronograph (made without any intervention of the observer) would evidently give us the same result as though the star had electrically recorded its own passage. Further, we may particularly notice that it is immaterial whether the star was at rest, when thus seen, or in motion. Now what we have just supposed as the single case of a favorable chance among hundreds for an equatorial star; with wire intervals of one second, it will be our task to *make* occur, whatever the wire interval, and for any star observed; and that our invention may be of practical utility, to find apparatus, whose use requires no unreasonable demand on the observer's time or skill, and which is simple and portable. After numerous failures, the following apparatus was devised a year since, but it has only been constructed and put to trial with promising success at this Observatory within the last month. In the described form it is especially intended for longitude work, where it is necessary to determine the clock error from time stars (whose declination does not exceed 60°), and most desirable that the results shall be independent of that personal error in the observer, which presents itself on this class from the star's rapid motion.

On the transit pier (or in any other convenient locality) is a small clock, with a conical pendulum, whose bob slides freely up and down the graduated rod, retaining its position where left. A small horizontal wheel in the clock is controlled by the pendulum, and turns once for a certain constant number of its revolutions. This wheel revolves once for each equatorial interval of the transit wires, when the bob is set at a mark near the top of the rod, and by sliding the bob sufficiently downward; with the use of a readily-constructed table, we can, given the declination of any star between the limits 0° and ± 60°, set the pendulum, so that this wheel shall make exactly one revolution while the star passes from wire to wire. This wheel carries near its periphery a mercury drop or other contact piece, which once in a revolution is carried past a point fixed near the periphery of a stationary horizontal wheel, concentric with the first, and immediately above it, but insulated and entirely detached from it. This upper wheel, while thus related to the lower, is entirely disconnected from the machinery of the clock, and is thus far stationary, but it can be revolved by cords passing from a groove in its circumference to the hand of the observer at the transit. As the upper, or ordinarily fixed, and the lower or constantly moving, wheel have, a common vertical axis of revolution, and as the radial distance of the point in the upper from this axis is the same as that of the contact piece on the lower, it will be seen while the upper wheel remains motionless, electric contact accompanied by a simultaneous flash, if we desire it, at the transit lantern or elsewhere, will be made at equal and uniformly recurrent epochs, the interval between which depends only on the adjustment of the pendulum. If the upper wheel be rotated forward by hand, through a small distance, and then left, the next contact will still occur, but at a later epoch, owing to the lower wheel's having to complete more than one revolution to make contact, but after this the contact and simultaneous flash will recur at the same intervals, and with the same regularity as before. If the upper wheel be moved backward, the flash will occur once, earlier, and thereafter with regularity. Moving the upper wheel, then, changes the epoch from which any series of such flashes dates and adjusting the pendulum bob, fixes the interval between subsequent flashes. In practice the lamp is removed from the transit lantern, and the two terminals of a battery or induction coil in its place, cause the flash to be thrown upon the wires, whenever the mercury drop is in contact with the point, and at the same instant a mark is made automatically on the chronograph and interpolated in the regular record of the beats of the sidereal clock, which go on in the usual way quite independently of any reference to the apparatus just described. The method of connecting the wires so as to give these results, will so readily suggest itself to the practiced observer that we need not occupy our present general description with it. I here speak of the instrument in actual use, where the contact piece makes circuit, but a break circuit is easily substituted, and we may use a Geissler tube in place of the spark.

The mode of observation will be anticipated. Before the transit of any star the observer adjusts the conical pendulum beside him (this is the work of but a few seconds), and then seats himself at the instrument holding the cords in one hand like the "reins" of an equatorial. If a flash occur just as a star is crossing the first wire (which is most unlikely) he has nothing to do, except possibly to note which was the middle wire, for each records itself on the chronograph without any intervention of his. But if the star be, for instance, two-thirds of the way from the first to the second wire at the first flash, he will draw one of the cords, accelerating the flash and thus causing the star to appear nearly coincident with the second wire when the next spark comes, and repeat the adjustment by the light of subsequent flashes, till the bisection is perfect. Three or four trials are in practice found to yield a bisection which will satisfy a fastidious eye, and when a satisfactory one has been once made, the effect is automatically repeated. Of course, no increase in number of the wires, under these circumstances, adds real weight to that from the first satisfactory bisection, but, with the usual five tallies of five wires each, the observer can easily, if he please, obtain five independent bisections,* or one for each tally, and in this case the chronographic record corresponding to the last wire of each tally is assumed to be the significant one, unless the contrary is recorded.

Under the general conception, then, of the possibility of diminishing to any limit personal error, by employing brief views of the star or wire and utilizing the phenomena of persistence of vision, the particularly described device assumes to dispense with the observer's record upon the chronograph altogether, and to substitute a purely automatic one, giving the same virtual result as though the image of the star were a tangible object, itself making electric contact with each wire. The share of personality in any observation, is relegated to the prior act of bisecting a star, virtually motionless with relation to the bisecting wire, so that if (as seems to be the case) this act is independent of quickness or slowness of perception, of the time of cognition, or of the speed of nerve transmission; personality in the technical sense, appears not to intervene at all.

ART. IX.—*Observations of Comets made at the Litchfield Observatory of Hamilton College*; by C. H. F. PETERS.

1. *Comet* 1877, II (Winnecke's):

1877.	Mean t. H. C.			App. AR.			App. Dec.			No. of Comp.
Apr. 6.	16^h	18^m	56^s	22^h	8^m	46·29^s	+16°	23′	12·7″	10
" 8.	15	39	25	22	10	23·76	18	46	6·0	10
" 10.	15	25	24	22	12	13·71	21	22	7·2	10
" 12.	15	30	34	22	14	18·84	24	10	11·5	10
" 14.	14	54	27	22	16	36·48	27	7	9·8	14
" 23.	14	8	32	22	32	39·34	43	3	33·9	10
May 2.	14	0	48	23	12	23·07	62	25	28·1	10
" 12.	13	11	17	2	50	42·20	79	48	19·5	8
" 13.	12	46	23	3	38	25·44	80	10	32·7	8
" 14.	9	58	52	4	21	43·23	80	8	25·0	8
" 29.	12	2	6	8	41	11·96	+62	21	31·6	9

* I regret that this lengthy description may convey an impression of complexity as to a really very simple apparatus, all we ask of which, as a timekeeper, is that its rate shall be sensibly constant during the star's brief passage through the field. It consists only of a small conical pendulum with maintaining power and the two contact wheels described. Its installation consists in placing it in a level position and connecting it with the wires, and its size need not exceed that of the break-circuit chronometer box; it may indeed for field-work be conveniently encased with the latter.

Notes.—This comet showed always a fine star-like concentration of light, which permitted an accurate pointing, so that the observations are good. The tail was never very bright, but the coma large. Instead of forming an envelope, as there seemed to be a tendency on April 8, the denser portion of the coma on May 2 appeared to consist of small discrete particles, exactly like a star cluster or nebula just at the point of being dissolved.

2. *Comet* 1877, III (Swift-Borelly's):

1877.	Mean t. H. C.	App. AR.	App. Decl.	No. of Comp.
May 3.	11^h 6^m 23^s	* — $25{\cdot}80^s$	----	6
" 3.	10 56 31	----	* $-2'$ $22{\cdot}0''$	4
" 4.	10 3 5	5^h 3^m 25·93	$+60°$ $2'$ 25·1	8
" 5.	10 10 38	5 15 50·04	59 30 24·7	8
" 12.	10 6 41	6 29 25·59	54 7 31·2	10
" 30.	9 58 1	8 13 1·60	+35 45 34·3	10

The comparison star for May 3 is D'm. +60°,854, and its position 1877·0 approximately $\alpha = 4^h\ 51^m\ 42^s$; $\delta = +60°31{\cdot}2$.

The observations of May 3, 4 and 5 were made by Professor J. G. Porter with the ring micrometer of the four-inch Steinheil refractor. All the other observations were obtained by myself with the filar micrometer of the 13½ inch refractor, using a power of 270, and illuminated wires.

Comet III had always a more or less blurred aspect, without distinct nucleus, rendering the pointing difficult.

Clinton, N. Y., June 1, 1877.

Art. X.—*On Complex Inorganic Acids.* From a letter of Dr. Wolcott Gibbs to one of the Editors, dated Cambridge, June 14th, 1877.

You will doubtless remember that about twelve years since Marignac described three acids which he obtained by boiling silicic hydrate, $Si(OH)_4$, with an acid alkaline tungstate, and which he called respectively silico-tungstic, tungsto-silicic and silico-deci-tungstic acid. The two first mentioned are isomeric or metameric, and are represented by the formulas:

$$12WO_3 . SiO_2 . 4OH_2, \text{ or } W_{12}O_{34}Si(OH)_8,$$

while the third has the formula

$$10WO_3 . SiO_2 . 4OH_2 \text{ or } W_{10}O_{28}Si(OH)_8.$$

It occurred to me that these results might be generalized in various ways, and I have in fact obtained some very interesting new series of acids of the same or similar types. Platinic hydrate $Pt(OH)_4$ boiled with an acid sodic tungstate yields two isomeric or metameric sodium salts which have the formula:

$$10WO_3 . PtO_2 . 4ONa_2 + 25\text{ aq}.$$

One of these gives magnificent olive-green crystals; the other equally fine honey-yellow prisms with a very strong adamantine luster. They are readily soluble in water and give flocky or sub-crystalline precipitates with solutions of the heavy metals and of the higher alkaloids. The corresponding potassium and ammonium salts have respectively the formulas:

$$10WO_3 . PtO_2 . 4OK_2 + 9 \text{ aq. and } 10WO_3 . PtO_2 . 4OAm_2 + 12 \text{ aq.}$$

but both belong to the yellow series. I have not yet obtained the 12-atom series corresponding to Marignac's silico-tungstates. The platino-deci-tungstates dissolve tungstic hydrate, $W(OH)_6$, on boiling, but the hydrate separates again on cooling without change. Acid molybdate of sodium also dissolves platinic hydrate giving a deep olive-green solution which appears red in thick layers. The only salt of this series yet studied crystallizes in amber-colored tabular plates which have the formula:

$$10MoO_3 . PtO_2 . 4ONa_2 + 29 \text{ aq.}$$

They are very soluble and give sub-crystalline precipitates with many metallic solutions. I think I have also obtained the corresponding metameric series, but of this more in due time. The acids corresponding to the salts above briefly described are crystalline and may be obtained from the respective barium salts by sulphuric or from the silver salts by chlorhydric acid. Nearly all the salts of both series effloresce strongly and the alkaline salts have a very distinct acid reaction, so that the limit of the basicity is certainly higher than eight. I am endeavoring to generalize these results still farther by replacing platinic hydrate by other hydrates of the same type, as for instance by those of the other metals of the platinum group and by $Zr(OH)_4$ $Ti(OH)_4$, $Sn(OH)_4$, &c., but though I have in many cases indications of the formation of new complex acids I have nothing definite at present. Silico-molybdic acid appears however to be formed by boiling acid sodic molybdate with $Si(OH)_4$ when colorless or very pale yellow crystals are formed.

Nearly five years since Scheibler discovered two phospho-tungstic acids which, according to his analyses contained, respectively, six and twenty molecules of tungstic oxide, WO_3 to one of P_2O_5. As he has published nothing whatever upon the subject since, I have thought that I could fairly enter upon the same field and have begun the study of the 20-molecule series. I have already established some very important facts with respect to the compounds of this series, and have further generalized my own results to a most unusual extent.

According to my analyses, phospho-tungstic acid has the formula

$$20WO_3 . P_2O_5 . 8OH_2 \text{ or } W_{20}O_{57}P_2(OH)_{16}$$

independently of water of crystallization. I have obtained salts of this series having respectively the formulas:

$$20WO_3 . P_2O_5 . ONa_2 . 7OH_2 + 16 \text{ aq.}$$
$$20WO_3 . P_2O_5 . 2BaO . 6OH_2 + 18 \text{ aq.}$$
$$20WO_3 . P_2O_5 . 6BaO . 2OH_2 + 44 \text{ aq.}$$
$$20WO_3 . P_2O_5 . 7OK_2 . OH_2 + 27 \text{ aq.}$$
$$20WO_3 . P_2O_5 . 8OK_2 + 18 \text{ aq.}$$

All these salts have an acid reaction except the 8-molecule potassium salt, and I consider this—provisionally at least—as determining the limit of the basicity of the acid. This is important as showing that it is not phosphoric oxide, P_2O_5, which alone is saturated. Debray considered the corresponding phospho-molybdic acid as 6-basic, but written with the newer atomic weights it would of course be regarded as 12-basic, if his view were correct. He describes however a 7-atom silver salt which I should write

$$20MoO_3 . P_2O_5 . 7OAg_2 . OH_2 + 24 \text{ aq.}$$

and which is clearly the analogue of my potash salt above mentioned. All or nearly all the phospho-tungstates effloresce quickly in dry air. I regard the formulas above given as well ascertained excepting possibly that of the very acid sodium salt which heads the list. The analyses of these salts as well as of the platinum series are difficult, and the ready efflorescence is another obstacle to very precise work. All but the first mentioned sodium salt are colorless; the 7 and 8-atom potassium salts are splendid, and there is at least one ammonium salt which is precipitated as a very heavy snow-white crystalline powder. I have not used Scheibler's method of preparing these compounds, but obtain the acid sodium salt by mixing normal sodic tungstate and hydro-disodic phosphate, $WO_4Na_2 + 2$ ag. and $PO_4Na_2H + 12$ ag., in the proportion of 20 molecules of the former to 2 of the latter and adding NO_3H until the very alkaline liquid becomes acid. I have had much success in generalizing these results. The corresponding arseniotungstic acid and its salts are easily obtained, and I have more or less distinct indications of vanadio-tungstic and antimonio-tungstic acids. It may prove that there are also niobio-tungstic and tantalo-tungstic acids, and experiment will soon decide this point. But generalization is also possible in other ways. Thus I find that when in my process oxyfluo-tungstate of sodium, $WO_2F_4Na_2$, is substituted for the normal tungstate, splendid crystalline salts are formed with both arsenates and phosphates. In place of normal sodic arsenate the oxyfluo-arsenate may be employed and new acids result both with normal tungstate and oxyfluo-tungstate of sodium. The same statements are probably true with respect to molybdic compounds, only the resulting salts are not always well defined. You see that in this way the number of new acids is very great and that I have a heavy task before me. It is of course too soon to speculate on the theoretical structure of the new acids. I have given the simplest possible formulas in all cases, but it may be that those of the platino-tungstic and platino-molybdic acids must be doubled. In this case their analogy to the phospho-tungstates, &c., will be more easily seen, as we shall have for the sodium salts for instance,

$$20WO_3 . Pt_2O_4 . 8ONa_2, \text{ and } 20WO_3 . P_2O_5 . 8ONa_2,$$

meantime I have as yet seen no satisfactory reason for the change. I am disposed to think that the well known and very singular $\frac{3}{7}$ tungstates and molybdates, $3ONa_2 . 7WO_3$ and $3ONa_2 . 7MoO_3$, should be multiplied by 3 and written

$$20WO_3 . WO_3 . 9ONa_2, \text{ and } 20MoO_3 . MoO_3 . 9ONa_2.$$

They will then fall naturally into the 20-atom series. It seems also possible that the curious salt of Wöhler usually written $WO_4Na_2 + W_2O_5$ may be represented by such a formula as $16WO_3 . 4WO_2 . 7ONa_2$ or $W_{20} . W . O_{49}(ONa)_{14}$. I shall devote myself to these compounds until I have exhausted the subject as far as possible, and meantime anticipate many new results.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Effect of Pressure on Chemical action.*—Berthelot calls attention to Quincke's statement that in some experiments which he made in which sulphuric acid and zinc were placed in contact, the pressure of the evolved hydrogen rose in a few days from 1½ to 10 atmospheres (varying with the apparatus), in five months from 27 to 54 atmospheres, and in 17 years, from 25 to 126 atmospheres, and remarks that these experiments, made for an entirely different purpose, conclusively prove that the evolution of hydrogen is not arrested by pressure, but is only diminished in rapidity, confirming his results of twelve years ago. In this case, chemism is not modified, but only the nature and extent of the surface of attack, the metal becoming covered with an adherent gaseous layer, while the acid close to it becomes saturated. Hence, in his opinion, the evolution of hydrogen would go on indefinitely, limited in time only by the strength of the vessels containing the reagents.—*Bull. Soc. Ch*, II, xxvii, 347, April, 1877. G. F. B.

2. *New method of determining the Specific gravity of a readily decomposable body.*—In order to determine the specific gravity of iodine trichloride, a body not only exceedingly volatile at low temperatures, but also readily dissociated except in presence of chlorine gas, Christomanos has devised a new and simple method for this purpose. In a cylindrical glass vessel closed at the ends by two suitable glass cocks and previously filled with dry chlorine gas, and weighed, the trichloride is placed and the weighing is repeated. The difference in weight is the weight of the trichloride less the weight of chlorine equal in volume to it. To determine this latter weight and thus the volume of this chlorine (which of course is the volume occupied by the trichloride) the experiment is repeated at a suitable temperature using carbon dioxide in place of chlorine. From this second difference, the known weight-relations between the gases being given, the weight of the chlorine is obtained by means of the formula $Cl = \frac{71}{27}(c_1 - b_1 - c + b)$ in which b and b_1, c and c_1 represent the first and second weighings with chlorine and carbon dioxide respectively. This weight

known, the volume is calculable at the temperature and pressure of the experiment, and hence the volume V of the trichloride is known. Its weight, $W, = \frac{27}{71(c_1 - b_1) - 44(c - b)}$, in grams. From these data, the density is obtained since $\frac{V}{W} = D$. The result with ICl_3 gave 3·1107, which the author thinks too high.—*Ber. Berl. Chem. Ges.*, x, 782, May, 1877. G. F. B.

3. *On the Determination of High Melting Points.*—CARNELLEY has proposed a new process for fixing the melting points of less readily fusible salts, founded on the principle that if three metallic salts A, B and C, which fuse at different temperatures such that A fuses before B and B before C, be arranged on a cold block of smooth iron and this be placed in a muffle kept at a constant high temperature, and if x be the number of seconds which elapse between the melting of A and B and y, the number of seconds between the melting of A and C, then the ratio $\frac{y}{x}$ is approximately constant for the same three salts whatever may be the temperature of the muffle, provided only it is considerably higher than that at which C fuses. Thus in sixteen experiments, using the three substances, sulphur, silver nitrate and potassium nitrate, the experiments being made at widely different temperatures, the ratio in each was 2·67, 2·68, 2·81, 2·80, 2·72, 2·67, 2·67, 2·67, 2·56, 2·62, 2·58, 2·87, 2·65, 2·88, 2·71, 2·91; mean 2·72. If the ratios obtained with different salts be reduced to the same scale, as by assuming the ratio between sulphur and potassium nitrate and any other third salt to be any given number, the value for a given salt is constant, whatever the other salts used with it in the experiment. From these ratios, time-values are obtained for nine standard salts, S, $AgNO_3$, KNO_3, $KClO_3$, TlCl, $PbCl_2$, KI, KCl, and Na_2CO_3. Thus if in four experiments, 27, 39, 45, and 65 seconds respectively elapse between the melting of S and $AgNO_3$, and 72, 106, 120, and 170 between S and KNO_3, then if we assume a constant value, say 10 seconds, for the former, the latter becomes constant; i. e., 26·7, 27·2, 26·7, 26·7 seconds. This (or the mean of a larger series 26·4) is the "time-value" for KNO_3. So 32 is the time value for $KClO_3$, 45 for TlCl, 59 for $PbCl_2$, 115 for KI, 197 for KCl, and 258 for Na_2CO_3. From the equation $\frac{y}{x} = r$, in which r is the experimental ratio for any salt, the time-value of that salt may be obtained. Thus with S, $AgNO_3$ and $KClO_3$, if $r = 2·72$, $\frac{y}{x} = 2·72$; whence if $x = 10$, $y = 27·2$, the time-value. Or, again, the value of r for $PbCl_2$, KCl and Na_2CO_3 is 1·50. Since the time-values of the two former are 59 and 197, $x = 138$, and $y = 207$; or Na_2CO_3 melts 207 seconds after $PbCl_2$; and since $PbCl_2$ melts 59 seconds after S, the time-value of Na_2CO_3 is 266 seconds. By accurately determining the melting points of these nine salts, and collating

them with their time-values, a table may be obtained from these data, either by direct or by graphic interpolation, from which, knowing the time-value for any salt, its melting-point can be obtained.—*Jour. Chem. Soc.*, xxxi, 365, April, 1877. G. F. B.

4. *New Vapor Density Method.*—GOLDSCHMIEDT and CIAMICIAN have modified somewhat Victor Meyer's method of fixing vapor densities, and by substituting mercury for fusible metal, have contrived an apparatus which is simple and effective. A glass bulb of 150 c.c. capacity has at its lower portion a tube which turns and passes upward to about the diameter of the bulb above it, and to which, just below its top is attached a lateral tube. A weighed substance being placed in the bulb, this is filled with mercury till it flows away by the lateral tube. The whole is placed in a bath of water or paraffin as is necessary, and heated. The production of vapor expels its volume of mercury which is received in a tarred vessel and weighed. This volume corrected is the volume of the vapor; whence its vapor is the quotient of its weight by this.—*Ber. Berl. Chem. Ges.*, x, 641, April, 1877.

G. F. B.

5. *On the Condensation of Isobutylene.*—BOUTLEROW has obtained a curious body, which he calls isodibutylene, by the action of diluted sulphuric acid upon trimethylcarbinol. It is a colorless liquid, having a boiling point between 102° and 104°, and is by its chemical characters, a hydrocarbon of the ethylene series, forming direct addition products with bromine, with hydrochloric and with hydriodic acids. Moist silver oxide acts on the iodide thus obtained, giving rise to a new octyl alcohol, isodibutol, having a characteristic smell of camphor, and boiling at 146·5°–147·5°. When isodibutylene or isodibutol is oxidized with chromic acid, the principal products are acetone and trimethyl-acetic ether; hence the constitution of the hydrocarbon is represented by the formula $\begin{matrix}CH_3\\CH_3\end{matrix}{>}C{=}\underset{H}{C}{-}C\begin{matrix}\diagup CH_3\\ -CH_3\\ \diagdown CH_3\end{matrix}$. It is isobutylene, in which an atom of hydrogen belonging apparently to the methylene group, is replaced by tertiary butyl.—*Bull. Soc. Ch.*, II, xxvii, 370, April, 1877. G. F. B.

6. *New method of producing Salicylic acid.*—HERMANN, who studied some time ago the action of sodium on succinic ether, now finds that if the action be long continued, there is formed, probably by the action of the metal on the succinyl-succinic ether at first produced, considerable quantities of salicylic acid. The production of this substance in this way is doubly interesting; first, because since succinyl-succinic acid, whose formula is $\begin{matrix}CH_2{-}CO{-}CH.COOH\\ | \qquad\qquad | \\ CH_2{-}CO{-}CH.COOH\end{matrix}$, is a member of the fatty series, while salicylic acid, $C_6H_4\left\{\begin{matrix}COOH\\OH\end{matrix}\right.$ belongs to the aromatic, it shows a conversion of one into the other, the closed ring of six carbon atoms in the former suffering a further condensation and develop-

ing a true benzene ring; and second because from this mode of formation it is clear that in salicylic acid the hydroxyl and the carboxyl groups occupy the para position.—*Ber. Berl. Chem. Ges.*, x, 646, April, 1877. G. F. B.

7. *On the Formation of Coumarin, and of Cinnamic and other analogous acids.* — PERKIN, who synthesized coumarin $C_6H_3\left\{\begin{matrix}C_2H_3O\\CO\end{matrix}\right.$ several years ago, now finds that this substance is readily produced when salicyl hydride is boiled with acetic oxide and sodium acetate. He was thus led to try other aldehydes in the same way. On boiling benzoic aldehyde with acetic oxide and sodium acetate for a day, a considerable quantity of an acid was obtained which on examination proved to be cinnamic or phenyl-acrylic acid $C_6H_5.CH.CH.COOH$. Using propionic oxide and sodium propionate, the product of the reaction was phenyl-crotonic acid, $\left\{\begin{matrix}CH_2(C_2H_2C_6H_5)\\|\\CO(OH)\end{matrix}\right.$. From butyric acid and sodium butyrate, was obtained phenyl-angelic acid, $\begin{matrix}CH_2(C_3H_4.C_6H_5)\\|\\CO(OH)\end{matrix}$. From benzoic aldehyde, succinic acid and sodium succinate, isophenyl-crotonic acid. From cuminic aldehyde, acetic oxide and sodium acetate, cumenyl-acrylic or isopropylphenylacrylic acid $C_6H_4(C_3H_7).C_2H_2.COOH$, was obtained. Substituting propionic oxide gave cumenylcrotonic acid, while butyric oxide gave cumenylangelic acid. Cinnamic aldehyde with acetic oxide and sodium acetate gave cinnamenylacrylic acid, propionic oxide gave cinnamenylcrotonic acid, and butyric oxide gave cinnamenylangelic acid. Anisic aldehyde gave methylparoxyphenylacrylic, methylparoxyphenylcrotonic and methylparoxyphenylangelic acids, when thus treated. Methylsalicylic aldehyde gave methylorthoxyphenylacrylic, methylorthoxyphenylcrotonic and methylorthoxyphenylangelic acids.—*J. Chem. Soc.*, xxxi, 388, April, 1877. G. F. B.

8. *New Urea reaction.*—SCHIFF has observed that when a solution of urea in three parts of a concentrated aqueous solution of furfurol is treated with a few drops of hydrochloric acid and warmed, a splendid purple-violet color is developed.—*Ber. Berl. Chem. Ges.*, x, 773, May, 1877. G. F. B.

9. *Notes from the Chemical Laboratory of the Johns Hopkins University.* Nos. 1, 2, 3. 16 pp. 8vo: Baltimore, May, 1877.—The papers here included are: Oxidation of Mesitylene-sulphonic acid, by L. B. HALL and Professor REMSEN; on the oxidation of the Sulphoacids derived from metaxylene, by M. W. ILES and Professor REMSEN; on isomeric nitrotoluenesulphonic acids from paranitrotoluene, by E. HART and Professor REMSEN.

II. Geology and Mineralogy.

1. *Volcanic Eruptions on Hawaii;* by Rev. Titus Coan.—On the 6th and 7th of January, 1873, the great terminal pit of Mauna Loa, Mokua-weo-weo, was intensely active, exciting the attention of spectators around all the shores of Hawaii and Maui. The scene was brilliant beyond what I had ever before witnessed in that lofty crater. But it was as transient as it was bright. We were favored with only two nocturnal exhibitions, when the curtain dropped and the lights were extinguished.

On the 20th of April, 1873, this crater fired up again, and for months the illumination was grand by night, and the column of smoke and gases rose in a magnificent pillar by day.

In January, 1874, another marvellous boiling commenced in Mokua-weo-weo, and continued for fifteen months. During all this period parties could ascend the mountain, look down into this awful cauldron, listen to the surging and roaring, and startling detonations of the fiery abyss, and watch the jets as they spouted upward hundreds of feet, and the glowing waves as they rolled and dashed against the walls of the pit.

I think it was on the 11th of August, 1875, that another brilliant eruption occurred in Mokua-weo-weo, lighting up the firmament, and awakening the enthusiastic admiration of beholders. This continued but one week.

On the 13th of February, 1876, we were entertained by another grand display of Pele's fire-works, keeping thousands of people on the watch at midnight, but this also was of short duration.

All these demonstrations were confined to the great mountain crater. There were no overflowings and no lateral outbursts. The last eruption was on the 14th of last February, between 9 and 10 in the evening, and it was the sublimest scene we had ever witnessed about Mokua-weo-weo. The display of light was most glorious. It looked as if the summit of the mountain was melted, as if the heavens were on fire. Vast columns of illumined steam rose like flaming gases from the burning pit, rushing upward with fearful speed to the height of 14,000 to 17,000 feet, where it spread out into a vast fiery cloud, which shone down upon and lighting up Hilo as if the firmament were on fire, projecting shadows of the objects around. This continued through the night. In the morning the mountain had on a veil of thick clouds, the rain fell, and the gorgeous scene was hid from our eyes. After some days the clouds were dispersed, but no vestige of the marvellous scene remained. No smoke! no fire! on the mountain, but only an occasional subterranean thud, as of Vulcan's trip hammer, and a smoky atmosphere. So sudden and complete was the cessation, that all spectators were amazed and disappointed. People in Kau and Kona sent messages to Hilo, enquiring if we were having the eruption all to ourselves; and we sent back the inquiry to them, "What has become of the volcano?" while the mountains stood above in silent and solemn grandeur. The steamer came up to Kona and to Kau, loaded with passengers, curious to witness the eruption, but the fire had become extinguished, and they returned disappointed. But before the vessel was fairly out of sight, a remarkable bubbling was seen in the sea about three miles south of Kealakekua—where Capt. Cook fell,—and a mile from the shore. Approaching the boiling pot, it was found emitting steam and throwing up pumice and light scoria, many specimens of which were gathered. This boiling was active when we last heard. It is in deep water. On the island new fissures have been opened in the pahoihoi, which extend up to the higher lands, indicating the course of a subterranean lava stream, that terminated in a submarine eruption—a new feature in our modern volcanic phenomena. About the time of this eruption beneath the sea, a tidal or earthquake wave of considerable force was observed along the coast of Kona.—*Letter to Prof. C. S. Lyman, dated Hilo, March 17th*, 1877.

2. *Geological Survey of Pennsylvania.*—The following Reports of work in this Survey have recently been issued by the Board of Commissioners, Harrisburg.

(1) *Report of Progress in the Counties of York, Adams, Cumberland and Franklin*, illustrated by maps and cross-sections showing the magnetic and micaceous ore-belt near the western edge of the Mesozoic Sandstone, and the two Azoic systems constituting the mass of the South Mountains; with a preliminary discussion of the Dillsburg Ore-bed; by PERSIFOR FRAZER, Jr. 400 pp. 8vo, with maps and sections. 1877.

(2) *Report of Progress in the Cambria and Somerset District of the Bituminous Coal-fields*, by F. and W. G. PLATT. Part I, Cambria. 194 pp. 8vo, with 44 wood-cuts and 4 maps and sections. 1877. This report gives from "the elaborate hypsometric map of Edmund Smith yet to be published," the heights of the crests of the Allegheny Mountains, showing for the western crest a range from 2,190 to 2,810 feet; and for the outer crest, 1,490 to 2,510 feet; also those of the principal summits of Laurel Hill, 2,270 to 2,450 feet.

(3) *Special Report on the Coke Manufacture of the Youghiogheny River Valley in Fayette and Westmoreland Counties, with geological notes on the Coal and Iron-ore beds*, by FRANKLIN PLATT. To which are appended a Report on methods of Coking by John Fulton, and a Report on the use of natural gas in the Iron Manufacture, by J. P. Pearse and F. Platt. 252 pp. 8vo, with maps and plates and wood-cuts.

3. *Bulletin of the U. S. Geological and Geographical Survey of the Territories.* F. V. HAYDEN, Geologist-in-Charge. Vol. III, No. 3. This number contains the following papers: Comparative vocabulary of Utah dialects, by E. A. BARBER; on methods of making Stone Weapons, by P. SCHUMACHER; by A. C. PEALE, on a peculiar type of Eruptive Mountains; by E. D. COPE, on the Geology of the Judith River and on Vertebrate fossils from the Missouri region;

C. A. WHITE, papers on Judith River group Unionidæ and Physidæ; Uniones and a new genus of fresh-water Gasteropoda from Tertiary of Wyoming and Utah; Comparison of the Unionidæ and associated mollusks with living species; paleontological characteristics of the Green River Cenozoic and Mesozoic; Dr. E. COUES, U. S. A., notes on American Insectivorous Mammals; Ornithology of source of Red River of Texas; S. AUGHEY, catalogue of land and fresh-water shells of Nebraska; A. D. WILSON, on the Geographical work of the Survey. A further notice is deferred to another number.

4. *Geological Survey of Canada*, ALFRED R. C. SELWYN, Director. Report of Progress for 1875–76. 432 pp. 8vo, with maps and plates. 1877.—This volume opens with an Introductory Report, reviewing the work of the year, by Mr. SELWYN, after which come special reports: on British Columbia, by Mr. SELWYN; on the same region, by G. M. DAWSON; and on other western areas, by Prof. MACOUN, J. F. WHITEAVES, R. W. ELLS, ROBERT BELL, and S. BARLOW; and on New Brunswick and Nova Scotia, by S. BARLOW, L. W. BAILEY, G. F. MATTHEW, R. W. ELLS, and H. FLETCHER; with a chemical Report, by C. HOFFMANN; on the Insects of the Tertiary at Quesnel, by S. H. SCUDDER; and List of Coleoptera collected on the Lower Peace and Athabasca Rivers, by Prof. J. L. LECONTE.

Mr. Selwyn states that Mr. H. G. Vennor has found a large variety of crystalline rocks in Western Quebec and Eastern Ontario, characterized by Eozoon, great beds of magnetite, apatite, and graphite; and that in Renfrew and Pontiac the labradorite rocks are interbedded with the lowest limestones; that these beds rest probably unconformably on the "Lower Laurentian or reddish gneiss.

Mr. Dawson describes the region between the Cascade Range and Fraser River, the 52d and 54th parallels of latitude. It contains extensive basaltic areas; porphyritic rocks of uncertain age; lignitic beds generally if not always beneath the basalts, which are "undoubtedly Tertiary;" Cretaceous rocks; besides gneisses, granites, diorytes, etc. The Report on New Brunswick, by Bailey and Matthew, describes the Silurian crystalline rocks of the Mascarene series, including chloritic rocks, diorytes, felsytes and argillytes. They are shown to be Upper Silurian.

5. *Shifting of the earth's axis.*—Prof. Haughton has a mathematical paper, on the shifting of the earth's axis caused by the elevation of the existing continents, in the Proceedings of the Royal Society, vol. xxvi, p. 51. He finds by calculation that the displacement would be as follows:

	Toward Greenwich. Miles.	Toward Behr. Str. Miles.	Toward Yucatan. Miles.	Toward Rangoon. Miles.
Europe and Asia,	----	58·7	199·4	----
Africa,	----	26·9	----	3·4
North America,	15·2	----	----	105·5
South America,	19·9	----	35·1	----
Australia,	----	30·2	----	30·2

The power of Europe and Asia in moving the pole is partly due to the extension of this continent along the parallel of 45°, which is the most effective latitude.

6. *Samarskite of North Carolina.*—A letter to one of the editors, from J. Lawrence Smith, dated Louisville, June 15, states that he "has succeeded in detecting and separating thoria from the North Carolina Samarskite, in which it exists to the extent of a few tenths of one per cent." And that he has discovered a new method of separating thoria from the mixed earths, easily used, and giving accurate results even when the amount present is very small.

7. *Analysis of Samarskite by Miss Ellen H. Swallow.*—The analysis of Miss Swallow (now Mrs. Professor R. H. Richards), cited on page 364 of volume xiii of this Journal, contains errors, and is therefore here given as published in the Proceedings of the Boston Society of Natural History, vol. xvii, p. 424.

Metallic acids of the tantalic group	54·96
Oxide of tin	0·16
Oxide of uranium	9·91
Oxide of iron	14·02
Oxide of manganese	0·91
Oxide of cerium (La, Di)	5·17
Yttria	12·84
Magnesia	0·52
Insoluble residue from the oxalate of cerium	1·25
Loss on ignition	0·66
	100·40

The loss was determined on another sample of the mineral.

III. Botany and Zoology.

1. *On the Development and Systematic Arrangement of the Pithophoraceæ.* By Veit Brecher Wittrock. Upsala, 1877. 4to.—In this pamphlet the writer gives an account of certain species from tropical countries, which had previously been placed in the genus *Cladophora.* Instead, however, of producing zoöspores as is the case with species of *Cladophora*, the upper portion of the cells swells and the contents pass into the swollen portion, leaving the rest empty. A cell wall is then formed, cutting off the swollen portion from the rest, and the spore is thus formed. It may be noticed as an innovation that the article is written in English. This practice is of late rather common in Scandinavia. It is to be hoped that this example will be imitated by others, since it not unfrequently happens that Swedish botanists do not receive full credit for their work, owing either to the small number of foreigners who read Swedish, or to the imperfect adaptability of Latin to modern scientific writing. W. G. F.

2. *Ueber Sprossung der Moosfrüchte und den Generationswechsel der Thallophyten.* N. Pringsheim.—An important paper, in which the writer shows that protonemata, precisely similar to the ordinary protonemata produced from the spores, may be made to

grow directly from the setæ of mosses. The latter part of the article in which Pringsheim discusses the alternation of generations in Thallophytes is excessively recondite and difficult to follow.

W. G. F.

3. *Algæ Exsiccatæ Americæ Borealis ;* curantibus W. G. Farlow, C. L. Anderson, D. C. Eaton, editæ. Fasciculus I. Bostoniæ, 1877.—Nothing helps the student of seaweeds like specimens, and fortunately in no department of botany are specimens so attractive. To help our own students and amateurs in this respect, and also to make known to foreign algologists, in an authentic way, the importance of our authors' own collections and studies in this department, they have combined to issue sets of specimens, with printed tickets, &c. This first fasciculus contains fifty species, all of real interest, many of them new or next to new, at least in collections. The specimens are full and beautiful, and the fasciculus is in every way attractively prepared. We have no announcement of the price, but we understand that a limited number of copies are to be put on sale. Professor Eaton at Yale College, Professor Farlow at Harvard, and Dr. Anderson at Santa Cruz, California, could be applied to by those who wish to obtain these sets. Algæ from the Californian coast have until now been unattainable; and those from Florida almost equally so since the late Dr. Harvey's time. The few species from our New England coast are all choice and rare, being such as *Lomentaria rosea*, *Hormactis Farlowii* of Bornet, *Lingbya Wollei*, a new fresh-water species by Farlow, *L. nigrescens*, *Calothrix crustacea* and *C. pulvinata*. Among the Californian species of Dr. Anderson's collection is Agardh's *Farlowia compressa*. A. G.

4. *Orchis rotundifolia* of Pursh, which Richardson referred to *Habenaria* (it was confidently supposed with good reason), and Lindley after him to *Platanthera*, is a genuine *Orchis*, having a pouch to the pollinia-disks as manifest as that of *O. spectabilis*. This is seen in fresh flowers of the living plant sent by Mr. Pringle from Vermont to the Cambridge Botanic Garden. A. G.

5. *Beiträge zur Entwickelungsgeschichte der Flechten. Heft.* I, *Ueber die geschlechtliche Fortpflanzung der Collemaceen.*—E. Stahl. Leipzig, 8vo, pp. 55.—This important contribution on the reproductive organs of lichens, forms the first portion of a work of which the author gave a preliminary notice in the Botanische Zeitung, 1874, p. 177. He has avoided any discussion of the Schwendener theory with regard to the gonidia and has sought in the study of the reproductive organs of lichens to discover their relationship to other groups. In part first, he treats of *Collema mycrophyllum* and other species of *Collema*, *Physma*, etc. The reproductive organs consist of spermatia, male, and carpogonia, female. The anatomy of the former has been known for some time, but the latter organs are now described for the first time. The carpogonia consists of two portions, the ascogone and the trichogyne. The ascogone is a coiled filament composed of several cells and is in all respects similar to the body of the same name in

the ascomycetous fungi. The trichogyne, also composed of several cells, is a more slender filament which proceeds outwards from the ascogone until it makes its way to the surface of the thallus. The experience of Stahl shows that the trichogynes seek the surface in that part of the thallus exposed to the light. In the majority of cases the spermatia and carpogonia are distinct. In the genus *Physma*, however, the ascogone is in the base of the same cavity in which the spermatia are found, a condition which Stahl maintains must prove conclusively that the spermatia are really organs of the lichen itself and not parasitic organizations as some have supposed. Stahl has often seen the spermatia attached to the exposed tip of the trichogyne, but exactly how they are attached is a difficult point to determine owing to their small size. He is inclined to believe that the process of union is similar to that which takes place in the *Florideæ*. In consequence of this union, a change takes place in the ascogone by which the asci are formed, as in the *ascomycetes*. The whole question is very candidly discussed and well illustrated by four plates. W. G. F.

6. *North American Starfishes;* Vol. V, No. 1, *of the Memoirs of the Museum of Comparative Zoology*, by ALEXANDER AGASSIZ. Cambridge, June, 1877. 137 pp. 4to, with 20 plates.—The plates, which are excellent, were drawn on stone more than twelve years ago, to illustrate a fifth volume of the Contributions to Zoölogy, by Professor Agassiz, which, unfortunately, was not completed. The first part of the volume, relating to the embryology of starfishes, was published separately by Mr. A. Agassiz in 1864, and is reprinted in the present volume with such additions as the progress of discovery has made necessary. The remainder of the volume is devoted to descriptions, especially of the hard parts, of various species (belonging to Asterias, Echinaster, Crossaster, Pycnopodia, Brisinga, Luidia, Asterina, Asteropsis, Pentaceros, Solaster, Cribrella, Astropecten) most of which are beautifully illustrated. An important chapter is also devoted to the homologies of Echinoderms. A. E. V.

7. *Ninth Annual Report on the noxious and beneficial and other insects of the State of Missouri;* by C. V. RILEY, State Entomologist. 130 pp. 8vo, with many figures and a map. Jefferson City, Mo., 1877.—Mr. Riley's report like its predecessors, is eminently practical as well as scientific. It treats of the worms that infest the Gooseberry, Currant, Strawberry and White Pine; of the Colorado Potato-Beetle, the Army Worm, the Wheat-head Army Worm, and the Rocky Mountain Locust; and also of the "innoxious Insects" the Hellgrammite and Yucca Borer. Of the Colorado beetle Mr. Riley remarks that its eastward progress was at the average rate of eighty-eight miles a year (though not over fifty miles a year over the region west of the Mississippi), and that it has now invaded nearly 1,500,000 square miles, or more than one-third the area of the United States. It does not thrive where the thermometer reaches near 100° F., and hence "it may never extend its range very far south of the territory now occupied;" but its northern spread is not limited, and it may push to the

northernmost limit of the potato-growing country—a limit which it has already well nigh reached. It travels by means of wings. But "it undoubtedly availed itself to no considerable extent, of every means of transportation afforded to other travelers, and often got a lift on eastward bound trains; and it most probably crossed the more barren plains bordering its native confines through man's direct agency, that is, by being carried." "Even the winds and waters aided its progress."

8. *Bulletin of the U. S. Entomological Commission—U. S. Geol. and Geogr. Survey*,—No. 1, 12 pp. and No. 2, 14 pp. 8vo.—The Entomological Commission consists of C. V. Riley, A. S. Packard, Jr., and Cyrus Thomas. Their first bulletin treats of the methods of destruction of the young or unfledged locusts; and No. 2 of their natural history and habits in the young unfledged state, with wood-cuts, and a map of the region east of the Rocky Mountains overrun by the insect.

IV. Astronomy.

1. *Astronomical and Meteorological Observations made during the year* 1874 *at the U. S. N. Observatory, Rear-Admiral* Davis, *Supt.* Washington, 1877.—This volume contains the observations of the year 1874 at the Naval Observatory, with the reduced results. The astronomical work has been mostly done by means of the three instruments, the transit circle, the 26-inch equatorial, and the mural circle. The latter instrument has been under the charge of Prof. Yarnall, who is preparing a revised edition of the general catalogue of stars observed at the Observatory. There are two appendices to the volume: I. Instruments and Publications of the U. S. N. Observatory (see p. 242, vol. xiii, of this Journal), illustrated with heliotypes of the instruments; II. Report on the difference of longitude between Washington and Ogden, Utah, by Professor Eastman. This difference is found to be $2^h\ 19^m\ 47^s{\cdot}41$. H. A. N.

2. *Relative ages of the Sun and certain fixed Stars.*—Professor Kirkwood closes a communication upon this subject to the American Philosophical Society with the following summary of his conclusions:

(1.) The history of the solar system is comprised within twenty or thirty millions of years.

(2.) From the fact that the larger component of Alpha Centauri radiates twice as much light as the sun while the mass of the former is *less* than that of the latter, we infer the probability that our solar system is the more advanced in its physical history.

(3.) 61 Cygni seems to have reached a greater degree of condensation than the sun, since, on the hypothesis of equal density, the surface of the larger member is one-third that of the sun, while the intrinsic light is less than one-ninth.

(4.) The companion of Sirius appears to have reached a stage of greater maturity than the sun, while the contrary seems to be true in regard to the principal star. H. A. N.

3. *Annals of the Astronomical Observatory of Harvard College.* Vols. VIII and X.—The first seven volumes of the Annals of the Astronomical Observatory of Harvard College contained the results of the work done under its first two Directors, W. C. Bond and G. P. Bond.

Three catalogues gave the observed places of 16,084 stars observed in zones between the equator and 1° N. declination. The great comet of 1858, the nebula of Orion, and spots on the sun, each filled a volume, and the planet Saturn filled one part of a volume. The second part of vol. IV has not yet appeared, but is in course of publication. The eighth volume contains in its first part an historical account of the Observatory from 1855 to 1876, and is richly illustrated by engravings of the instruments and apparatus of the Observatory. The second portion consists of the "Engravings from the Observatory of Harvard College," which has been furnished separately to subscribers, and has been heretofore noticed in this Journal. They are thirty-five in number (making more than fifty engravings in the volume), and constitute a most valuable contribution to Descriptive Astronomy. The tenth volume of the Annals contains the first portion of the work, with the new Meridian Circle under Prof. Winlock. The observations were made in 1871 and 1872 by Prof. W. A. Rogers, aided by Mr. A. McConnel, and the reduction of them and the editing of the volume was by Prof. Rogers. There were 564 stars observed, mostly bright ones. The introduction contains an elaborate comparison of these observations with the places given for the same stars in twenty-seven earlier catalogues. The volume concludes with three catalogues: 1st, of 289 primary stars, being those which are in the list of fundamental stars of the Astron. Gesellschaft; 2d, of the 275 stars not in that list; 3d, of about 600 stars observed in R. A. in 1867 and 1868, with the transit circle, by Mr. E. P. Austin. H. A. N.

4. *Meteoric Fireballs.*—Professor Kirkwood gives an account of eight large bolides between July, 1876 and February, 1877, to the American Philosophical Society. The more important ones have been noticed in this Journal, except one of July 8th, 1876, at 8^h 45^m P. M., which from an altitude of 88 miles passed N. 78° W. across the N. E. corner of Indiana, and exploded over Lake Michigan at a height of 34 miles. The path was inclined 21° to the horizon; no detonation reported; train visible 40 minutes.

5. *On the part of the motion of the lunar perigee which is a function of the mean motions of the Sun and Moon*; by G. W. Hill. Cambridge, 1877. 4°, pp. 28.—The motion of the lunar perigee as observed does not agree with any of those computed by theory within the limits of error of the observations. This may be due to not carrying the approximations far enough and the author undertakes to compute its value, so far as it depends on the mean motions of the sun and moon, with a degree of accuracy that shall leave nothing further to be desired.

6. *Chicago Observatory.*—Referring to the statement of Mr. Burnham in this number (p. 31) we beg of the friends of science in Chicago to see if it is not possible to secure for him in some way the use of the telescope in the Observatory. For many years this large instrument (for a part of the time the largest refractor in the world) has lain idle, not at all to the credit of Chicago. It should have been steadily doing service in astronomy, such service as almost no other instrument can do. Mr. Burnham has shown that he can do good work, and the friends of science everywhere have a right to complain that the instrument lies idle when he is willing to use it.

7. *The Observatory, a Monthly Review of Astronomy.* Edited by W. H. M. Christie, M.A. Nos. 1 and 2, April and May.—This is a new monthly of thirty-two pages, published by Taylor & Francis, London. For convenience of American subscribers currency will be received at the rate of one dollar for three months' subscription. These two numbers contain accounts of the April and May meetings of the Royal Astr. Soc.; and the following besides other articles: Photographic Spectra of Stars, by W. Huggins; Determination of the Solar Parallax, by D. Gill; the Twinkling of the Stars, by E. Ledger; also Notes, Correspondence, Memoranda, Ephemerides, &c.

8. *An Elementary Treatise on Elliptic Functions;* by Arthur Cayley. Deighton, Bell & Co. Cambridge and London. 8°, 1876.—There has been hitherto no elementary separate treatise in English upon elliptic functions. The thanks of mathematicians are due to Professor Cayley for supplying the want. An excellent feature of the book is the *general outline* which fills the first chapter.

V. Miscellaneous Scientific Intelligence.

1. *American Association.*—The American Association will hold its twenty-sixth meeting in Nashville, during the week commencing with the 29th of August. The Local Committee is making arrangements for the private entertainment of the members where they may desire it, and also for free return tickets as far as practicable, besides providing, by means of excursions and in other ways, for the pleasure and profit of those who shall be present. The president of the meeting is Simon Newcomb, of Washington, and the vice-presidents, Edward C. Pickering, of Cambridge and O. C. Marsh, of New Haven. Mr. J. Berrien Lindsley is Secretary of the Local Committee.

2. *New American Scientific Museums.*—A bill to establish a Historical Library and Natural History Museum at Springfield, Illinois, has been passed by the Legislature of the State. It appropriates to it one of the large halls of the New Capitol building. The valuable collections made in connection with the geological survey of the State, many specimens of which are the types of new species described in the volumes of Reports, will here have safe

keeping. Professor Worthen writes, that about it will be built up an institution of science that will be an important addition to the educational resources of the West.

At St. Louis, Missouri, the "St. Louis Museum of Arts and Sciences" has recently been instituted. It includes among its officers the names of prominent men of science of Missouri, and promises to be a center of great scientific activity.

3. *Earthquake oceanic wave of May 9th and 10th*, 1877.—The Monthly Weather Review for May, published by the Signal Service under Gen. Albert J. Mayer, contains many details respecting this earthquake wave, and a table of data for estimating approximately the velocity. About 8.50 P. M. of May 9th, heavy earthquake shocks were felt over the region between Arica and Mexillones (border of Peru and Bolivia). The oceanic wave which immediately followed was of great violence along the adjoining South American coast, and was felt also as far north as California, the rise at Anaheim (33° 8′), being 12 feet in a few minutes. The wave at Callao, Peru, was felt at 11 P. M.; at San Francisco, perceptible at 6^h 18′ A. M., May 10, and 14 inches in rise (maximum) at 8^h 20′; the Sandwich Islands, on eastern Hawaii, at Hilo, at 4 A. M., and the great wave, 36 feet high, came in at 4^h 45′; at Honolulu, first felt at 4^h 45′, and the great wave at 5^h.

Rev. T. Coan, in a letter to one of the editors dated May 11, states that "thirty-six hours subsequent to the catastrophe at Hilo, the pulsations of the tidal wave still continued, the incoming and outflowing wave occupying about an hour, the latter leaving the channels nearly bare."

4. *A practical Treatise on Lightning Protection;* by HENRY W. SPANG. 180 pp. 12°. Philadelphia, 1877. (Claxton, Remsen & Haffelfinger.)—This treatise discusses the various questions that arise in the construction of lightning rods, and their application to different kinds of structures. The great defect of most lightning rods, that of imperfect earth connections, with the remedies, are very fully treated. The directions are such that an intelligent mechanic can carry them into effect.

With many minor statements of the author we should not agree. Thus (p. 176) he says, "a building over 100 feet square cannot be properly protected unless in addition to the conductors and earth-terminals upon the outside thereof, a suitable number of conductors are employed through the interior, etc." The book, however, as a whole, is one to be heartily commended.

5. *Natural Philosophy for Beginners;* Part I, *the Properties of Solid and Fluid Bodies;* by I. TODHUNTER, M.A., F.R.S. 368 pp. small 8vo. London, 1877. (MacMillan & Co.)—The character of this little work will be best understood by the following quotation from the author's preface:—"The design of the work is to furnish a simple and trustworthy manual for those who are beginning the study of natural philosophy; and it ventures to claim a distinct position among the numerous publications

which have appeared with somewhat similar aims. On the one hand great pains have been taken to render the book intelligible to early students; the amount of mathematical knowledge assumed is merely a familiarity with the elements of arithmetic. On the other hand the subject is presented, it may be hoped, with adequate fullness, so that a person who has mastered the work will have gained considerable acquaintance with the principles of natural philosophy. Moreover, a collection of examples for exercise (above 500 in number) is added." The many excellent text-books of Prof. Todhunter are now so well known that it is unnecessary to add more than a general commendation of the manner in which the author's plan, as above expressed, has been carried out. The second part of the work is now in the press.

6. *Third Biennial Report of the Vermont Board of Agriculture, Manufactures and Mining, for the years* 1875–76. By HENRY M. SEELY, Secretary of the Board. 704 pp. 8vo. Rutland, 1876.—This volume is made up of brief original reports by various citizens of Vermont on topics of general interest connected especially with agriculture, and to some extent with manufactures. Among the interesting chapters there is one on the relation of bees to fruit culture, by J. E. Crane, of Bridport; others —on an analysis of fertilizers, by Prof. Seely; Pisciculture with reference to farming, by G. B. French, of Woodstock; Experiments in the hybridization of cereals, by C. G. Pringle, of Charlotte; Insects injurious to the potato and apple, by Prof. G. H. Perkins.

7. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters.* Vol. III, 1875–76. 270 pp. 8vo. Madison, Wisconsin.—Among the original scientific papers in this volume there are the following: Kaolin in Wisconsin, by R. Irving; on the Geology of Northern Wisconsin, by E. T. Sweet; on some of the small lakes of Wisconsin, by I. A. Lapham; on Copper tools found in Wisconsin, by J. D. Butler; Report of Committee on Exploration of Indian Mounds in the vicinity of Madison.

8. *Journal of the Academy of Natural Sciences of Philadelphia,* Vol. VIII, part 2.—This part contains papers on Batrachia and Reptilia of Costa Rica and elsewhere, by E. D. Cope; on the Ichthyology of Lake Titicaca, by the same; and a descriptive catalogue of the Scalidæ of the West India Islands, by O. A. L. Mörch.

Manchester Science Lectures for the People. Eighth series, 1876–77, in pamphlets of 45 to 64 pages, 12mo.—Why the Earth's Chemistry is as it is; three lectures by J. NORMAN LOCKYER, F.R.S.; 60 pp.—The Succession of Life on the Earth; three lectures by Professor W. C. WILLIAMSON, F.R.S.; 62 pp.—Technical Chemistry, by Professor ROSCOE, F.R.S., 46 pp. Macmillan & Co., London and New York.

OBITUARY.

ELKANAH BILLINGS.—The decease of Mr. Billings a year since, at Montreal, was announced in this Journal, in volume xii, at page 80. We are indebted to his successor as paleontologist in the Canada Geological Survey, Mr. J. F. Whiteaves, for the following facts connected with his labors in science.

Mr. Billings was born near Ottawa City, on the 5th of May, 1820, and died on the 14th of June, 1876. In 1839 he commenced the study of law, and for seven years, beginning with 1844, his pursuit was that of a barrister. For the four years following he added the duties of editor of the "Ottowa Citizen." But between 1852 and 1856 a large proportion of his time was devoted to the collection and study of the Lower Silurian fossils of the country about Ottawa City, and this brought him into familiar correspondence with Sir William Logan, and led to his appointment, in 1856, to the position of paleontologist of the Geological Survey of Canada. He had been elected a member of the Canadian Institute of Toronto in 1854, and published the same year, in its Journal, his first paleontological paper—"On some Genera and Species of Cystidea from the Trenton limestone." In 1856, he commenced the publication of the "Canadian Naturalist and Geologist;" but he was relieved of the responsibility of editor the following year by a committee of the Natural History Society of Montreal, while continuing to be a large contributor to its pages. With the exception of part of the year 1858, which was spent in Great Britain and Paris, studying and comparing such foreign and North American British fossils as threw light on Canadian species, the remainder of his life was passed at Montreal, in the study of the Canadian collections, and in excursions among the fossiliferous rocks of Canada and adjoining portions of the United States. Besides numerous papers contributed to the Canadian Journal of Toronto, the Canadian Naturalist of Montreal, the Geological Magazine, and to the pages of this Journal, he published the following more extended memoirs: An illustrated monograph of Lower Silurian Cystidea and Asteriadæ, and on the Crinoidea of the same formation: these two memoirs constituting Decades 3 and 4 of "Canadian Organic Remains;" Palæozoic Fossils, vol. i, 526 pp. 8vo, with numerous figures, 1865, and vol. ii, part 1, 144 pp. 8vo, with nine plates and many wood-cuts, 1874; and "Catalogues of the Silurian Fossils of the Island of Anticosti."

Mr. Billings's knowledge of the invertebrates of the Silurian and Devonian formations was extensive and profound, and his descriptions of fossils are both lucid and scrupulously accurate. To his critical acumen we are indebted for a very considerable part of our knowledge of American paleontology; and especially for his elaboration of the remarkable, and still somewhat enigmatical, fauna of the Quebec Group, of the south shore of the St. Lawrence, in Eastern Canada, and of the northern extremity of Newfoundland. His paper "on the remains of the Fossil Elephant found in Canada,"* and another on the bones of a Beluga dug up at Cornwall (Ontario),† show that he was well versed in comparative osteology, and many of his earlier contributions to the "Canadian Naturalist" bear witness to the eagerness with which he prose-

* Canadian Naturalist, First Series, vol. viii, 1863.

† Read before the Natural History Society of Montreal, but never published.

cuted his zoological studies. Entomology and mineralogy were favorite departments of science with him, and he made at one time a tolerably complete collection of Canadian Coleoptera, which he presented to the Natural History Society of Montreal a few years before his death.

For many years Mr. Billings was one of the Vice-Presidents of the Natural History Society of Montreal. He was frequently pressed to accept the office of President, but invariably declined. He was elected a Fellow of the Geological Society of London in 1858. The silver medal of the Montreal Natural History Society was voted him by the members at the annual meeting held in 1867, by way of testifying to their appreciation of "his long continued and successful labors for the promotion of science in Canada."

Mr. Billings possessed great firmness and strength of character coupled with a winning simplicity of manner and unaffected modesty. To these traits were added inflexible love of truth and justice, disinterested and self-sacrificing zeal for the acquisition of knowledge, and untiring industry in his pursuits.

In 1845 Mr. Billings married a sister of Mr. Wilson, of Toronto, now the Hon. Judge Wilson, but then the junior partner in the legal firm of Messrs. Baldwin & Wilson, in whose office he studied the last year prior to his being called to the bar. Since his decease the members of the Natural History Society of Montreal have passed resolutions expressing their high estimation of his personal character and writings; and a few of his more intimate friends in the society have subscribed for a fine life-sized portrait of their distinguished associate, which now adorns its lecture room.

Colonel Ezekiel Jewett, died at Santa Barbara, Cal., May 18th, aged 86. He was born at Rindge, N. H., Oct. 16, 1791. He was an officer in the U. S. army in the war of 1812, and afterward took part in the Chilian war, under Gen. Carrera. He has long been well known to geologists and conchologists as an enthusiastic and indefatigable collector of fossils and shells. An extensive geological collection, made by him, is now the property of Cornell University. For several years past he has devoted himself entirely to conchology and had accumulated a valuable collection of shells, embracing over 12,000 species. He collected extensively on the west coast of Florida.

Dr. Philip P. Carpenter, one of the ablest modern conchologists, well known especially for his several excellent works on the mollusca of the west coast of North America, died at Montreal, May 24th, aged fifty-eight. A more extended notice is necessarily deferred to another number.

Robert Dale Owen, died on the 24th of June, at his summer residence on Lake George, at the age of seventy-six.

APPENDIX.

ART. XI. — *Principal Characters of the Coryphodontidæ*; by Professor O. C. MARSH. With plate IV.

NEAR the base of the Eocene, in the Rocky Mountain region, are numerous remains of a well marked group of mammals which the writer has termed the *Coryphodontidæ*.* These animals are of peculiar interest, both on account of their structure and affinities, and especially as they are among the oldest of Tertiary Mammals, and mark a definite geological horizon in this country and Europe. Only the single genus, *Coryphodon*, is known, and this was established, in 1846, by Owen, who described a characteristic fragment of a lower jaw from the London Clay of England.† Other imperfect specimens were subsequently found in France, and fully described by Hébert,‡ but up to the present time very little is known of this genus from European specimens.

The identification of the American remains with the genus *Coryphodon* of Owen, and the determination thereby of a definite horizon, common to the two countries, and containing the oldest known Tertiary Mammals, was published by the writer in April, 1876, and subsequently in the following number of this Journal (vol. xi, p. 425.)§

The Museum of Yale College contains a large collection of *Coryphodon* remains from Utah, Wyoming, and New Mexico, and this material is amply sufficient to indicate all the more important characters of the group. Among these specimens are portions of the same individuals described by Cope under the names *Bathmodon* and *Loxolophodon*,‖ both of which are synonyms of *Coryphodon*, as the remains on which they were based clearly belong to that genus. One of the species best represented in the Yale collection is *Coryphodon hamatus* Marsh, and this has afforded many of the characters given below.

* This Journal, vol. xi, p. 428, May, 1876.

† British Fossil Mammals and Birds, p. 299.

‡ Annales des Sciences Naturelles, tome vi, p. 87, 1856.

§ In the American Naturalist (vol. xi, p. 95), Prof. Cope has recently claimed this discovery on the strength of a paper which he read before the Spring Meeting of the National Academy, in 1876. He knew, however, at the time that my article was already published, and during the reading of his paper, a printed copy of my publication was in the room, in the hands of a member.

‖ Proceedings American Philosophical Society, 1872, p. 420.

The skull of *Coryphodon*, in all its more important characters, is of the perissodactyl type. It is elongated, and the facial portion is most produced. A line drawn from the lower margin of the foramen magnum along the palate is nearly straight. The zygomatic arches are expanded, but the malar is comparatively slender, and unites with the maxillary in front of the orbit. The general form of the skull is shown in the accompanying plate, figure 1. The maxillaries are massive, and usually deeply indented on the sides behind the canines. The lachrymal forms the anterior border of the orbit, and its foramen is inside the orbital margin. The nasals are slender in front, and broad posteriorly. The premaxillaries are expanded transversely, and the narial aperture is wide. The occipital condyles are well separated, and there are condylar foramina. Between the basisphenoid and the periotic, there is a large opening. There is a paroccipital, and a post-glenoid process.

The dental formula of *Coryphodon* is as follows:

$$\textbf{Incisors } \frac{3}{3}; \textbf{ canines } \frac{1}{1}; \textbf{ premolars } \frac{4}{4}; \textbf{ molars } \frac{3}{3}; \times 2 = 44.$$

The teeth in American specimens do not differ essentially from those described by Owen and Hébert, which are well represented in the memoir of the latter author, cited above.

The brain cavity in *Coryphodon* is perhaps the most remarkable feature in the genus, and indicates that the brain itself was of a very inferior type. It was quite small, as in all Eocene mammals, but its most striking features were the small size of the hemispheres, and the expanded cerebellum. The form and relative size of these are shown in the accompanying plate, figure 1.

The olfactory lobes were large, and entirely in advance of the hemispheres. They were bounded in front by a well ossified cribriform plate, and partially separated by a vertical bony septum. The cerebral lobes were ovate in form, and very small, a transverse section exceeding but little that of the medullar opening. In shape and relative size, the hemispheres and olfactory lobes of this genus are somewhat similar to those of *Dinoceras*. The cerebellum was proportionally large, and widely expanded transversely. Its peculiar form is shown in figure 1, which is drawn from a cast of the brain-cavity of *C. hamatus*. This portion of the brain nearly or quite equaled the hemispheres in size, thus differing widely from any known mammal. There is a well marked pituitary fossa, but no clinoid process. The foramina for the exit of the optic nerves are small, but for the others very large. The brain as a whole was very low in grade, and precisely such as might be expected in a mammal from the oldest Tertiary deposits.

These essential characters of the brain of *Coryphodon* were determined and published by the writer more than a year ago, with figures of a very perfect cast of the brain-cavity. (This Journal, vol. xi, p. 427.) Two skulls, in remarkable preservation, were examined during the investigation, and the results have since been confirmed by other specimens in the Yale Museum.

These facts are important, since Cope has recently published a paper on the same subject, and given descriptions and figures of the brain case of *Coryphodon* which differ materially from my own.* He makes no reference to my article, although perfectly familiar with it. A comparison of his figures with the specimens mentioned above, shows at once that he has made most serious mistakes in his observations. What he represents as olfactory lobes, are unlike anything in nature, and are merely a cast from an imperfect skull in which the mesethmoid septum, and the cribriform plate are both evidently imperfect or wanting. Similar errors are apparent in other portions of the figures, and his classification, based on these and like observations, is untenable, as the known facts are against it.

The vertebræ of *Coryphodon*, in their more important characters, resemble those of *Dinoceras.* The cervicals are proportionately longer. The odontoid process of the axis is a short peg. The articular faces of the cervicals and dorsals are nearly flat. The caudals indicate a tail of moderate length.

The limbs of *Coryphodon* were comparatively short. The scapula is acuminate above, as in *Dinoceras* and the Elephant. The humerus is much less massive than in *Dinoceras*, but otherwise resembles it. The deltoid ridge extends beyond the middle of the shaft. The distal end of the humerus is compressed antero-posteriorly, and the ulnar side of the articulation is much more prominent than the radial, thus approaching the Rhinoceros where it departs from *Dinoceras.* The radius is proximally smaller, compared with the ulna, than in Rhinoceros. Its distal end is larger than that of the ulna.

The femur of *Coryphodon* is of the perissodactyl type, and has a distinct third trochanter. The tibia, when in position, was not in the same line with the femur, as in *Dinoceras* and the Elephant, but was inclined at a moderate angle. The fibula was entire, and its distal end articulated with both the astragalus and calcaneum.

The feet of *Coryphodon*, hitherto essentially unknown, resemble most nearly those of *Dinoceras*, and can perhaps be best illustrated by a direct comparision with them. In the following figures (see plate iv), the feet of these two genera are placed side by side, and in the same position. The main points of difference between them are stated below.

* Proceedings American Philosophical Society, p. 616, 1877.

The manus and pes of *Coryphodon* had each five short digits. The carpal bones are shorter, measured in the line of the foot, than in *Dinoceras*, and the distal row present more curved articular faces to the metacarpal bones, indicating greater freedom of motion. The pyramidal is destitute of the tubercle projecting outward and forward for the support of the fifth digit, seen in *Dinoceras*. The metapodial bones and phalanges are throughout less roughened and tubercular than in *Dinoceras*, and all their articular faces indicate greater flexibility in the feet. The ungual phalanges expand laterally for the support of the hoofs, instead of being rounded, as in *Dinoceras*.

In the hind foot, the astragalus, and in a less degree the cuboid and navicular bones are shorter, along the line of the foot, than the corresponding bones of *Dinoceras*. The astragalus has the tibial articulation less convex, and the fibular articulation more extensive, covering the whole exterior or fibular side of the bone. The navicular and cuboid faces are more distinctly separated, and make a greater angle with each other than in *Dinoceras*. The calcaneum approaches the ordinary perissodactyl type, the shaft being much longer than in *Dinoceras*, and the tubercular surface below for the support of a plantar pad, seen in the Elephant and *Dinoceras*, is undeveloped. The cuboid is of peculiar shape, being sub-triangular. The calcaneal face is long and oblique, reaching nearly to the face for the fifth metatarsal. Both the metatarsal articulations are essentially in one plane, and are separated only by a very slight ridge. The navicular articulates very slightly, if at all, with the cuboid, but covers the face of the astragalus, and fully supports the ectocuneiform. The latter bone is not at all supported by the astragalus, as asserted by Cope (Catalogue of Vertebrata of the Eocene of New Mexico, p. 27). He has also published a remarkable figure of the hind foot of *Coryphodon* (Bathmodon), showing the hallux with three phalanges, and the fifth digit reduced to a rudiment (loc. cit., p. 28).

The average size of the animals of this genus was about that of the existing Tapir. Some were smaller, and others nearly twice as large. Their mode of life was probably similar.

A careful consideration of the characters of *Coryphodon*, so far as now known, indicates that the genus represents a distinct family of perissodactyl Ungulates, the *Coryphodontidæ*. The skull is clearly of this type, and the skeleton and feet present no differences sufficiently important to justify a separation from that natural order. Only a slight modification of the limits of the *Perissodactyla*, would bring this five-toed genus into it, and simplify classification.

The geological horizon of *Coryphodon* in this country is near the base of the Eocene, in the strata named by the Survey of

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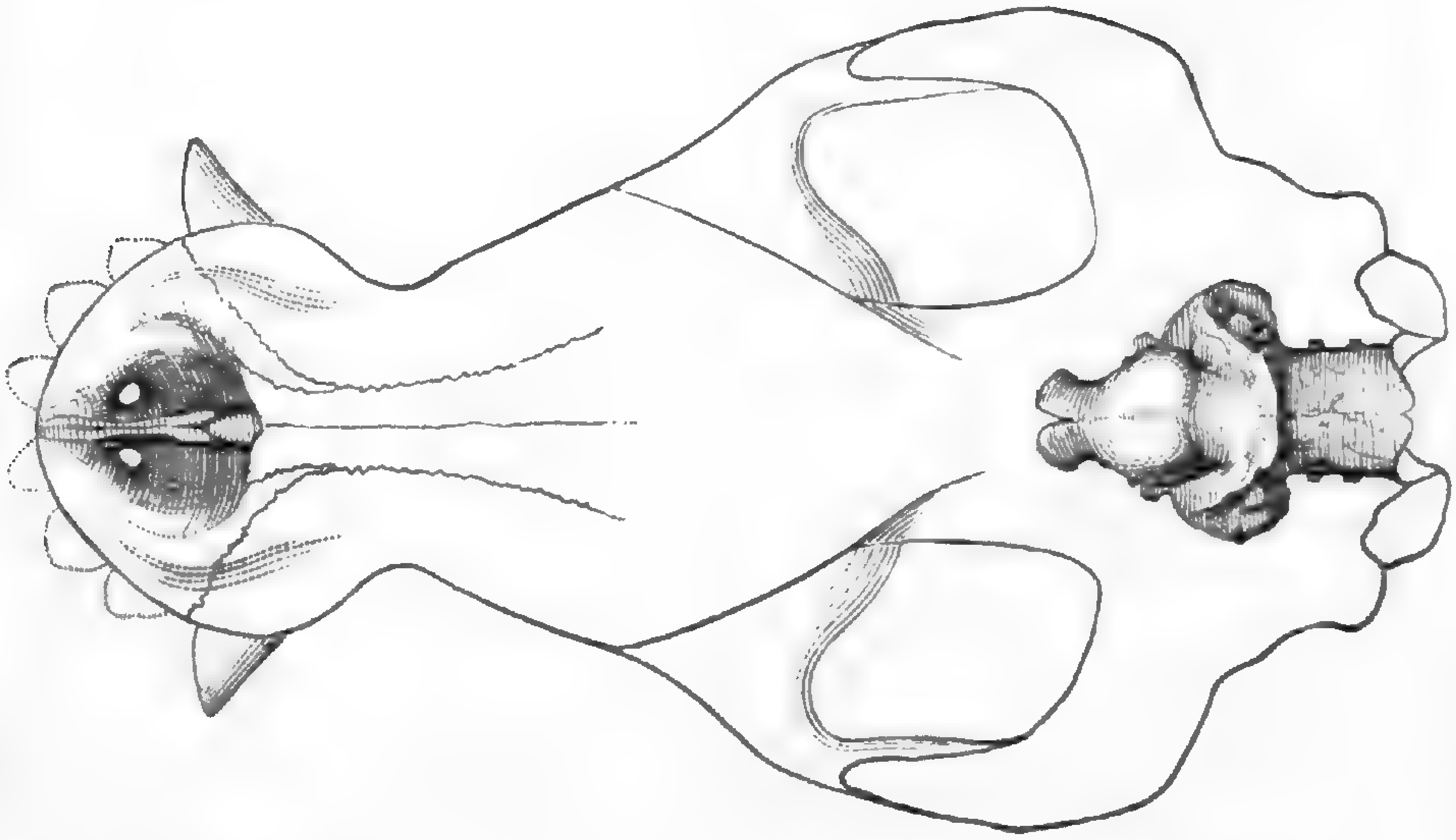

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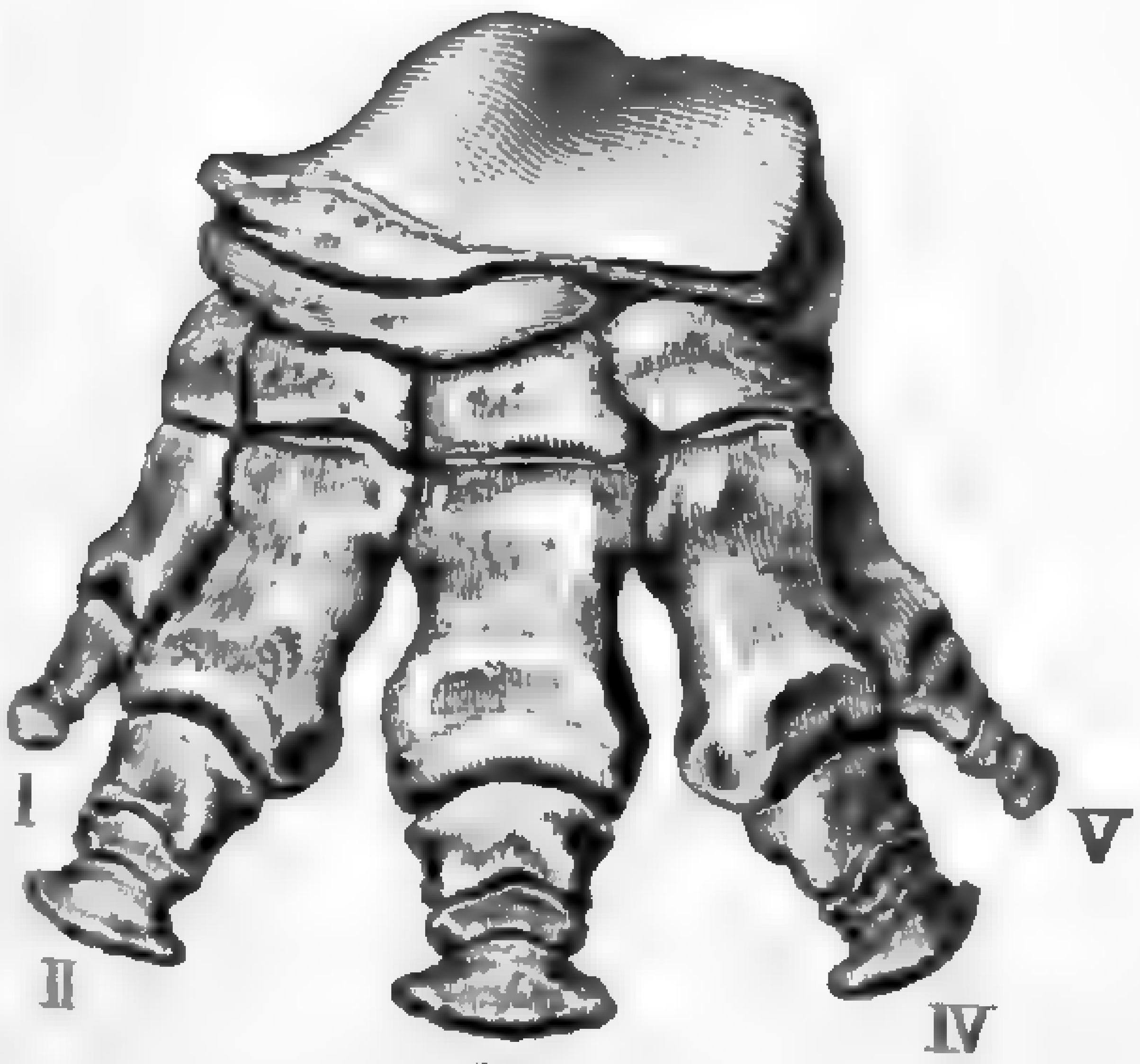

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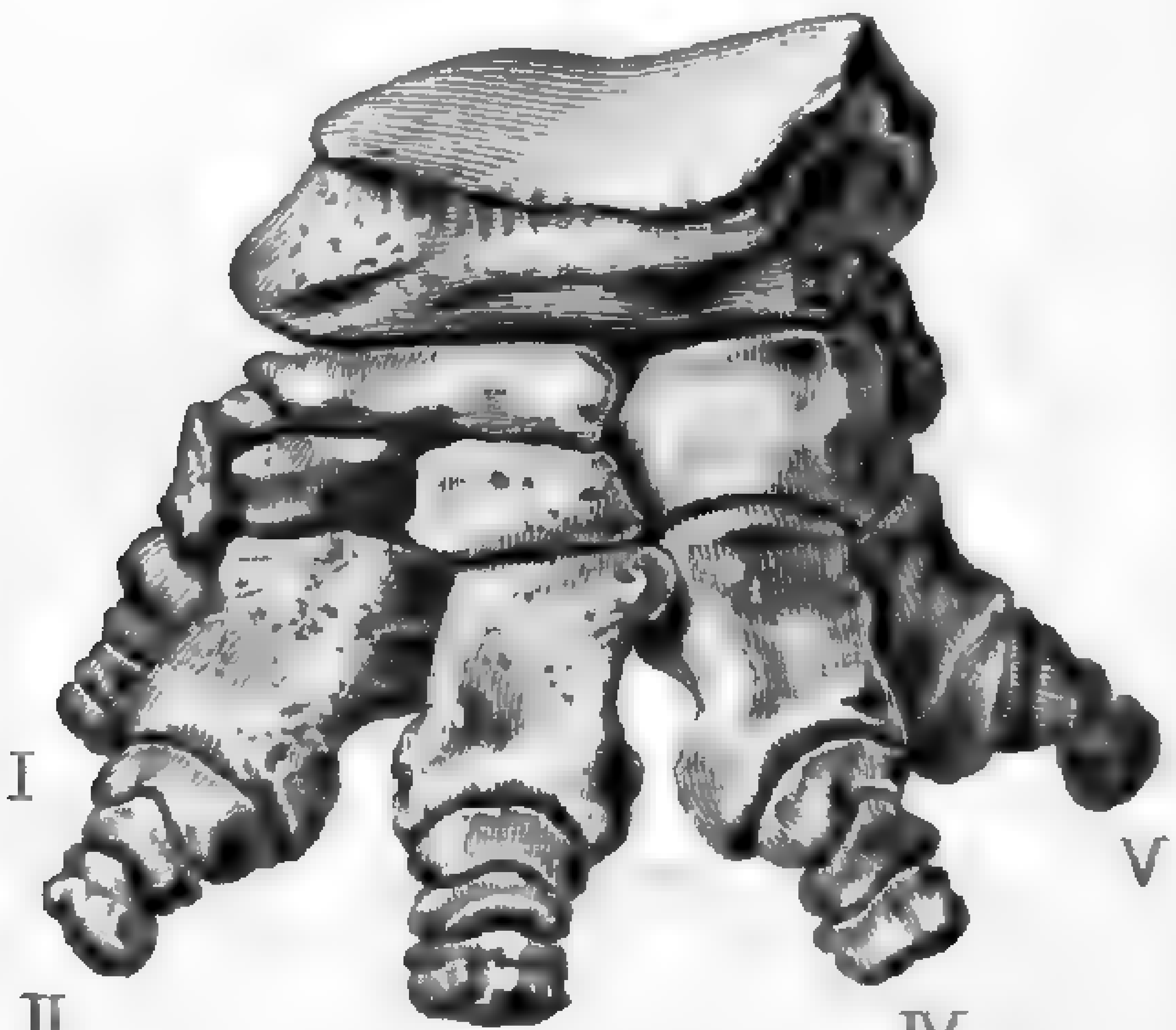

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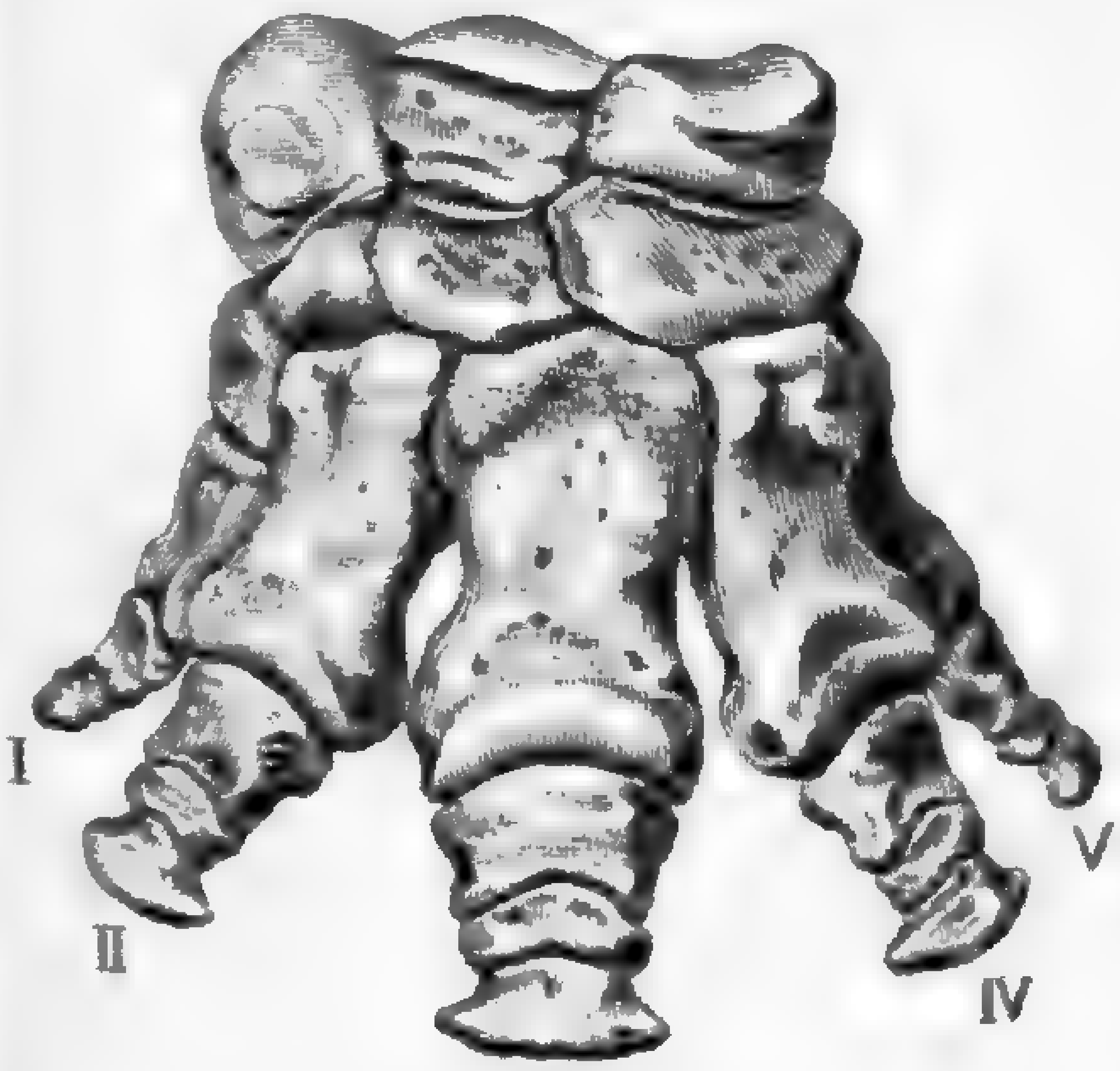

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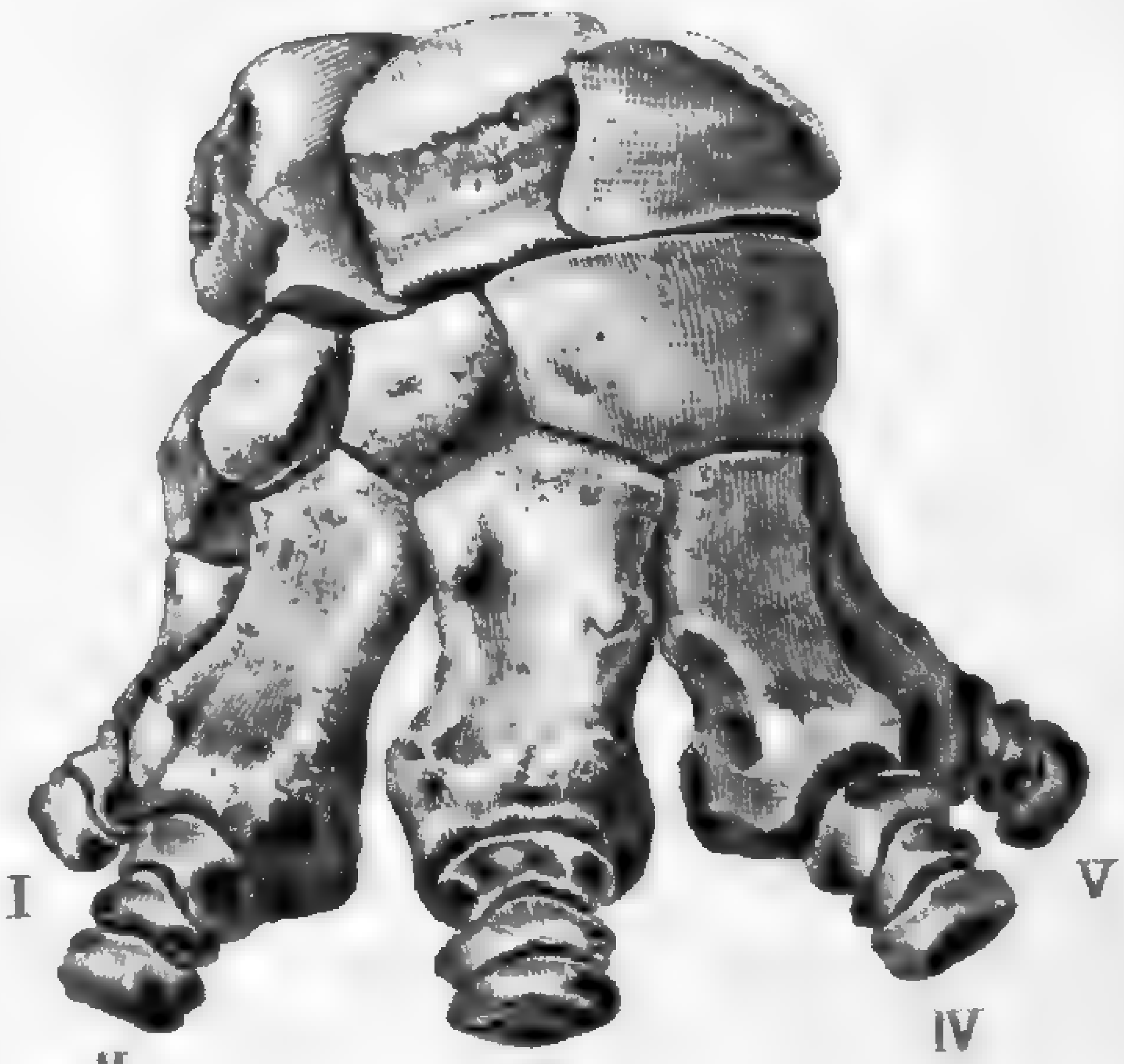


Figure 1.—Outline of skull and brain-cavity of *Coryphodon hamatus* Marsh: top view. About one-fifth natural size.
Figure 2.—Hind foot of *Coryphodon*; front view.
Figure 3.—Fore foot of *Coryphodon*; front view. Both one-third natural size.
Figure 4.—Hind foot of *Dinoceras*; front view.
Figure 5.—Fore foot of *Dinoceras*; front view. Both one-fifth natural size.

the Fortieth Parallel, under Clarence King, the Vermillion Creek series, and by Hayden the Wasatch group. The known localities are in Utah, Wyoming and New Mexico. Among the associate mammals are the equine *Eohippus*, and the suilline *Helohyus*, showing clearly that we must look to Cretaceous strata at least for the parent form of the Ungulates.

Yale College, June 12th, 1877.

ART. XII.—*Characters of the Odontornithes, with Notice of a new allied Genus;* by Professor O. C. MARSH. With plate V.

THE Cretaceous birds with teeth, (*Odontornithes*), described by the writer, prove on careful investigation to possess some important characters in addition to those already published.* This is especially true of *Hesperornis*, which is now represented in the Yale College Museum by so large a number of specimens that almost every part of the skeleton is known, and all the more important points in its structure have been determined.

The most marked features in this genus already announced, are: the teeth in grooves; sternum without keel, and rudimentary wings; and posterior limbs closely resembling those of modern diving birds. The last character, which seemed at first sight to indicate the near affinity of *Hesperornis* with the *Colymbidæ*, proves to be only an adaptation; while the skull, scapular arch, and other important portions show unmistakably that the nearest existing allies of the genus are the *Ratitæ*, or Ostrich group, the most reptilian of modern birds. The characters that show this affinity are nearly identical with those laid down to distinguish the *Ratitæ* by Huxley in his important memoir on the Classification of Birds.† They may be briefly stated as follows:

1. The sternum is devoid of a crest.
2. The long axes of the adjacent parts of the scapula and coracoid are parallel, or identical.
3. The posterior ends of the palatines, and the anterior ends of the pterygoid are very imperfectly, or not at all, articulated with the basisphenoid rostrum.
4. Strong "basipterygoid" processes, arising from the body of the basisphenoid, and not from the rostrum, articulate with facets which are situated nearer the posterior than the anterior ends of the inner edges of the pterygoid bones.
5. The upper, or proximal, articular head of the quadrate bone is not divided into two distinct facets.

* This Journal. vol. x, p. 403, Nov., 1875.

† Proceedings Zoological Society, 1867, p. 448.

The vomers are separate, as in lizards and a few modern birds. In the pelvic arch, the ilium, ischium and pubis are free at their distal ends, as in the Emu, and the acetabulum is perforated only by a moderate foramen.

The scapular arch of *Hesperornis* is represented in plate V, figure 1. Its position in the skeleton is shown in the restoration, figure **2.**

The scapula is long and slender, and has no acromial process. The clavicles are separate, but meet on the median line, as in some very young existing birds. The coracoids are short, and much expanded where they join the sternum. The latter has no distinct manubrium, and is entirely without a keel. The wings were represented by the humerus only, which is long and slender, and without any trace of articulation at its distal end. Its position was close to the ribs, and it was probably nearly or quite concealed beneath the integuments, as in *Apteryx.* This rendered the rudimentary wings of no possible service in flight or swimming.

Baptornis advenus, gen. et sp. nov.

The existence of a small swimming bird cotemporary with *Hesperornis* is indicated by a nearly perfect tarso-metatarsal bone from the same geological horizon. This specimen, although pertaining to a bird not fully adult, is in excellent preservation, and is so characteristic that it may be readily distinguished from any forms already described.

In general shape and proportions, this bone most nearly resembles the corresponding part in *Hesperornis*, but differs from it decidedly in the outer metatarsal, which at its lower end scarcely equals the adjoining one in size and length. In *Hesperornis,* on the contrary, the outer metatarsal is more than double the size of the third. In the present specimen, the three trochlear articulations of the distal ends are nearly equal. The existence of a hallux is indicated by a small elongated depression on the inner metatarsal, a short distance above the articulation. As in *Hesperornis*, there are no canals or grooves for tendons on the posterior face of the proximal end.

The principal dimensions of this tarso-metatarsal are as follows:—

Entire length	76· mm
Transverse diameter of proximal end	17·
Antero-posterior diameter	8·
Length of second metatarsal	64·5
Length of third metatarsal	72·
Length of fourth metatarsal	72·
Antero-posterior diameter of distal articulation of second metatarsal	8·5

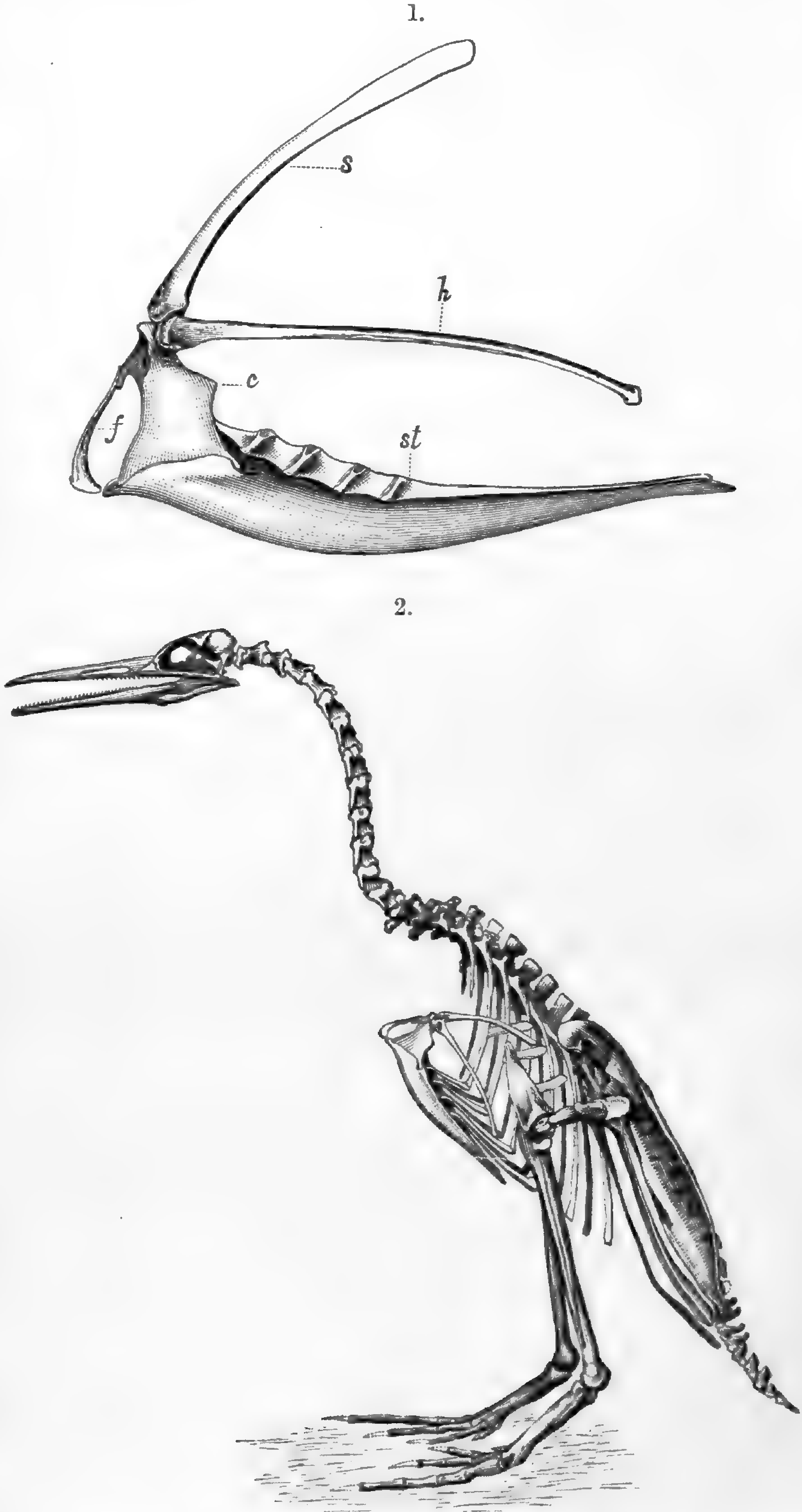


Figure 1. Scapular arch of *Hesperornis regalis* Marsh, one-half natural size. *s.* scapula; *h.* humerus; *f.* furculum; *c.* coracoid; *st* sternum.
Figure 2. Restoration of *Hesperornis regalis*, about one-tenth natural size.

Transverse diameter	5·mm
Antero-posterior diameter of distal articulation of third metatarsal	9·2
Transverse diameter	6·
Antero-posterior diameter of distal articulation of fourth metatarsal	9·
Transverse diameter	5·5

This specimen indicates a bird about as large as a loon, and apparently of similar habits. The locality of the only remains at present known is in Western Kansas, in the same Cretaceous beds that contain the *Odontornithes* and *Pteranodontia.*

Art. XIII.—*Notice of a new and Gigantic Dinosaur;* by Professor O. C. Marsh.

The Museum of Yale College has recently received from the Cretaceous deposits of Colorado a collection of reptilian remains of much interest. Among these specimens are portions of an enormous Dinosaur, which surpassed in magnitude any land animal hitherto discovered. The most characteristic bones preserved are portions of the sacrum, and posterior limbs. The former is represented by the last two vertebræ with their transverse processes, nearly complete, and by other fragments. The last sacral vertebra has its centrum moderately concave below on each side of the median line, but only near its anterior end can indications of a keel be observed. The next sacral vertebra has its inferior lateral surface so deeply concave as to materially lessen its bulk. This is also true of the next anterior centrum, and may be considered a distinctive character of these vertebræ. A more important character of the same centra is a very large cavity in each side, connected with the outer surface by an elongated foramen, below the base of the neural arch. The inner surface of this cavity indicates that it was not filled by cartilage, and it probably was a pneumatic opening, designed to lessen the weight of the enormous sacral mass. The transverse processes of these vertebræ are very stout, and of moderate length. Their distal ends are firmly coössified, forming a powerful support for the ilium. Between these processes are large oval openings.

The following measurements give the more important dimensions of these interesting fossils:

Length of centrum of last sacral vertebra	300·mm
Transverse diameter of distal end	270·
Vertical diameter of distal end	250·
Distance between extremities of transverse processes	850·

Length (approximate) of next sacral vertebra	280· mm
Transverse diameter of posterior end	200·
Least transverse diameter of centrum	85·
Distance between extremities of transverse processes	680·
Antero-posterior diameter of opening between transverse processes of above vertebræ	150·
Tranverse diameter	115·
Antero-posterior diameter (approximate) of shaft of femur	230·
Transverse diameter	350·

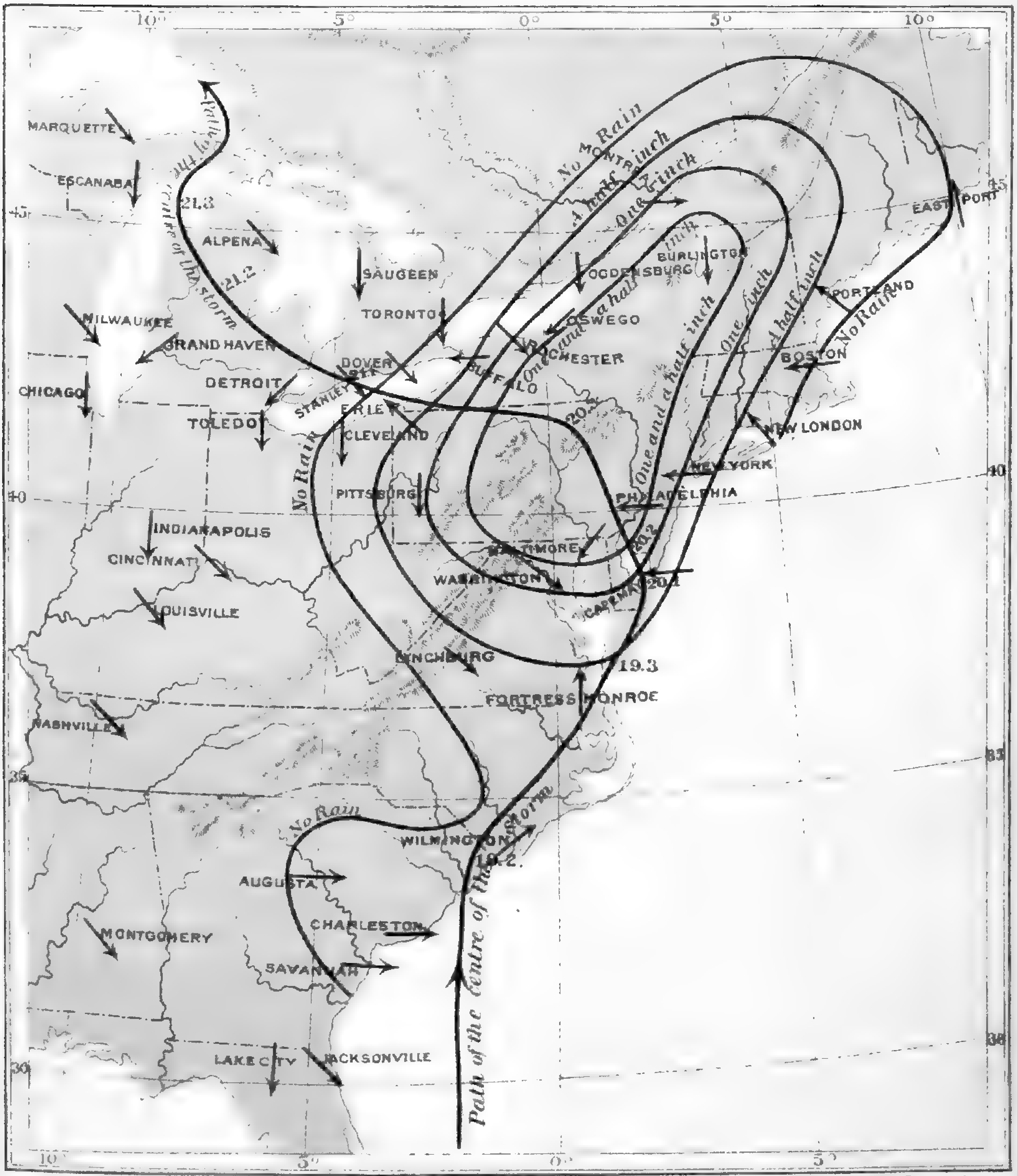
These dimensions would indicate for the entire animal a length of probably fifty to sixty feet. It was apparently an herbivorous reptile, and as it is quite distinct from any hitherto described, the species may be called *Titanosaurus montanus.* It was perhaps a distant ally of the comparatively small *Hadrosaurus agilis* Marsh, the only Dinosaur hitherto found in the Cretaceous of Kansas.

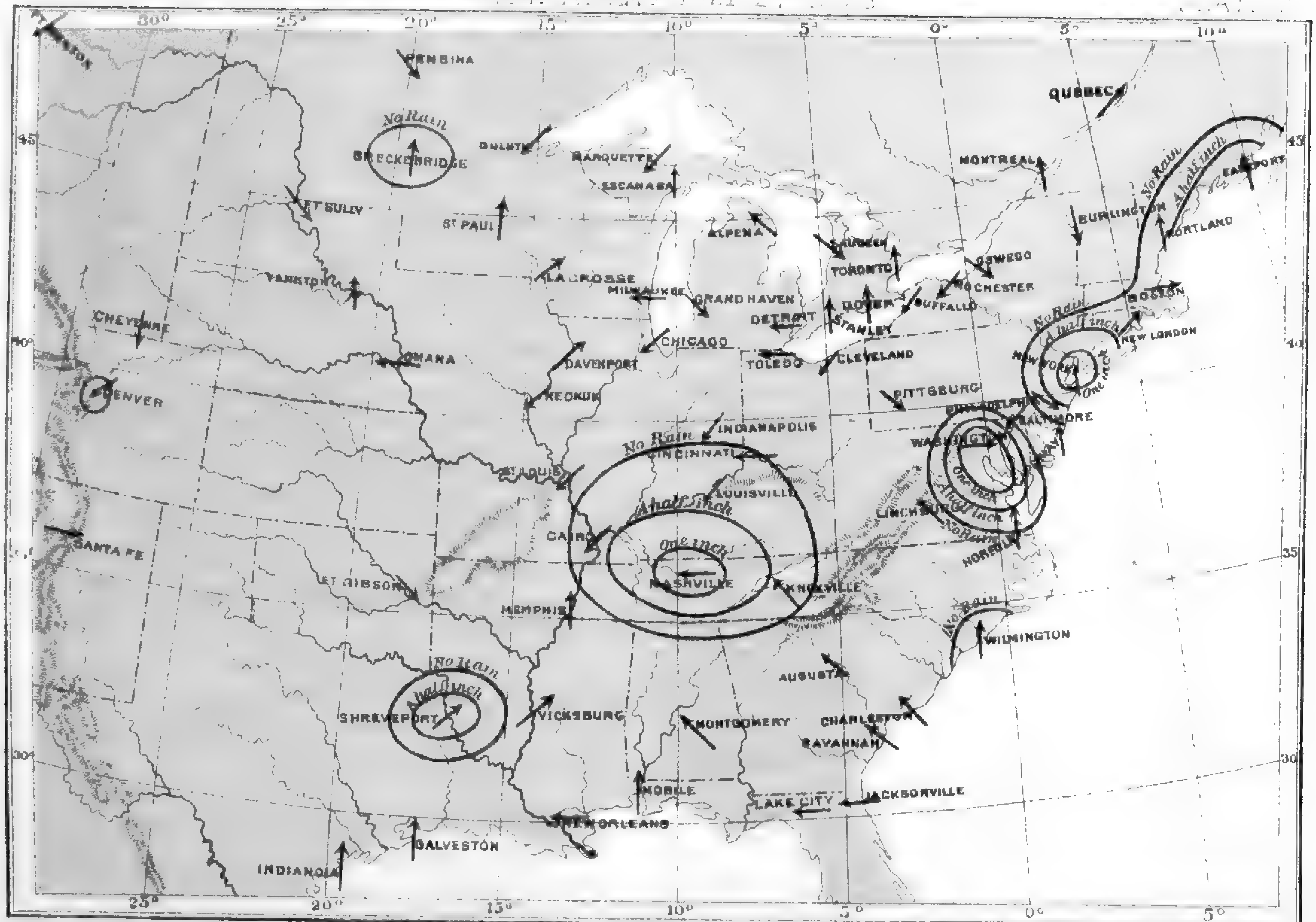
With the remains here described were found portions of a much smaller carnivorous reptile of the same order, which apparently belongs to the genus named by Cope *Lælaps.** These remains, with those already noticed, will soon be more fully described by the writer. Their locality is in the Dakota group of Colorado, on the eastern flanks of the Rocky Mountains, where they were discovered by Professor Arthur Lakes and Captain H. C. Beckwith, U. S. N.

Yale College, New Haven, June 20th, 1877.

* This name *Lælaps* is preoccupied, having been used by Koch in 1835, and again by Walker in 1843. It may, therefore, be replaced by *Dryptosaurus.* This genus is allied to *Megalosaurus*, and is represented in American Cretaceous strata by several species, among them *Dryptosaurus aquilunguis.*

RAIN AREA OCT. 20. 1873. PLATE I.





PEMBINA
No Rain
BRECKENRIDGE
DULUTH
MARQUETTE
ESCANABA
QUEBEC
MONTREAL
BURLINGTON
PORTLAND
EASTPORT
No Rain
A half inch
FT SULLY
ST PAUL
ALPENA
TORONTO
OSWEGO
ROCHESTER
BUFFALO
DOVER
STANLEY
YANKTON
LACROSSE
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CINCINNATI
LOUISVILLE
ST LOUIS
CAIRO
NASHVILLE
KNOXVILLE
LINCHBURG
NORFOLK
SANTA FE
FT GIBSON
MEMPHIS
WILMINGTON
AUGUSTA
SHREVEPORT
VICKSBURG
MONTGOMERY
CHARLESTON
SAVANNAH
MOBILE
LAKE CITY
JACKSONVILLE
NEW ORLEANS
GALVESTON
INDIANOLA

ISOBARIC CURVES OCT. 19-21. 1872.

DISCOVERY OF OXYGEN IN THE SUN BY PHOTOGRAPHY, BY PROFESSOR HENRY DRAPER, M. D. 1876.

The upper part of the photograph is the spectrum of the Sun, the lower part is the spectrum of the Oxygen and Nitrogen of Air. The letters and figures on the margin are printed with type on the negative; with this exception the photograph is absolutely free from hand work or retouching. O. indicates Oxygen, N. Nitrogen, Fe. Iron, Al. Aluminium. The figures above the Sun's spectrum are wave-lengths; G. h. H., are prominent Solar lines at the violet end of the spectrum. The important point to examine is the coincidence of the bright Oxygen lines with bright lines in the Solar spectrum. The picture is printed from Draper's original negative by Bierstadt's Albertype process.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

Art. XIV.—*Discovery of Oxygen in the Sun by Photography, and a new Theory of the Solar Spectrum;** by Professor Henry Draper, M.D.

I propose in this preliminary paper to indicate the means by which I have discovered oxygen and probably nitrogen in the sun, and also to present a new view of the constitution of the solar spectrum.

Oxygen discloses itself by bright lines or bands in the solar spectrum, and does not give dark absorption lines like the metals. We must therefore change our theory of the solar spectrum and no longer regard it merely as a continuous spectrum with certain rays absorbed by a layer of ignited metallic vapors, but as having also bright lines and bands superposed on the background of continuous spectrum. Such a conception not only opens the way to the discovery of others of the non-metals, sulphur, phosphorus, selenium, chlorine, bromine, iodine, fluorine, carbon, etc., but also may account for some of the so-called dark lines by regarding them as intervals between bright lines.

It must be distinctly understood that in speaking of the solar spectrum here, I do not mean the spectrum of any limited area upon the disc or margin of the sun, but the spectrum of light from the whole disc. I have not used an image of the sun upon the slit of the spectrocope, but have employed the beam reflected from the flat mirror of the heliostat without any condenser.

* Read before the American Philosophical Society, July 20th, 1877.

In support of the above assertions the accompanying photograph of the solar spectrum with a comparison spectrum of air, and also with some of the lines of iron and aluminium, is introduced. The photograph itself is absolutely free from handwork or retouching. It is difficult to bring out in a single photograph the best points of these various substances, and I have therefore selected from the collection of original negatives that one which shows the oxygen coincidences most plainly. There are so many variables among the conditions which conspire for the production of a spectrum, that many photographs must be taken to exhaust the best combinations. The pressure of the gas, the strength of the original current, the number of Leyden jars, the separation and nature of the terminals, the number of sparks per minute and the duration of the interruption in each spark, are examples of these variables.

In the photograph the upper spectrum is that of the sun and above it are the wave-lengths of some of the lines to serve as reference numbers. The wave-lengths used in this paper have been taken partly from Angström and partly from my photograph of the diffraction spectrum published in 1872. The lower spectrum is that of the open air Leyden spark, the terminals being one of iron and the other of aluminium. I have photographed oxygen, nitrogen, hydrogen and carbonic acid as well as other gases in Plücker's tubes, and also in an apparatus in which the pressure could be varied, but for the present illustration the open air spark was, all things considered, best. By other arrangements the nitrogen lines can readily be made as sharp as the oxygen are here, and the iron lines may be increased in number and distinctness. For the metals the electric arc gives the best photographic results as Lockyer has so well shown, but as my object was only to prove by the iron lines that the spectra had not shifted laterally past one another, those that are here shown at 4325, 4307, 4271, 4063, 4045, suffice. In the original collodion negative many more can be seen. Below the lower spectrum are the symbols for oxygen, nitrogen, iron and aluminium.

No close observation is needed to demonstrate to even the most casual observer, that the oxygen lines are found in the sun as bright lines, while the iron lines have dark representatives. The bright iron line at G (4307), on account of the intentional overlapping of the two spectra can be seen passing up into the dark absorption line in the sun. At the same time the quadruple oxygen line between 4345 and 4350 coincides exactly with the bright group in the solar spectrum above. This oxygen group alone is almost sufficient to prove the presence of oxygen in the sun, for not only does each of the four components have a representative in the solar spectrum, but the relative strength and the general aspect of the lines in each case is similar. I do not think that in comparisons of the spectra of the elements and sun, enough stress has been laid on the general appearance of lines apart from their mere position; in photographic representations this point is very prominent. The fine double line at 4319, 4317, is plainly represented in the sun. Again there is a remarkable coincidence in the double line at 4190, 4184. The line at 4133 is very distinctly marked. The strongest oxygen line is the triple one at 4076, 4072, 4069, and here again a fine coincidence is seen though the air spectrum seems proportionately stronger than the solar. But it must be remembered that the solar spectrum has suffered from the transmission through our atmosphere, and this effect is plainest in the absorption at the ultra-violet and violet regions of the spectrum. From some experiments I made in the summer of 1873, it appeared that this local absorption is so great when a maximum thickness of air intervenes, that the exposure necessary to obtain the ultra-violet spectrum at sunset was two hundred times as long as at mid-day. I was at that time seeking for atmospheric lines above H, like those at the red end of the spectrum, but it turned out that the absorptive action at the more refrangible end is a progressive enfeebling as if a wedge of neutral tinted glass were being drawn lengthwise along the spectrum toward the less refrangible end.

I shall not attempt at this time to give a complete list of the oxygen lines with their wave-lengths accurately determined, and it will be noticed that some lines in the air spectrum which have bright analogues in the sun are not marked with the symbol of oxygen. This is because there has not yet been an opportunity to make the necessary detailed comparisons. In order to be certain that a line belongs to oxygen, I have compared, under various pressures, the spectra of air, oxygen, nitrogen, carbonic acid, carburetted hydrogen, hydrogen, and cyanogen. When these gases were in Plücker's tubes a double series of photographs has been needed, one set taken with and the other without Leyden jars.

As to the spectrum of nitrogen and the existence of this element in the sun there is not yet certainty. Nevertheless even by comparing the diffused nitrogen lines of this particular photograph, in which nitrogen has been sacrificed to get the best effect for oxygen, the character of the evidence appears. The triple band between 4240, 4227, if traced upward into the sun has approximate representatives. Again at 4041, the same thing is seen, the solar bright line being especially marked. In another photograph the heavy line at 3995, which in this picture is opposite an insufficiently exposed part of the solar spectrum shows a comparison band in the sun.

The reason I did not use air in an exhausted Plücker's tube for the production of a photograph to illustrate this paper, and thus get both oxygen and nitrogen lines well defined at the same time, was partly because a brighter light can be obtained with the open air spark on account of the stronger current that can be used. This permits the slit to be more closed and of course gives a sharper picture. Besides the open air spark enabled me to employ an iron terminal and thus avoid any error arising from accidental displacement of the reference spectrum. In Plücker's tubes with a Leyden spark the nitrogen lines are as plain as those of oxygen here. As far as I have seen oxygen does not exhibit the change in the character of its lines that is so remarkable in hydrogen under the influence of pressure as shown by Frankland and Lockyer.

The bright lines of oxygen in the spectrum of the solar disc have not been hitherto perceived probably from the fact that in eye-observations bright lines on a less bright background do not make the impression on the mind that dark lines do. When attention is called to their presence they are readily enough seen even without the aid of a reference spectrum. The photograph, however, brings them into greater prominence. From purely theoretical considerations derived from terrestrial chemistry and the nebular hypothesis, the presence of oxygen in the sun might have been strongly suspected, for this element is currently stated to form eight-ninths of the water of the globe, one-third of the crust of the earth and one-fifth of the air and should therefore probably be a large constituent of every member of solar system. On the other hand the discovery of oxygen and probably other non-metals in the sun gives increased strength to the nebular hypothesis, because to many persons the absence of this important group has presented a considerable difficulty.

At first sight it seems rather difficult to believe that an ignited gas in the solar envelope should not be indicated by dark lines in the solar spectrum, and should appear not to act under the law, "a gas when ignited absorbs rays of the same refrangibility as those it emits." But in fact the substances hitherto investigated in the sun are really metallic vapors, hydrogen probably coming under that rule. The non-metals obviously may behave differently. It is easy to speculate on the causes of such behavior, and it may be suggested that the reason of the non-appearance of a dark line may be, that the intensity of the light from a great thickness of ignited oxygen overpowers the effect of the photosphere, just as if a person were to look at a candle flame through a yard thickness of ignited sodium vapor, he would only see bright sodium lines and no dark absorption lines. Of course such an explanation would necessitate the hypothesis that ignited gases, such as oxygen, give forth a relatively large proportion of the solar light. In the outburst of T *Coronæ*, Huggins showed that hydrogen could give bright lines on a background of spectrum analogous to that of the sun.

However all that may be, I have no doubt of the existence of substances, other than oxygen, in the sun, which are only indicated by bright lines. Attention may be called to the bright bands near G, from wave-length 4307 to 4337, which are only partly accounted for by oxygen. Further investigation in the direction I have thus far pursued will lead to the discovery of other elements in the sun, but it is not proper to conceal the principle on which such researches are to be conducted for the sake of personal advantage. It is also probable that this research may furnish the key to the enigma of the D_3 or helium line and the 1474 K or corona line. The case of the D_3 line strengthens the argument in favor of the apparent exemption of certain substances from the common law of the relation of emission and absorption, for while there can be no doubt of the existence of an ignited gas in the chromosphere giving this line, there is no corresponding dark line in the spectrum of the solar disc.

In thus extending the number of elements found in the sun we also increase the field of inquiry as to the phenomena of dissociation and recomposition. Oxygen especially, from its relation to the metals, may readily form compounds in the upper regions of the solar atmosphere which can give banded or channelled spectra. This subject requires careful investigation. The diffused and reflected light of the outer corona could be caused by such bodies cooled below the self-luminous point.

This research has proved to be more tedious and difficult than would be supposed, because so many conditions must conspire to produce a good photograph. There must be a uniform prime moving engine of two horse power, a dynamo-electric machine thoroughly adjusted, a large Ruhmkorff coil with its Foucault break in the best order, a battery of Leyden jars carefully proportioned to the Plücker's tube in use, a heliostat which of course involves clear sunshine, an optical train of slit, prisms, lenses and camera well focussed, and in addition to all this a photographic laboratory in such complete condition that wet sensitive plates can be prepared, which will bear an exposure of fifteen minutes and a prolonged development. It has been difficult to keep the Plücker's tubes in order; often before the first exposure of a tube was over the tube was ruined by the strong Leyden sparks. Moreover to procure tubes of known contents is troublesome. For example, my hydrogen tubes gave a spectrum photograph of fifteen lines, of which only three belonged to hydrogen. In order to be sure that none of these were new hydrogen lines it was necessary to try tubes of various makers, to prepare pure hydrogen and employ that, to examine the spectrum of water, and finally to resort to comparison with the sun.

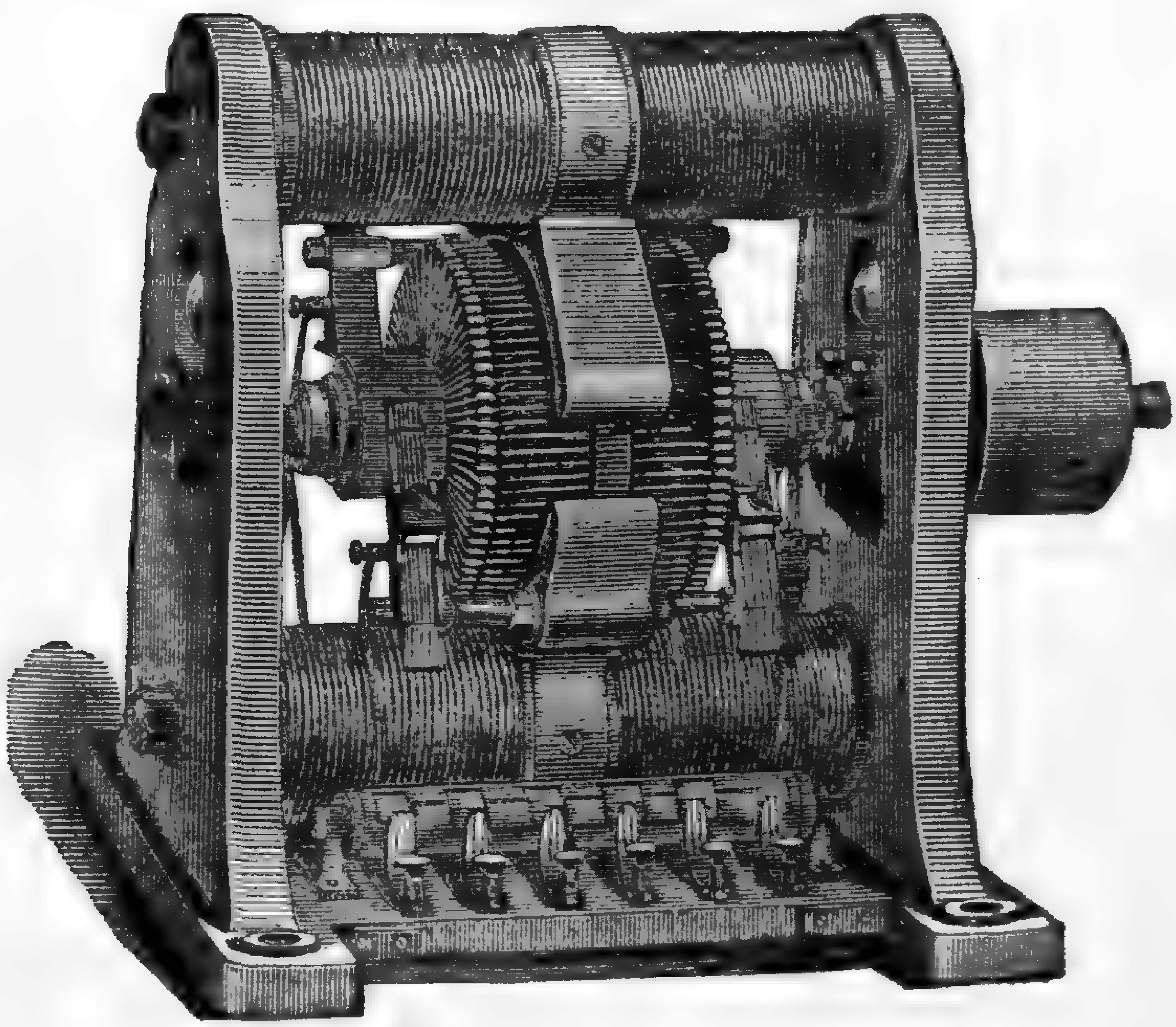
The object in view, in 1873, at the commencement of this research, was to secure the means of interpreting the photographs of the spectra of stars and other heavenly bodies, obtained with my 28-inch reflector. It soon appeared that the spectra of nitrogen and other gases in Plücker's tubes could be photographed, and at first some pictures of hydrogen, carbonic acid and nitrogen were made, because these gases seemed to be of greatest astronomical importance on account of their relation to stars, nebulæ and comets. Before the subject of comparison spectra of the sun was carefully examined, there was some confusion in the results, but by using hydrogen the source of these errors was found out.

But in attempting to make a prolonged research in this direction it soon appeared that it was essential to be able to control the electrical current with precision, both as to quantity and intensity, and, moreover, to have currents which when once adjusted would remain constant for hours together. These conditions are almost impossible to attain with any form of battery, but on the contrary are readily satisfied by dynamo-electric machines. Accordingly I sought for a suitable dynamo-electric machine and motor to drive it, and after many delays procured a combination which is entirely satisfactory. I must here acknowledge my obligations for the successful issue of this search to Professor Geo. F. Barker, who was the first person in America to procure a Gramme machine. He was also the first to use a Brayton engine to drive a Gramme.

The dynamo-electric machine selected is one of Gramme's patent made in Paris and is a double light machine, that is, it has two sets of brushes, and is wound with wire of such a size as to give a current of sufficient intensity for my purposes. It is nominally a 350 candle-light machine, but the current varies in proportion to the rate of rotation, and I have also modified it by changing the interior connections. The machine can produce as a maximum a light equal to 500 standard candles, or by slowing the rotation of the bobbin the current may be made as feeble as that of the weakest battery. In practical use it is sometimes doing the work of more than fifty large Grove nitric acid cells and sometimes the work of a single Smee.

The Gramme machine could not be used to work an induction coil when it first reached me, because when the whole current was sent through the Foucault interruptor of the Ruhmkorff coil, making 1,000 breaks per minute, the electro-magnets of the Gramme did not become sufficiently magnetized to give an appreciable current. But by dividing the current so that one pair of the metallic brushes, which collect from the revolving bobbin, supplied the electro-magnets, the other pair could be used for exterior work, no matter whether interrupted or constant. The current obtained in this way from one pair of brushes when the Gramme bobbin is making 1,200 revolutions per minute, is equal to one hundred candles, and is greater in quantity and intensity than one would like to send through a valuable induction coil. I usually run the bobbin at 622 revolutions per minute, and this rate will readily give 1,000 ten-inch sparks per minute with the eighteen-inch coil. Of course a Plücker's tube lights up very vividly, and generally, in order to get the maximum effect, I arrange the current so that the aluminium terminals are on the point of melting. The glass, particularly in the capillary part, often gets so hot as to char paper. The general appearance of the machine is shown in fig. 1.

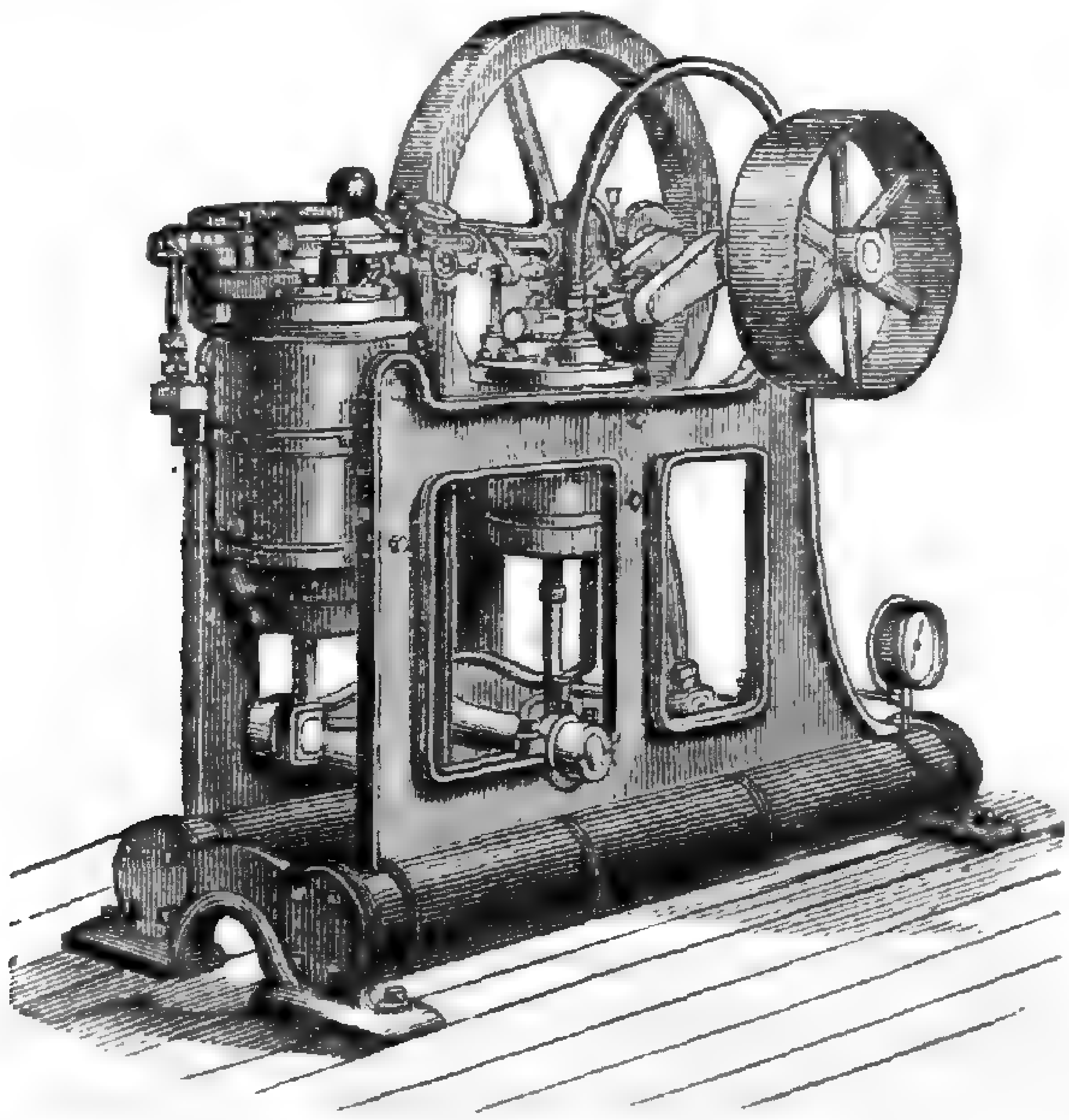
1.



The Gramme Machine.

As long as the Gramme bobbin is driven at a steady rate the current seems to be perfectly constant, but variations of speed make marked differences in the current, and this is especially to be avoided when one is so near the limit of endurance of Plücker's tubes. A reliable and constant motor is therefore of prime importance for these purposes. A difference of one per cent in the speed of the engine sometimes cannot be tolerated, and yet at another time one must have the power of increasing and diminishing through wide limits. The only motor, among many I have examined and tried, that is perfectly satisfactory, is Brayton's Petroleum Ready Motor. This remarkable and admirable engine acts like an instrument of

2.



Brayton's Petroleum Motor.

precision. It can be started with a match, and comes to its regular speed in less than a minute; it preserves its rate entirely unchanged for hours together. Moreover, it is economical, cleanly and not more noisy than a steam engine. The one of two horse power I have ran for six months, day and night, supplying water and air to the aquaria in the Centennial Exhibition at Philadelphia. At any time on going into the laboratory it can be started in a few seconds, even though it has not been running for days.

Henry Draper's Observatory, Hastings-on-Hudson, New York.

Art. XV.—*On the Theory of the Action of certain Organic Substances, in increasing the Sensitiveness of Silver Haloids*; by M. C. Lea.

In the early days of photo-chemistry, it was observed that all the silver haloids gained in sensitiveness by being in contact with a soluble silver salt; that when the soluble silver salt was removed by careful washing, a considerable diminution in sensitiveness followed. After a time it was noticed that certain organic substances placed in contact with the washed haloid, appeared to take, to some extent, the place of the silver salt removed, and that the silver haloid was distinctly more sensitive when in contact, for example, with tannin, than when isolated.

In explanation of the fact, a theory was published by M. Poitevin that these organic substances acted in virtue of their affinity for the halogen. That in the case, for example, of tannin and silver iodide, the iodide was more readily attacked by light in the presence of tannin, because the affinity of tannin for iodine came into play in aid of the action of light. Shortly after, Dr. H. Vogel published the same theory.

It is a little remarkable that neither of the authors of this theory, or rather hypothesis, has at any time thought it necessary to support it by experiment or proof of any kind, but both have continued up to the present time to treat the theory as self-evident. In endeavoring to show that this explanation of the reaction cannot be received, I shall have no argument on the other side to combat, or experiments to discuss, as I can find none. I shall, therefore, state what I conceive to be the true explanation, and endeavor to support it adequately by proof.

When we examine all the substances known to be capable of increasing the sensitiveness of the silver haloids, we notice that the one property which they possess in common is, *not* an affinity for the halogen, as the Poitevin–Vogel theory would lead us to expect, but that they *are all reducing agents.* The natural view, therefore, of their action on a silver haloid is, not that they abstract the halogen from it, but that their affinity for oxygen comes into aid of the affinity of the halogen for hydrogen, and that under the influence of light, an atom of water is decomposed. That in the case of silver iodide and tannin, for example, the tannin is oxidized, the iodine is converted into hydriodic acid, and the silver salt is more or less completely reduced, probably to subiodide. According to this view, when silver iodide is exposed to light in presence of an organic body capable of accelerating the action of light, there should be traces of free acid formed, whereas, according to the Poitevin–Vogel theory the result of the action should be the formation of an iodo-substitution compound.

1. Silver iodide was precipitated in the presence of a slight excess of potassium iodide, and thoroughly washed. A small quantity of pyrogallol was added and the mixture was exposed to sunlight for fifteen minutes in contact with water. The liquid at first neutral, at the end of fifteen minutes, showed a distinctly acid reaction, increasing with continued exposure.

[Pyrogallol was used in preference to tannin (gallotannic acid) because the former is perfectly neutral to test paper, and cannot confuse the reaction as would be the case with tannin, which of itself reddens blue litmus paper].

Again: if the Poitevin–Vogel theory were correct, it would afford a criterion as to what substances should, and what should not, exalt the sensitiveness of the silver haloids. Substances having an affinity for iodine should increase the sensitiveness, and substance not possessing such affinity, should have no such action. This is not the fact. There are substances which exalt an affinity for iodine, that do not exalt the sensitiveness of silver iodide and conversely, for example:

2. Silver iodide was exposed to light for a month under a solution of potassium carbonate, in a test tube, with another test tube, for comparison, containing silver iodide under water only. The alkali did not in the least increase the tendency of the iodide to darken.

3. Starch, which has a well-known affinity for iodine, does not appear to increase the sensitiveness of silver iodide by contact with it.

These experimental results appear to be incompatible with the Poitevin–Vogel theory.

The view which I have here offered is, moreover, very strongly supported by the phenomena of alkaline development. When a sensitive surface has been exposed to light, the image may be developed by pyrogallol, a neutral organic substance. This development is greatly stimulated by the presence of an alkali, a fact which the Poitevin–Vogel theory leaves unexplained. But according to the view here proposed, viz: that the result of the action of the organic body is not a substitution product, but a halogen acid, (e. g. HI, etc.), it is natural that the presence of an alkali should increase the tendency to form an acid for which it has a strong affinity.

Also, this new explanation is in harmony with received views of the action of the halogens in analogous cases, and particularly with that of the action of chlorine in bleaching organic substances. The modern view of the action is, not that the chlorine attracts the organic body with formation of a substitution compound, but that, by the coöperating affinity of the organic substance for oxygen, and that of the chlorine for hydrogen, an atom of water is decomposed, with formation of hydrochloric acid and peroxide of hydrogen, which latter substance attacks the oxidizable organic body. It will be observed that the reaction is exactly the same in both cases, the bleaching and the photo chemical. In fact, the parallelism is in all respects as complete as it can possibly be, and the analogy lends a strong support to the view that I have here expressed.

I conclude, therefore, that such organic bodies as increase the sensitiveness of the silver haloids to light, do so, not by forming substitution compounds with the halogen, but by promoting, in virtue of their affinity for oxygen, the decomposition of water by the halogen.

There is, probably, another affinity which plays some part in the tendency to form the halogen acid, and that is the tendency shown by the silver haloid to form combinations with the corresponding halogen acids, e. g. hydroargentic iodide AgIHI, etc., in the absence of an alkali.

Philadelphia, June 26, 1877.

ART. XVI.—*On Critical Periods in the History of the Earth and their Relation to Evolution: and on the Quaternary as such a Period*;* by JOSEPH LECONTE.

IN the series of rocks representing the history of the earth there occur at different horizons, *unconformities*. In most cases these do not occur at the same horizon in different places; but there are a few which seem to be very general. Associated with these unconformities, as is well known, there is nearly always a marked change in the fossil species. The greatness of this change is always in direct proportion to the generality of the unconformity. These general unconformities attended with very great changes in organic forms are the natural boundaries of the great divisions of time, and the less general unconformities attended with less sweeping change of organic forms, of the subdivisions.

The earlier geologists, under the influence of the *then* dominant idea of frequent supernatural interference with the course of nature, imagined that these unconformities marked the times of instantaneous cataclysm which disturbed the rocks and destroyed all living things, sometimes locally, sometimes generally; and that these exterminations were followed by re-creations of other and wholly different species at the beginning of the subsequent period of tranquility. *Now*, however, we believe that no such instantaneous general exterminations and re-creations ever occurred. Now we know that unconformity simply indicates eroded land-surface, and therefore marks a period of time during which the observed place was land and received no sediment—that two series of rocks unconformable to each other indicate two periods of comparative quiet, during which the observed place was sea-bottom receiving sediment steadily, separated by a period of oscillation producing increase and decrease of land, during which the observed place

* Read before the National Academy of Sciences, April 18, 1877.

was raised into land-surface with or without crumpling of the strata, deeply eroded and then sunk again below sea level to receive the second series of strata. The length of the two periods of repose is roughly measured by the thickness of the two conformable series. The length of the period of commotion is roughly measured by the amount of erosion at the line of unconformity.

Evidently, therefore, every case of unconformity marks a period of time, often a long period, during which there was no record made in strata and fossils at the observed place; certain leaves, often very many, are there missing from the Book of Time. Is it any wonder then, that skipping over these pages when we commence reading again we find the matter entirely new? Evidently, then, the suddenness of the change in organic forms is only apparent. If we could recover the record, which was doubtless carried on elsewhere, the break would disappear; if we could recover the missing leaves the reading would be continuous. In every such case therefore there is a *lost interval* of history. In cases of local unconformity we recover the lost record in other places, and thus fill up the blank in the history. But in some cases of very general unconformity, such as those which mark the great divisions of time, the loss is not yet recovered, perhaps is irrecoverable; though doubtless the more complete knowledge of the geology of the whole earth-surface will go far toward filling blanks and making the record continuous.

The view above presented is now held by all geologists, but there seems to be danger, under the influence of the *now* dominant views of evolution, of erring on the other extreme. Assuming a *uniform rate* of evolution, many, it seems to me, commit the mistake of measuring the amount of lost interval by the amount of change of organic forms, and thus discredit the real value of the geological record by exaggerating greatly its fragmentary character. On the contrary there seems good reason to believe that the evolution of the organic kingdom, like the evolution of society and even of the individual, has its periods of *rapid movement*, and its periods of *comparative repose* and re-adjustment of equilibrium. Geological history, like all other history, has its periods of comparative quiet, during which the forces of change are gathering strength; and periods of revolution during which the accumulated forces manifest themselves in conspicuous changes in physical geography and climate, and therefore in rapid movement in the march of evolution of organic forms—periods when the forces of change are *potential*, and periods when they become *active*. Conformable rocks represent the periods of comparative quiet, during which organic forms are either permanent or change slowly; unconformity represents a time of oscillation with increase and decrease of land, and therefore of rapid changes of physical conditions and correspondingly rapid movement in evolution. The general unconformities, of course, mark times of very general commotion—of wide-spread changes of physical geography and climate, and therefore of exceptionally rapid and profound changes in organic forms.

These periods of revolution in all history are *critical;* and therefore are of especial interest to the philosophic historian and to the evolutionist; but they are also in all history periods of *lost record.* And as in human, so also in geological history, the farther back we go, the longer are the lost intervals and the more irrecoverable the lost records. We will now give examples of such lost intervals and show their significance in evolution.

The first and by far the greatest of these lost intervals is that which occurs between the Archæan and the Paleozoic. In every part of the earth where the contact has been yet observed the Primordial lies unconformably on the upturned and eroded edges of the Archæan strata. This relation was observed first in Canada, then in various parts of the eastern United States, then in Scotland, Hebrides, Bavaria, Bohemia, Scandinavia. Unconformity in such widely separated localities, indicates wide-spread changes in physical geography, and therefore presumably of all those physical conditions included in the word *climate.* These changes of physical geography are best illustrated in the United States. The break between the Archæan and the Primordial has been observed in very many places all over the wide area of the United States east and west; not only in Canada, in New York, in the Appalachian region, in Wisconsin, Missouri, Arkansas and Texas, but also all over the Rocky Mountain region, in Nebraska, Montana, Idaho, Wyoming, Colorado, Utah, Nevada, New Mexico and Arizona. As upturned eroded outcropping strata mean land-surface, it is evident that there was at that time *a very large area, or else several large areas of land,* in the place now occupied by the American Continent. In comparison with the subsequent Silurian it was *a continental Period.* This land is often spoken of as *Archæan land.* It was indeed land of *Archæan rocks,* but for that very reason not of Archæan times: for these rocks were of course formed at the bottom of the sea in Archæan times, and therefore these localities were all sea-bed receiving sediment at that time. We know absolutely nothing of the land of Archæan times, and never can know anything until we find still older rocks from the debris of which Archæan sediment, were formed. The land spoken of above, was *land of the Lost Interval.* That the interval was immensely long is evident from the prodigious erosion. That it was a period of wide-spread oscillation is also evident; for all the places mentioned were sea-bed in Archæan, land during the interval, and again sea-bed during the Silurian. But of this long interval not a leaf of record remains.

Evidently then at the end of the Archæan an enormous area of Archæan sea-bottom was raised up and crumpled and became land. After remaining land for a time sufficiently long to allow enormous erosion of the crumpled strata it again went down to the old Primordial shore-line and the Silurian age commenced. This time of elevation is the lost interval.

Now, when the record closed in the Archæan, as far as we know, only the lowest forms of Protozoan life yet existed. The beginnings of life had not yet differentiated into what might be called a fauna and flora. When the record again opened with the Primordial we have already a varied and highly organized fauna, consisting of representatives of many classes and of all the great types of animal structure, except vertebrates. Nor are these representative the lowest in three several departments; for Trilobites and Orthoceratites can hardly be regarded as lower than the *middle of the animal scale* as it now exists. It is certain therefore that all the great departments except vertebrates, and most of the classes of these departments including animals as least half way up the animal scale, were differentiated during the lost interval. The amount of evolution during this interval cannot be estimated as less than all that has taken place since. Measured by the amount of evolution therefore, this lost interval is equal to all the history of the earth which has elapsed since. We escape this very improbable conclusion, only by admitting *a more rapid rate of evolution during critical periods.*

It is one of the chief glories of American Geology, to have first established the Archæan as one of the primary divisions of time. It is even yet reluctantly admitted as such by many European geologists. And yet, it is seen, that from every point of view, whether of the rock system or of the life system, it is by far the most widely and trenchantly separated of all the eras.

The next greatest lost interval (though far less than the preceding) is that between the Paleozoic and the Mesozoic. Here we have the next most general unconformity, indicating the next most wide-spread changes of physical geography and climate, accompanied by the most sweeping changes in organic forms, not only in species and genera, but also in families and orders. This change is the more striking as it occurs in the midst of an abundant life. It is the greatest and most sweeping change in the forms of organisms which has ever occurred in the history of the earth. *It took place, again, during a lost in-*

terval. A portion of the loss is recovered in the Permian; but the most critical time, the time of most rapid change, viz: that between the Permian and the Trias, is still missing. How we long to find the steps of this great change! What a flood of light would it shed on the process of evolution! But although the change in the organic kingdom was, just here, so enormously great, yet the lost interval does not seem very long; for in England the Trias and Permian seem to be conformable, though probably with change from marine to fresh water conditions. It is impossible therefore to resist the conclusion that the steps were just here fewer and longer, and the progress more rapid than usual. As in human history revolutions are the times of the birth of new social ideas, upon which during the subsequent period of tranquillity, society is re-adjusted in prosperity and happiness on a higher plane; so also in geological history, critical periods are times of origin of new and higher organic forms and the subsequent periods of tranquillity are times of re-adjustment of equilibrium and prosperous development of these forms.

Like the previous lost interval, this was also a period of oscillation—a period of great increase of land, which was again partly submerged to inaugurate the Trias. It was therefore, again, *a continental period.* The land-making commenced at the end of the Coal period, in this country with the formation of the Appalachian Mountains, continued through the Permian and culminated in the lost interval, which is in fact for that very reason lost.

Far less in length of time and perhaps in the sweeping character of the change of organisms, but far more important and interesting on account of the high position of the animals involved is the lost interval between the Mesozoic and Cenozoic. The length of time lost here is comparatively small. In America in many parts of the west the uppermost Cretaceous seems to pass into the lowermost Tertiary without the slightest break of continuity. There may be some break, some unconformity, some lost record, but certainly it cannot be large. Yet the change especially in the higher animals is immense. In America the break and the lost interval is much greater between the Jurassic and Cretaceous than between the Cretaceous and Tertiary, yet the organic change is far greater in the latter case. The reason is that the changes of physical geography and climate in the latter were *more general.* Although in America the break and the lost interval is greater at the end of the Jurassic, yet taking the strata all over the earth, the break is far more general at the end of the Cretaceous; and it is these *general* changes in physical geography which affect climate the most and which therefore produce the profoundest changes in organic forms.

Now it is almost impossible to imagine a clearer proof of the fact of rapid evolution-movement during critical periods, than we find in the shortness of the lost interval and yet the greatness of the change in higher organisms just at this horizon in the rocky series. Nothing can be more astonishing than the abundance, variety and prodigious size of Reptiles in America up to the very close of the Cretaceous, and the complete absence of all the grander and more characteristic forms in the lowest Tertiary; unless, indeed, it be the correlative fact of the complete absence of mammals in the Cretaceous and their appearance in great numbers and variety in the lowest Tertiary. If Cretaceous mammals existed in *America*, surely their remains would have been found in the wonderfully rich Cretaceous strata. It seems certain that in America, or at least in that portion which has been examined, mammals appeared somewhat suddenly and in great numbers on the scene and were a principal agent in the extermination of the great reptiles. The wave of reptilian evolution had just risen to its crest and perhaps was ready to break, when it was met and overwhelmed by the rising wave of mammalian evolution.

We have dwelt only on the great change in the higher classes, but the change really extended to all classes. This was therefore a time of exceptionally general and rapid changes in all departments alike. In other words it was a critical period in organic evolution.

That it was also a time of very great changes in Physical geography, here in America as well as elsewhere, is well known. The Cretaceous sea which extended from the Gulf of Mexico to the Arctic Ocean, covering the whole western plains and plateau region, and thus divided the American continent into two, an eastern Appalachian continent and a western or Basin region continent, was abolished at the end of the Cretaceous, and replaced by great fresh water lakes in the same region, and the continent became one. Moreover it is probable that it was a period of wide-spread oscillation, i. e., of upheaval and again subsidence to the condition of things found at the beginning of the Tertiary. It is probable that the upheaval which abolished the Cretaceous sea went much beyond the condition of things afterwards—that just at the interval the land was higher and larger than in the Tertiary—that, in short, this was again a *continental period* and probably a period of greater cold than the subsequent Tertiary.

The change in physical geography, then, was immense, but in most places by bodily upheaval, not by crumpling of the strata, and therefore the usual signs of such change, viz: unconformity is often wanting. The change of climate all over the American continent was no doubt very great and the change in organic forms correspondingly great everywhere and in all departments; but this was especially true of all water-inhabiting species, in the region of the old Cretaceous interior sea; for here there was a change not only in climate but from salt to fresh water through the intermediate condition of brackish water. The Cretaceous marine species rapidly disappeared, partly by extermination and partly by transmutation into fresh water species, as has been observed, recently, to take place in some crustaceans under this change of conditions.* The Tertiary fresh-water species rapidly appeared partly by transmutation from the previous marine and partly by transportation in various ways from other fresh lakes. But all this occurred in some places without the slightest break in the continuity of the strata.

The great change of climate and other physical conditions perhaps sufficiently explain the change in *invertebrate* species, but it is impossible to account for the somewhat sudden appearance of mammals in the lowest Tertiary except by *migration* from other regions where they had existed in late Cretaceous times, having originated there by derivation in the usual way. That marsupials existed somewhere in Cretaceous times (though possibly not in America or Europe) there can be no doubt; for they existed we know in the preceding Jurassic and the following Tertiary, and they exist *now*. It is from these rather than from Cretaceous reptiles, that Tertiary mammals were doubtless derived; and this derivation took place probably at rapid rate in the latest Cretaceous or during the lost interval in some unknown locality whence they migrated into the Tertiary lake region of the United States during the interval. This migration came most probably from northern Asia; for it must be remembered that the interval was a continental period and therefore probably a period of broad land connections between Nearctic and Palearctic regions. The complete examination of the uppermost Cretaceous of different portions of Asia will probably reveal the immediate progenitors of the early Tertiary mammals of Europe and America. This introduces us to a most important element of rapid local faunal change especially in higher animals, viz: *migrations*. If we do not dwell longer now on this, it is only because we shall have to recur to it again.

I have preferred, thus far, to speak of *general* evolution-changes of organisms, whether slow or rapid, as produced by varying pressure of external conditions; and the most striking *local* changes by migrations from other regions where the apparently suddenly-appearing species had previously existed, having originated there by evolution in the usual way. I have

* Arch. des Sciences, Nov., 1875, p. 284.

preferred, thus far, to represent the organic kingdom as lying, as it were, *passive* and plastic under the moulding hands of the environment. I have done so because it is in accordance with true method to exhaust the more obvious causes of evolution before appealing to the more obscure and doubtful.

It is possible that general movements affecting alike all classes may be accounted for in this way alone. But there are many facts in the evolution of the organic kingdom, especially the sudden appearance of new forms in the quietest times, which can hardly be thus explained. There seem to be *internal* as well as *external* factors of evolution. Again the internal factors may be either in the form of *tendencies* to change or of *resistance* to change. Of these, however, the latter seems to be most certain. There may be in the organic kingdom an "*inherent tendency*" to change in special directions, similar to that which directs the course of embryonic evolution—a tendency, in the case of the organic kingdom, inherited from physical nature from which it sprung, as in the case of the embryo it is inherited from the organic kingdom through the line of ancestry. This cause, however, is too obscure, and I therefore pass it by.

But whether or not there be any such inherent tendency to change, there certainly is an inherent tendency to *stability*—to persistence of organic form. If there be no inherent force of progress, there certainly is an inherent force of *conservation* greater in some species than others. It seems probable that in many of the more rigid types this stability is so great, and therefore variation of offspring is so slight, that progressive change of form is too slow to keep pace with change of external conditions especially in critical periods. If this be so, then an organism may be regarded as under the influence of two opposing forces, the one conservative, the other progressive; the one tending to equilibrium, the other to motion; the one to permanence, the other to change of form; the one static, the other dynamic; the one internal, *the law of heredity*, the other external, the *pressure of a changing environment*. Under the influence of two such forces, the one urging, the other resisting, it is evident that even with steady changes of external conditions, the change of organic forms would be more or less paroxysmal. Other kinds of evolution, physical and social, evidently advance paroxysmally from this cause. As therefore in the gradual evolution of earth-features there are periods of comparative quiet, during which the forces of change are gathering strength, but produce little visible effect, being resisted by crust-rigidity, and periods when the accumulating forces finally overcome resistance and determine comparatively rapid changes; as also in social evolution there are periods in which forces of social change are gathering strength, but make no visible sign, being resisted by social conservatism—rigidity of the social crust—and periods in which resistance gives way and rapid changes occur; so also in the evolution of the organic kingdom the forces of change, i. e. pressure of changing environment, may accumulate but make little impression, being resisted by the *law of heredity*—of *like producing like*—or type-rigidity, until finally the resistance giving way, the organic form breaks into fantastic *sports* which are at once seized by natural selection and rapid change is the result.

Some persons seem to think that paroxysmal evolution is inconsistent with the uniformity of Nature's laws. On the contrary, it is in perfect accord. Laws and forces are indeed uniform, but phenomena are nearly always paroxysmal. The forces of volcanos and earthquakes, of lightning and tempests are uniform, but the phenomena are paroxysmal. Winds at the earth's surface, where the resistance is great, *blow in puffs.* A thin sheet of water over a smooth sloping surface *runs in waves.* The law may be illustrated in a thousand ways. In all cases where an accumulating force is opposed by a constant resistance, we have phenomena in paroxysms.

But whatever be the cause, the *fact* of paroxysmal movement of organic evolution is undoubted. All along the course of geological history, from beginning to end, even when the times were quietest, where the record is fullest and apparently without any missing leaf, species come and go and others take their place, and yet only rarely do we find any transition-steps. If this were only once or twice or thrice, or to any extent exceptional, it might be explained by loss of record here and there, but it occurs thousands and tens of thousands of times. Now if evolution moves only at uniform rate—if it takes 100,000 years to transmute one species into another (as it certainly does when evolution is moving at its usual rate)—if there are at least 100,000 steps (represented each of course by a whole generation of many individuals), between every two consecutive species, it is simply incredible that all the individuals representing the intermediate steps, so infinitely more numerous than the species they connect, should be so generally, almost universally lost. But the phenomena as we find them, are easily understood, if a few generations represent the transition step, and many generations the permanent form.

A similar rapid, almost sudden appearance and extinction of *genera*, *families* and higher groups at certain horizons, are also common. In these cases the intermediate steps of transition are often found, and constitute in fact the chief demonstrative evidence of the truth of evolution. But the difficulty on the assumption of a uniform rate of evolution is none the less here, for the time required to evolve a new genus or a new family is of course immensely greater than in the case of a new species.

We will illustrate the difficulties of the ordinary view by one striking example. In the Upper Silurian in the midst of a conformable series, where if there be any break—any lost record—surely it must be very small, appear suddenly, without premonition, *Fishes:* not a connecting link between fishes and any form of invertebrates, but perfect, unmistakable fishes. Here we have, therefore, the appearance not only of a new class, but of a new sub-kingdom or type of structure, *Vertebrata.* Now to change from any previously existing form of invertebrate, whether worm, crustacean or mollusk, into a vertebrate, by a series of imperceptible steps represented by successive generations—steps so imperceptible that it would take 100,000 of them to advance from one intermediate species to another—would require an amount of time which is inconceivable to the human mind, and a number of steps, each be it remembered, represented by thousands of individuals, which can scarcely be expressed by figures. And yet we must believe that these innumerable transitional forms, each represented by innumerable individuals, are all lost, and that this prodigious time shows no evidence in the rocky record. If this case were exceptional we might possibly admit that fishes appeared in Great Britain by migration (as they probably did), but only after having previously existed untold millions of ages, somewhere else; but similar cases are too common to be explained in this way.

Now the whole difficulty disappears—we avoid the incredible imperfection of the geological record (imperfect at best)—we avoid also the necessity of extending geological time to a degree which cannot be accepted by the physicist—if we admit that the derivation of one species from another is not necessarily by innumerable imperceptible steps, but may sometimes be by a *few decided steps;* and that the same is true for the origin of new genera, families, orders, etc.; in a word, that there are in the history of evolution of species, genera, families, orders, etc., and of the organic kingdom, *periods of rapid movement.* When the whole organic kingdom is involved in the movement, then we call the period *critical,* and the record of it is often lost.

Thus, on the supposition of such rigidity or resistance to change, in organic forms, varying in degree in different species and in different genera, families, orders, etc., a rigidity, also, *increasing by accumulated heredity so long as conditions remain unchanged,* it is evident that, in times of perfect tranquility all species grow more and more rigid. In times of very gradual change, the more plastic species change gradually *pari passu,* while the more rigid species change paroxysmally, now one, now another, as their resistance is overcome. Finally, in times of revolution nearly all forms yield to the pressure of external conditions and change rapidly; *only the very exceptionally rigid being able to pass over the interval to the next period of re-adjusted equilibrium.*

Thus, for example, the great and wide-spread changes of physical geography which occurred at the end of the Carboniferous, appropriately called in this country, the *Appalachian revolution,* was the death-sentence of the long-continuing and therefore rigid Paleozoic types. But the sentence was not immediately executed. The Permian represents the time between the sentence and the execution—the time during which the more rigid Paleozoic forms continued to linger out a painful existence in spite of changed and still changing conditions. But the most critical time—the time of most rapid change—the time of actual execution—was the *lost interval.* Only a very few most rigid forms pass over this interval into the Trias.

The Quaternary, a Critical Period.

We have given examples of several general unconformities, the signs of wide-spread oscillations of the earth-crust, attended with increase and decrease of land, and therefore with great and wide-spread changes of climate and other physical conditions, and therefore also with great and rapid changes of organic species. These times of general oscillation are therefore the natural boundaries of the Eras or primary divisions of Time. We have called them critical periods, transition-periods, periods of revolution, because they are times of rapid change, both in the physical and the organic world—a change overthrowing an *old* and establishing a *new* order of things. They are also times of *lost record.* We have seen, also, that these critical periods, in comparison with the preceding and succeeding, are *continental periods,* and it is for this reason that their record is usually lost.

Now, the Quaternary is also such a critical or transition period, marking the boundary between two great Eras. The Quaternary is also a period of great and wide-spread oscillations, with increase and decrease of land—a period of upheaval, erosion, down-sinking, to rise again slowly to the present condition. The early Quaternary was, also, therefore, to a marked degree, a continental period. Here also we have newer rocks lying unconformably on the eroded edges of an older series—river sediments in old river valleys, marine sediments in fiords—in other words, we have unconformity on a grand scale. Also in connection with these oscillations we have great changes in physical geography, and corresponding and very wide-spread changes in climate, and therefore corresponding rapid changes in organic forms. Here then we have all the characteristics of one of the boundaries between the primary divisions of time. Here then we have a transition or *critical* period—a period corresponding to one of the lost intervals; only in this instance being so recent, and being also less violent than the preceding ones, *it is not lost.* The study of the Quaternary, therefore, ought to furnish the key which will unlock many of the mysteries which now trouble us. Some of the problems which have been or will be explained by study of the Quaternary, we will now briefly mention.

I. *Changes of species not sudden.*—If the Quaternary were lost and we compared the Tertiary rocks with the unconformably overlying recent rocks, and the Tertiary mammals with those now living, how great and apparently sudden seems the change! How like to a violent extermination and re-creation! But the Quaternary is fortunately not lost, and we see that there has been no such wholesale extermination and re-creation, but only gradual though comparatively rapid change.

II. *Migration one chief cause of change.*—But what is still more important, we are able to trace with something like certainty, the cause of these rapid changes, and we find that in the higher animals, chief among these have been *migrations*—migrations enforced by changes of climate, and migrations permitted by changes of physical geography opening gateways between regions previously separated by impassable barriers. This point is so important that we must dwell upon it. Only an outline, however, of some of these migrations and their effects on evolution can be given in the present condition of knowledge.

During Miocene times, as is well known, evergreens, allied to those now inhabiting Southern Europe, covered the whole of Europe as far north as Lapland and Spitzbergen. In America, Magnolias, Taxodiums, Libocedrus and Sequoias very similar to, if not identical with those now living on the Southern Atlantic and Gulf coast and in California, were abundant in Greenland. Evidently there could have been no *Polar ice-cap* at that time and therefore no Arctic species unless on mountain tops. During the latter part of the Pliocene the temperature did not differ much from the present; the polar ice-cap had therefore commenced to form, with its accompaniment of Arctic species. With the coming on of the *Glacial epoch*, the polar ice and Arctic conditions crept slowly southward, pushing Arctic species to middle Europe and Middle United States, and sub-Arctic species to the shores of the Mediterranean and the Gulf. With the return of more genial climate, Arctic conditions went slowly northward again, and with them went Arctic species slowly migrating generation after generation to their present Arctic home.

Similarly molluscous shells migrated slowly southward and again northward to their present position. But *plants* and some terrestrial invertebrates, such as *insects*, had an alternative which shells had not, viz: that of seeking Arctic conditions also *upward* on the tops of mountains. Many did so and were left stranded there until now. It is in this way that we now account for the otherwise inexplicable fact that Alpine species in Middle Europe are similar or even largely identical with those in the United States, and both with those now living in Arctic regions. These species were widespread all over Europe and United States in Glacial times; and while some of them afterward went northward to their present home, some in each country sought Arctic conditions in Alpine isolation. This explanation, which has been long recognized for plants, has been recently applied by Mr. Grote, also to Arctic insects found on the top of Mt. Washington and the mountains of Colorado.*

Undoubtedly changes of climate during this time enforced similar migrations among mammals also. But it is evident that while plants and invertebrates might endure such changes of climate and such enforced migrations with little change of form, the more highly organized and sensitive mammalian species must be either destroyed or else must undergo more profound changes. Moreover, the opening of land-connections between regions previously isolated by barriers would be far more quickly taken advantage of by mammals than by invertebrates and plants. The migrations of plants are of necessity very slow, i. e., from generation to generation. The migrations of mammals too, so far as they are *enforced* by changing climate, are of a similar kind; but the voluntary migrations of mammals *permitted* by removal of barriers may take place much more rapidly—even in a few generations. This introduces another element of very rapid local change, viz: the *invasion* of one fauna by another equally well adapted to the environment, and the struggle for life between the invaders and the autochthones.

For example: in America during the Glacial epoch, coincidently with the rigorous climate, there was an elevation of the continent, greatest in high latitude regions, but also probably greatest along the line of the Mississippi River; for in this region it extended southward even to and beyond the shores of the Gulf. Professor Hilgard has shown that the elevation at the mouth of the Mississippi River was at least 450 to 500 feet above the present condition. Until the Glacial times the two Americas were certainly separated by sea in the region of the Isthmus, as shown by the Tertiary deposits there. This barrier was removed by upheaval during the Glacial epoch,

* This application, with reference to Mount Washington and other Arctic insects in America, was previously made by Prof. A. S. Packard, Jr., in the Memoirs of the Boston Soc. Nat. Hist., i, p. 256, 1867.—Eds.

and a far broader connection existed *then* than now. Through this open gateway came the fauna of South America, especially the great Edentates, into North America. Similarly a broad connection then existed between America and Asia in the regions of the shallow sea between the Aleutian Isles and Behring Straits. Through this gateway came an invasion from Asia, including probably the Mammoth. With this invasion probably came also Man. It seems probable, therefore, that the earliest remains of man in America will be found on the Pacific coast.

Also the great Pliocene Lake, which stretched from near the shores of the Gulf far into British America, and possibly into Arctic regions, and formed a more or less complete barrier to the mammalian fauna east and west, *was abolished* by upheaval, and free communication was established. It is impossible that all these changes of climate and all these migrations, partly enforced by changes of climate and partly permitted by removal of barriers, and in this latter case especially attended with the fiercest struggle for life, should not produce rapid and profound changes in the mammalian fauna.

In Europe the process has been more accurately studied and is better known. In Quaternary times at least four different mammalian faunæ struggled for mastery on European soil. 1. The Pliocene Autochthones. 2. Invasions from Africa by opening of gateways through the Mediterranean—one by way of Italy, Sicily and Malta, and one by Gibraltar, both of which have been again closed. 3. Invasions from Asia, by removal of a great sea-barrier connecting the Black and Caspian with the Arctic Ocean. This gateway has remained open ever since. 4. Invasions from Arctic regions enforced by changes of climate. Probably more than one such invasion took place: certainly one occurred during the second Glacial epoch. The final result of all these climatic changes and these struggles for mastery was that the Pliocene Autocthones, adapted to a more genial climate, were mostly destroyed or else driven southward with some change into Africa; the African invaders were driven back also into Africa, and with some Pliocene Autocthones isolated there by subsidence in Mediterranean region closing the southern gateways, and still exist there under slightly modified forms; the Arctic invaders were again driven northward by return of more genial climate, and there remain to this day; while the Asiatics remained masters of the field, though greatly modified by the conflict. Or perhaps more accurately we might say that the existing European mammalian fauna is a resultant of all these factors, but the controling factor is the Asiatic. With the Asiatic invasion came man, and was a prime agent in determining the final result.

Thus, regarding the Tertiary and the Present as consecutive Eras and the Quaternary as the transition or critical period between; then, if the record of this period had been lost, corresponding with the unconformity here found, we should have had here an enormous and apparently sudden change of mammalian species. Yet this change of fauna, as great as it is, is not to be compared with that which occurred between the Archaean and Paleozoic, or between the Paleozoic and Mesozoic, or even that between the Mesozoic and Cenozoic; for the change during the Quaternary is mostly confined to species of the higher mammals, while the change during previous critical periods extended to species of all grades: and not only to species, but to genera, families, and even orders. We conclude, therefore, that *the previous critical periods or lost intervals were far longer than the whole Quaternary; or else that the rate of evolution was far more rapid in these earlier times.*

To sum up then in a few words the general formal laws of evolution-change throughout the whole history of the earth:

1. Gradual, very slow changes of form everywhere under the influence of all the factors of change, known and unknown—e. g., pressure of changing physical conditions whether *modifying the indiviaual*, certainly one factor, or *selecting the fittest offspring*, certainly another factor; improvement of organs by use and the improvement inherited, certainly a third factor, and perhaps still other factors yet unknown. This general evolution by itself considered would produce similar changes everywhere, and therefore would produce geological faunæ, but not geographical diversity. Determination of a geological horizon would in this case be easy, because fossil species would be identical everywhere.

2. Changes in different places and under different physical conditions taking different directions and advancing at different rates, give rise to *geographical faunæ.* This, if there were nothing more, would produce far greater geographical diversity and more complete localization of faunæ and floræ than now exists; so great that the determination of a geological horizon would be impossible.

3. The forces of change resisted by heredity, in some species and genera more than others, determines paroxysms of more rapid movement of general evolution affecting sometimes species, sometimes genera or families. The sudden appearance of species, genera, families, etc., in quiet times is thus accounted for.

4. *During critical periods*, oscillations of the crust, with rapid changes of physical geography and climate, determine a more rapid rate of change in all forms, 1st, by *greater pressure of physical conditions*, and, 2d, by *migrations* partly enforced by

the changes of climate and partly permitted by removal of barriers, and the consequent *invasion* of one fauna and flora by another and *severe struggle* for mastery. This would tend to *equalize again* the extreme diversity caused by the second law; but the effect would be more marked in the case of animals than plants because voluntary migrations are possible only in this kingdom. Hence it follows that *a geological horizon is far better determined by the fauna than by the flora.*

III. *Historic value of the Present time.*—Most geologists regard the Present as one of the minor subdivisions of the Cenozoic Era, or even of the Quaternary period. More commonly the Quaternary and Present are united as one age—the age of man—of the Cenozoic Era. The Cenozoic is thus divided into two ages; the age of mammals commencing with the Tertiary, and the age of man commencing with the Quaternary; and the Quaternary subdivided into several epochs, the last of which is the Present or Recent. But if the views above expressed in regard to critical periods, be correct, then the Present ought not to be connected with the Quaternary as one age, nor even with the Cenozoic as one era, but is itself justly entitled to rank as one of the *primary divisions* of time, as one of the great eras separated like all the other eras by a critical period: less distinct it may be, at least as yet, in species than the others, the inaugurating change less profound, the interval less long, but dignified by the appearance of man as the dominant agent of change, and therefore well entitled to the name *Psychozoic* sometimes given it. The geological importance of the appearance of man is not due only or chiefly to his transcendent dignity, but to his importance as an agent which has already very greatly, and must hereafter still more profoundly, modify the whole fauna and flora of the earth. It is true that man first appeared in the Quaternary; but he had not yet established his supremacy; he was still fighting for mastery. With the establishment of his supremacy the reign of man commenced. An age is properly characterized by the *culmination*, not the first appearance, of a dominant class. As fishes existed before the age of fishes, reptiles before the age of reptiles, and mammals before the age of mammals, so man also appeared before the age of man.

We, therefore, regard the Cenozoic and Psychozoic as two consecutive eras, and the Quaternary as the critical, revolutionary or transitional period between. But since the record of this last critical period is not lost and we must place it somewhere, it seems best to place it with the Cenozoic Era and the mammalian age, and to commence the Psychozoic Era and age of man with the completed supremacy of man, i. e. with the Present epoch.

Berkeley, California, March 15, 1877.

Art. XVII.—*Notes on the internal and external structure of Paleozoic Crinoids*; by Charles Wachsmuth.

The structure of fossil Crinoids has occupied the attention of many able writers, and numerous ingenious and plausible theories have been advanced to demonstrate the physiological functions of the various parts of their complicated organization. The results of investigations heretofore made have been by no means harmonious, and newly discovered evidence renders many of these theories wholly unsatisfactory. I have been favored with unusual facilities for obtaining accurate knowledge upon many of the questions involved in these researches, and therefore hope that I may contribute useful information on the subject. The collections of eighteen years at Burlington, Iowa, have brought to light material, unrivaled elsewhere, for this study. I have obtained upwards of four hundred species of Crinoids at that locality, many of the specimens in such a condition, that not only the whole calcareous skeleton of the animal, but even the most delicate internal organs are preserved almost as perfectly as in those dredged from our present seas. Careful observations, extending through many years, and study of this material in connection with extensive collections from other formations, have enabled me to add to the present knowledge of these forms many interesting and important facts, and have led me to conclusions which I present in the following pages.

1. *The mouth and the tubular skeleton below the vault.*

The apparent absence of a mouth has proved to be one of the most perplexing points in the investigation of the structure of Paleozoic Crinoids. In all Radiates (even of the most inferior groups), this organ is located invariably *at one end of the vertical axis*, although that axis or center is not always the center of figure. It occupies in the recent Crinoids the upper end of this axis, but in many at least of the Paleozoic Crinoids, the portion of the summit, where from analogy, we should expect to find the oral aperture, is perfectly covered by solid and immovable plates. The only aperture in connection with the visceral cavity is lateral or subcentral, placed outside of the radiation and within the interradial area, where, from analogy, we must expect to find the anus. If, as Mr. Billings,* Dr. White† and the older writers on Crinoids supposed, this aperture served both as mouth and vent, so that these Crinoids took in their food through the anus, this stands as the sole

* This Journ., 1869, vol. xlviii, No 142, p. 69.
† Journn. Nat. Hist. Boston, 1862, vol. vii, No. 4, p. 481.

exception to the rule governing the class. It is true, the Ophiurans, for instance, have no separate anal opening, and the same aperture performs both oral and anal functions, but it is placed within the radial center and therefore cannot be homologized with the interradial orifice of Paleozoic Crinoids. In *Antedon rosaceus*, although the nascent Crinoid develops already within the pseudembryo a separate mouth and vent, a single orifice serves for some time both as oral and anal aperture, yet it is the permanent mouth occupying the center of the ambulacral system.* While we thus find the mouth performing permanently or temporarily anal functions, we have on the other hand no evidence either from recent nature or from embryology that an anus ever becomes developed into, or performs the office of, a mouth.

The Crinoids of our present seas live exclusively on microscopic food, and we must expect to find that the Paleozoic Crinoids subsisted upon very similar food and had a very similar mode of alimentation. Whenever in *Antedon* alimentary particles fall upon the furrows of the arms or pinnulæ, they are transmitted downward along these furrows to the mouth wherein the furrows terminate. Dr. Carpenter remarks on this subject:†

"The transmission of alimentary particles along the ambulacral furrows is the result of the action of cilia with which their surface is clothed. Although I have not myself succeeded in distinguishing cilia on the surface which forms the floor of these furrows, yet I have distinctly seen such a rapid passage of minute particles along their groove as I could not account for in any other mode, and I am therefore disposed to believe in their existence. Such a powerful indraught, moreover, must be produced, about the regions of the mouth, by the action of the large cilia which fringe various parts of the internal wall of the alimentary canal, as would materially aid in the transmission of minute particles along those portions of the ambulacral furrows which immediately lead toward it; and it is, I feel satisfied, by the conjoint agency of these two moving powers, that the alimentation of Antedon is ordinarily effected."

It appears from these observations, that the mouth of Antedon has no special functions as such, but is merely a receiving center or general passage, into which the food which accidentally falls in contact with the furrows of the arms or pinnulæ, enters; a passage which might as well be external, hidden beneath a vault, as open to the surrounding element, pro-

* Sir Wyville Thomson, Phil. Trans. of the Royal Society.

† Researches on the Structure, Physiology and Development of *Antedon rosaceus*. Part I, by W. B. Carpenter, M.D., F.R.S., Phil. Trans. Roy. Soc., vol. clvi, Part II, 1866.

vided the food could be brought in contact with it. The large cilia on the inner wall of the alimentary canal, which Dr. Carpenter describes as being capable of producing such a powerful indraught to the region of the mouth, afford, it seems to me, also a very satisfactory explanation of the mode by which the transmission of food was effected in Paleozoic Crinoids. How much more powerful must have been the effects of these cilia in individuals, in which mouth and furrow were arched over and in which the current was unobstructed from without. Considering, further, that probably the covered parts of the food channels themselves were fringed with cilia of similar functions, it could have been of but little moment how remote from the mouth the food entered. We find another most striking example in confirmation of this supposition in *Hypomene Sarsi* Lovèn, a recent Cystidian, indicating in analogy with recent nature that Crinoids had the mouth sometimes internal. Prof. Lovèn found in the covered parts of its channels microscopic Crustacea, larval bivalves, and other remains of the food of the animal, apparently taken through the open parts of the channels. Applying this observation to Paleozoic Crinoids it seems very probable that their food was taken up along the open parts of the arms or pinnulæ, and conveyed through the closed parts to the concealed mouth.

Dr. Ludvig Schultze, in his excellent "Monograph on the Echinoderms of the Eifel, Vienna, 1867," was, so far as I know, the first author, who suggested the idea, that all Crinoids which are covered on their ventral side by solid plates, and have but one orifice, were provided with an internal mouth. He further suggested, that the food was conveyed by the open food groove to the inner cavity through the arm-openings at the base of the arms, by means of subtegminal channels along the inner surface of the vault.

Dr. Lütken, fully confirming Dr. Schultze's observations, gives a full description of the ducts and subtegminal galleries, and compares these with the covered food grooves in *Hypomene Sarsi*, expressing the opinion, that the galleries underneath the summit, which he considered to be closed at the bottom and thus transformed into ducts, were food passages.

Meek & Worthen describe and figure in the Illinois Geological Report, vol. v, from my former collection, now in the Museum of Comparative Zoology at Cambridge, several specimens of well-preserved digestive organs, and also an *Actinocrinus proboscidialis*, in which a skeleton of tubular canals proceeds from a point below the central axis of the vault, to the arms. There are in that specimen five main tubes which bifurcate midway toward the arm bases, each division bifurcating again, sending a branch to each one of the twenty arms of that species. The main tubes and branches are constructed on their lower side of alternating plates, upon which on either side, a second row of minute quadrangular interlocking plates is attached, longitudinally arranged, thus covering the tubes. The upper rows of plates are not preserved in this specimen, but I have found them in two specimens of *Strotocrinus*, which I obtained recently, in which they are well preserved and in place. The condition of the specimen, as Meek & Worthen remark, leaves but little doubt, but that the tubes form through the arm-openings of the calyx a continuation of the arm furrows. In removing parts of the vault, I unfortunately broke the upper part of the fragile skeleton, but enough is preserved to prove that the five main tubes did not connect directly with each other, but communicated at their upper end separately, as it seems, with an annular vessel of which traces are yet preserved. Such a vessel was found in wonderful preservation in a specimen of *Actinocrinus Verneuilianus* Shum. The radiating canals were here not preserved, but the little openings, through which they communicated, are plainly visible in the circular organ. There are, at the lower side of the ring, which is composed of minute interlocking plates, five other small openings, which, alternating with the former ones, were apparently in connection with organs of the interradial system (communicating perhaps with a circulatory system). The whole upper part of the stomach is here placed within the ring,—differing in this particular from *Actinocrinus proboscidialis*, in which only a spiral alimentary tube passes out from the interior of the convoluted digestive organ. The several tubes of the skeleton, though closely following the direction of the vault, but without touching it, are placed here within some obscure furrows along its inner surface.

Such furrows in the vault can be observed in many Paleozoic Crinoids. They are either elevations of the vault itself or are formed by ridges or partitions on the inner surface, which are always deepest toward the anal side. The grooves are sometimes closed underneath, particularly in very old specimens, thus forming regular ducts or tunnels. Their arrangement seems to be similar in all these Crinoids, no matter whether the species has a subcentral proboscis or merely a lateral opening, they always diverge from a plane on the inner wall of the vault, in front of the anus, and branch to the arm openings.

For further information on this subject, I will now call attention to some most excellent natural casts, mostly of Actinocrinidæ, which I obtained from cherty layers of the Upper Burlington limestone. The outer shell or limestone test was generally attached when I found them, but so much decayed, that it was removed by the least touch. The substance of which the casts are formed appears to have been a fine silicious mud which could penetrate the smallest pores. The internal organs are of course not preserved, but their impressions at the surface of the casts throw much light on the structure beneath the vault. The center of radiation appears here a small pentagonal, rounded, or in species with strong subcentral proboscis, subtriangular or even heart-shaped space or plane, enclosed by a deep groove, from which, in some of these specimens, elevated ridges, alternating with depressions, pass out toward the arms; but before quite reaching them, there proceeds, from below the ridges of the casts to every arm, a smaller ridge which clearly indicates the tubular canal, as described in *Actinocrinus proboscidialis.* The casts are so perfect that I can even detect at some places the impressions of the alternating minute plates of the tubes.

The casts are easily understood, if we remember that the broader ridges are impressions of the grooves in the vault, and that the depressions correspond to the partitions which formed the grooves. The radiating tubes, where they do not appear in the casts, were evidently placed at some distance from the vault, and therefore enveloped and obliterated by the material forming the casts; but on approaching the arm-bases, they closely underlie the test, and their counterparts are preserved.

I have already mentioned in the casts a pentagonal space, surrounded by a furrow, as being the center of radiation. It is located anterior to the proboscis, occupying a central or nearly central position. The middle of the space is occupied frequently either by a small opening or by a little cone indicating an aperture leading toward the inner cavity, but in these casts the aperture is isolated, and there appears on the surface no connection with the annular groove surrounding it. To understand this structure it becomes necessary to examine first some other casts from the same locality, mostly of *Strotocrinus* and *Actinocrinus*, but also several of *Batocrinus*, though of different species from those which I have just described. These casts have no annular groove, and the radiation which is marked by elevated rounded ridges, almost like strings overlying the surface, proceeds from *a point in the center where I noticed the little aperture* in the former casts. The strings diverge toward the arm-bases in the same manner as the tubular canals; they are stronger toward the center, decreasing in size with each bifurcation. That these ridges are remains of muscular cords is not probable from the perishable nature of such organs, and they are not their casts, or they should have left depressions in place of elevations. They can only be casts of passages which communicated with the central aperture, and which were evidently yet preserved when the siliceous mud, forming the casts, penetrated the body, but, their calcareous parts becoming in the course of time decomposed, a cast was left only of their inner channel, and this explains their string-like appearance. The little central aperture, located at the upper end of the vertical axis, occupied on the casts, and hence below the vault of these Crinoids, exactly the same position that *the internal mouth of Antedon occupies at the peristome*, while the position of the string-like ridges (in case they represent passages as I can hardly doubt), is analogous with that of the *open food grooves* of recent Crinoids.

The annular groove on the casts is probably an impression of the annular *vessel* of which the calcareous parts have decomposed. This organ, in the fossil state, heretofore only observed in the case of *Actinocrinus Verneuilianus*, existed undoubtedly in all Crinoids. That we find no trace of it in some of the casts is no proof to the contrary; it may have been sometimes composed of more perishable material and was not preserved, or situated at a greater distance from the vault and covered by the substance of which the casts were formed.

2. *The ventral furrow of the arms.*

The arms of Palæozoic Crinoids manifest great diversity in outer form and structure, but are invariably provided with a ventral furrow, which continues from the arm bases up to the tips of the arms and along the pinnulæ. The pinnulæ spring out alternately right and left from the arm-plates, their furrows connecting with that of the arm and forming in fact a continuation of the same.

The furrow appears, in specimens in ordinary preservation, as a simple groove, which communicates through the arm openings with the inner cavity of the body. Only in rare instances, has the furrow been found covered by minute plates, whose construction however has heretofore not been ascertained. The best specimen of this kind, that I have seen, is a *Cyathocrinus malvaceus*, in which the little plates above the furrow can be studied in all their details, with the greatest precision. The specimen is the property of Frank Springer, Esq., who had the kindness to leave it with me for investigation and description. The arms of Cyathocrinus are composed of long slender joints with a wide ventral furrow. They bifurcate frequently, each branch bifurcating at intervals again. There appears on the arms of *Cyathocrinus* no scar for the attachment of pinnulæ, and as these appendages have never been observed in the genus, it is probable that the many little branches performed their functions. In Mr. Springer's specimen the plates above the furrow consist of two rows of minute pieces, on either side, the inner rows of which join in the middle, interlock with each other, and form an apparently solid covering. The outer plates which are attached to the arm-joints are toward the upper end of the arms placed partly upon the edges of the joint, but nearer the calyx rest wholly against the edges of the upper part of the ventral furrow. They are longitudinally arranged, partly hidden from view by the inner plates. The visible part is quadrangular, with a narrow tooth-like projection toward the lower end of each plate, which is directed inward and slightly downward as a sharp, elongated process, and forms a support for the inner plates. The inner plates are elongated triangular, resting with their shorter sides against the inner faces of the outer series, and, between the tooth-like extensions, overlapping them with their beveled lateral edges, in such a manner that each plate exteriorly fits in and fills the space between each pair of similar triangular plates on the other side. The two longer sides interlock with corresponding sides of similar plates of the opposite row, their sharp angles or apices meeting the sutures between the opposite quadrangular plates. At each of these points of juncture, just beyond the apex of each triangular piece, on either side of the furrow, there is a little pore, which evidently communicates with the inner channel. There are six sets of plates to each arm-joint, all the plates being imbricated from the lower side upward,—that is, the lower ones lap slightly the edges of the upper ones —thus facilitating the movements of the arms.

In describing the skeleton below the vault, I suggested that the tubes were a continuation of the arm furrows. A transverse section of the arm, examined with the aid of a good magnifier, shows that the tubes themselves were, at least in this species, continued along the arms to their tips, and rested within the arm-furrow, with their sides closely attached to the upper edges of the arm-joint. The tubes do not touch the floor of the arm-grooves, but leave a good sized subtriangular channel underneath. The small plates, above described, form the upper or outer wall of the tube, and two sets of small plates enclose it below. The position of the two upper sets of quadrangular pieces is nearly erect, leaning inward, the triangular cross-pieces lying horizontally, thus forming a regular tube or tunnel with a nearly round channel.

I was at first of the opinion, after examining Mr. Springer's specimen, that the arm-furrows of Paleozoic Crinoids were permanently covered by solid plates, like the ventral side of their cup, but upon comparing these arms with those of a specimen of *Cyathocrinus viminalis* in my own collection, I became fully convinced, that the inner plates could be opened or shut at will by the animal. The arms of my specimen are spread out, their ventral furrows are open, the quadrangular pieces in place, their tooth-like extensions stand out like the teeth of a saw, and are so arranged that the indentations face the salient angles of the opposite side, thus giving to the furrow a strongly zigzag appearance.

The tooth-like processes in this species are so prominent, that from their similar form, and before I had recognized this peculiar structure in Mr. Springer's specimen also, I at first took them for the triangular cross-pieces, but on closer inspection I found no sutures between the projections and the quadrangular portions of the plates; and as the place of attachment for the triangular pieces is plainly visible, there can be no doubt but that these plates were not preserved in the specimen. Furthermore, as the quadrangular pieces are with slight interruptions found on all the arms of the specimens most beautifully preserved, it seems almost impossible to understand how the triangular pieces could have fallen out, if they had been fastened solidly to the adjoining plates. Supported by the tooth-like projections, and resting against the edges of the quadrangular plates, they were evidently better protected than the outer pieces, and it seems to me their destruction would have involved that of the entire covering. I therefore believe these plates were not firmly attached in the living animal, but merely leaned against each other as well as upon the tooth-like projections, being only attached to the inner edge of the quadrangular plates by muscular or interarticular substance, and that they were, in analogy with similar plates in recent Crinoids, movable. This seems further confirmed by the construction of the plates themselves, and especially by the manner of their attachment. The inner edges of the quadrangular plates (between the projections), being slightly convex, they rested in regular sockets which facilitated their opening in an outward direction. In case these plates, as I can no longer doubt, could be opened or closed, it seems reasonable, that they were open in my specimen when the animal died, or they otherwise would have been preserved.

The position and construction of the inner channel proves most satisfactorily and in analogy with recent Crinoids, that it contained the *food-groove* which conveyed the food through the arm-openings beneath the vault to the oral aperture. The small movable plates are evidently homologous with the "*saumplatten*" of Antedon, and the imbrications of these plates, as well as of the entire covering, seems to hint at the conclusion, that the furrow was always closed when the arms were folded up as in Mr. Springer's specimen; but that on the contrary, as in my specimen, the furrow was open when the arms were spread, and that in this position the animal took in its food.

In describing the covering of the furrow, I have already mentioned the presence of two rows of small pores located at the angles of the triangular pieces. There is nothing to indicate that these pores were sockets of pinnulæ, and if they were, the "saumplatten" could not have opened. From their position I infer they were passages for tentacles connecting with parts of the inner tube. If this is correct, it seems to me, there must have been located within the tube a passage in connection with the ambulacral system, since the tentacles form a part of it. This is evidently the case. In a transverse section of the arm, with the help of a magnifier, I think I have detected within the tube, traces of two passages: *a deep groove* occupying only the median region, and on each side of it *a small canal*, underlying the pores. The condition of the specimen does not enable me to say whether the two side passages connect at the bottom or not, but in either case, they undoubtedly represent *the ambulacral canal*, the food-groove occupying only the median and upper part of the channel.

It is to be regretted that in no instance the upper part of the tubular skeleton has been found in perfect preservation. There has been observed beneath the vault an annular vessel, constructed of plates similar to those of the radiating tubes, with small openings directed toward the radial sides of the specimen, with the alimentary canal passing through the inner space of the ring, but its connection with the surrounding parts was not preserved. The position of the annular organ in the center of radiation leaves but little doubt that it is *the æsophageal ring* or *center of the ambulacral system.* The great similarity in the construction of its plates, the presence of openings corresponding to the direction of the tubes, indicates most strongly that the tubes and the circular organ were connected, and that the ambulacral canal, which I recognized in the lower passage of the arms, communicated with the pores. But, as seen from the casts, there proceeded below the vault from the arm-bases to the center, another series of passages, which passing the region of the annular vessel, unite in the center. I hold these to be a continuation of the food-grooves in the arms, which evidently passing over the top of the circular organ terminated within the central orifice.

The position of the æsophageal ring seems at first sight to be not quite in harmony with recent nature; this organ, which in all Echinoderms with an external mouth, is attached to the inner side of the test, is located in Paleozoic Crinoids at a distance from the vault. However, considering that the aboral vault cannot be homologized with the oral skin of recent Crinoids, and that only the tubular skeleton corresponds to the radiating passages connecting with the peristome, the vault thus forming a mere covering, we shall find the position of the circular organ perfectly harmonious with that of all other Echinoderms.

I have mentioned already that there exists in the arm-groove of *Cyathocrinus*, beneath the tube and at the bottom of the furrow, another canal, as large or larger than the channel of the tube, whose functions are unknown. It was, apparently, through the bottom of the arm-openings, connected with the perivisceral cavity of the calyx and may have served for several offices, containing perhaps also the cœliac canal.

Dr. Schultze, in his "Monograph on the Echinoderms of the Eifel," p. 17, gives a most excellent description of the arm-furrow in *Cupressocrinus*. He found two sets of plates covering the furrow like a roof, and asserts, that the inner pieces could be turned back in the living animal. I had overlooked this in making out my descriptions, but it was pleasing and highly satisfactory to me to find that we both had arrived independently at the same conclusion. The construction of the arm-furrow of *Cupressocrinus* is very similar to *Cyathocrinus*. In a section of the arm of this genus, I readily distinguished, by transmitted light, the food-groove, which has a narrow and deep outline, a canal on both sides of it, and I have but little doubt but that the arm-furrows were similarly constructed in all Palæozoic Crinoids.

3. *The alimentary canal.*

Meek and Worthen publish in the Geological Report of Illinois, vol. v, most excellent descriptions and figures of an organ which occupies the greater part of the visceral cavity of Paleozoic Crinoids; they call it from its position in analogy with other Echinoderms "*the digestive organ.*" It is a large convoluted body, resembling in outer form and outline the shell of a Bulla, with a longer vertical axis, and open at both ends. The upper end is placed below the center of the ventral disc, the lower one directed toward the column, dilated above, contracted below, coinciding with the inner space of the visceral cavity to the walls of which it stands nearly parallel. In some cases it is subcylindrical and slightly truncate at both ends.

The organ is constructed of a great number of very minute pieces or bars with intervening meshes, but its delicate texture is but seldom observed, owing to the presence of incrustations of calcareous or siliceous matter which fill up the meshes, and give to the structure a rather dense appearance.*

* To these incrustations which are evidently deposits from the water, we owe in a great measure the preservation of these delicate organs, and as they are comparatively thicker in adult specimens, they seem to have accumulated already during the life of the Crinoids, and may have caused in many instances their death.

The convolutions are directed outward from left to right, varying in number from two to four in different species. Judging from external appearance only, the convoluted walls of the organ appear as mere partitions leading to the inner chamber of a bulla-shaped body. This however is not the fact. Examining the so-called walls in some transverse sections, I find them to be coiled, without touching each other at any point, and composed of two distinct partitions, placed side by side and closed at the edges, thus proving that the apparent walls are the coiled organ itself. According to this, the digestive organ consisted of a long flattened canal, rounded at the outer side, widest in the middle, tapering rapidly at both ends to a rather heavy flattened tube, the outer end ascending spirally toward the top of the visceral cavity, making two or more turns, while the inner one, winding in a spiral way around its own axis, passed upward to near the center of the dome.

In a specimen of *Actinocrinus* in which the digestive organ is apparently perfect, though showing the usual rough appearance, I succeeded in removing at one side the two upper convolutions, in such a manner that the detached parts can be replaced or lifted up for investigation. I had here an opportunity to examine the inner or more properly upper end of the alimentary canal (as distinguished from the outer end or terminal part). The top is unfortunately hidden below some inorganic matter, but enough can be seen to prove that it proceeded evidently from a place below the center of the dome. The organ, where it comes into view, is an elongated tube, which passing downward, widens first gradually to near the middle of the visceral cavity, then rapidly until it acquires the width of at least two-thirds of the entire length of the cavity. The upper end in descending spirally turns from right to left, but on becoming wider curves sharply in the opposite direction and the convolutions are now directed from left to right. The outer end also tapering rapidly and forming a flattened tube, ascends the outside spirally from below all the way up to the top, and I am inclined to suppose, proceeded to the proboscis, being probably analogous with the terminal intestine of the Echini, while the upper end communicated with the food-groove.

Such, with slight modifications, was probably the construction of the alimentary canal of all *Actinocrinidæ*, *Platycrinidæ*, etc., but not that of the genus *Ollacrinus*.* I found the alimentary

* Figured by Cumberland without generic or specific diagnosis or specific name, London, 1826, in the Appendix to Reliquiæ Conservatæ.

Synon.—*Gilbertsocrinus* Phillips, 1836, Geol. Yorkshire, Pl. II, p. 207. *Goniasteroidocrinus* Lyon & Casseday, Suppl. Geol. Rept., Iowa, p. 70. *Trematrocrinus* Hall, 1860, Suppl. Iowa Geol. Rept., p. 70.

As Cumberland's figure is perfectly correct and easily identified as *Ollacrinus* (*Gilbertsocrinus*) *calcaratus*, his generic name "*Ollacrinus*" must be retained according to the laws of nomenclature.

canal partly preserved in *Ollacrinus tuberculosus* Hall, in which it seems to have been composed of the same delicate network, but the organ consists here of a round canal which descends spirally, and contracting gradually, takes at the lower portion of the visceral cavity an upward direction. The upper part of the organ is unfortunately not preserved in this specimen.

4. *The anal aperture and the proboscis.*

The anus of Paleozoic Crinoids is placed always within one of the interradial series, which is generally wider than—and often constructed differently from—the others. The aperture is situated either in some part of the calyx itself, or at the top of a long proboscis. It is a most remarkable fact that genera which evidently belong to the same group, even species, apparently of the same genus, for instance *Strotocrinus*, differ so widely in the construction of this organ. Some having a long massive tube, reaching to several inches above the tips of their arms, while others are provided only with a plain lateral opening without any superstructure whatever.

I do not speak at present of the inflated or balloon-shaped proboscis of *Zeacrinus*, *Cœliacrinus*, *Poteriocrinus*, *Heterocrinus* and similar genera, in which this part is more properly called "*the ventral sac*," as it evidently formed a large portion of the visceral cavity. Its great size compared with the lower cup, the presence of large numbers of small pores, and the position of the anal aperture near the bottom instead of at the summit, seems to imply that the anal apparatus occupied in the internal economy of this sac only a limited space. The inflated sac can accordingly not be homologized with the slender, heavy plated tube of *Actinocrinus*. We can only compare its lateral opening, which is generally placed low down near the arm-bases, with the anal aperture of species in which the anus is located in the ventral disc.

In addition to its regular functions, the proboscis of Palæozoic Crinoids may have had the office of expelling the water from the system. This suggestion looks not unreasonable, if we consider that the solid body of the majority of these Crinoids had apparently no other outlet. I found in one instance the proboscis split open longitudinally, and within its inner cavity a well defined narrow tube, filling scarcely one-fourth of the inner space. This tube may have connected with the terminal intestine which I have described above, and the office of the surrounding canal may have been to eject the deoxygenated water from the body. The fact that some Crinoids were provided with a proboscis reaching beyond the region of the arms, and others with no proboscis whatever but simply a lateral opening, is easily explained, for if the rejected matter were emptied between the arms, it must have come constantly again in contact with the arm currents, which is obviated by either plan. This accounts also for the fact that the proboscis of some species of *Eretmocrinus* is constantly turned to one side. The proboscis formed a natural support for the slender arms, for they are found in most specimens leaning closely against it, while in *Dorycrinus* which has no proboscis, the arms appear always clinging to its long, heavy spines, which are evidently not weapons of defence, as some authors have supposed, but merely a support and protection for the arms.

Dr. C. A. White describes in the Boston Journ. of Nat. Hist., vol. vii, No. 4, p. 489, several specimens in which the proboscis diverges at some distance above the ventral disc into two distinct branches. This may be in some instances the result of accidental development, but is more frequently due to an obstruction of the anal canal. I found a specimen of *Batocrinus longirostris* in which close to the vault the proboscis branches into two equally heavy tubes, and there appears immediately above their junction a strong inflation or kind of abscess. In another specimen, a stoppage or disconnection must have occurred within the body, for a second proboscis was formed at the ventral disc, developed here, as in every other instance, within the anal series or posterior side of the Crinoid. In one remarkable specimen a second proboscis breaks forth even at the lower end of the calyx, just above the basal plates. The pressure against these parts must have been enormous, for it caused the destruction of an entire ray, the plates of which are bulging out, forming together with the anal plates, and intermingled with smaller plates, such as ordinarily compose the proboscis of this species, a large elongated cavity with a rather large aperture. All these instances give evidence of a pressure from within, and indicate that the outside opening of Paleozoic Crinoids was solely an ejective organ, and could not have had oral functions. I have already mentioned that the anus is separated from the radial series by deep partitions at the inner surface of the vault, thus excluding any connection with the upper end of the digestive organ. Moreover, the casts of *Actinocrinus* show that the course of the proboscis is directed toward the posterior side, and the development of the abnormal proboscis occurs invariably in the anal series. It is therefore hardly necessary to argue on Dr. White's supposition that the abnormal second proboscis, wherever it occurs, might have served as buccal orifice, as such a theory is unsupported by analogy.

(To be continued.)

ART. XVIII.—*Chemical constitution of Hatchettolite and Samarskite from Mitchell County, North Carolina;* by OSCAR D. ALLEN, Professor of Analytical Chemistry, Sheffield Scientific School. *Contributions from the Sheffield Laboratory.* No. XLVIII.

I. *Hatchettolite.*

IN an article on the Samarskite of Mitchell County, North Carolina, (this Journal, March, 1876), E. S. Dana described a mineral associated with it as possessing the following properties: Specific gravity, 4·794, crystalline form, regular octahedrons with cubical faces, also the planes 3-3, color yellowish brown, luster resinous, blowpipe characters agreeing closely with pyrochlore. At that time I was able to make only a partial qualitative analysis of this mineral with ·25 gram placed at my disposal by E. S. Dana. The result showed the presence of lime, uranium, iron, a trace of magnesia, tantalic and columbic acid, and probably titanic acid.

In an elaborate paper on American columbic acid minerals, published in this Journal (May, 1877), Professor J. Lawrence Smith has also given a description, accompanied by analyses, of this mineral, for which he has proposed the name Hatchettolite.

Having recently obtained from Mr. L. Stadtmüller a specimen of this new mineral, which he received in a lot of Samarskite sent to him from the locality above mentioned, I have analyzed it, hoping to gain some additional facts bearing on its chemical constitution. The specimen was a large, but imperfect crystal. It was broken into small pieces, and afforded twelve grams of material judged sufficiently pure for analysis. Pieces from different parts of the mass gave the specific gravities, 4·77, 4·84, 4·82, 4·90, 4·76. The results obtained are here presented, Nos. I and II, together with one of the analyses of Dr. Smith, No. III.

	(I.)	(II.)	(III.)
Tantalic acid	29·83	29·60	
Columbic acid	34·24	{ 35·94	67·86
Titanic acid	1·61	}	
Tungstic and stannic acids	·30		·60
Uranium oxide	15·50		15·63
Lime	8·87	8·89	7·09
Yttria and cerium oxides			·86
Iron protoxide	2·19	2·33	2·51
Magnesia	·15		
Potash	*trace**		1·21
Soda	1·37		
Water lost by heat	4·49		4·42
Lead	*trace*		*trace*
	98·55		100·18

* Not separated from soda.

A comparison of these numbers leaves no room to doubt that the same mineral was analyzed by Smith and myself. The sum of metallic acids in No. 1 being 65·68, in No. 2, 65·54, in No. 3 (of Smith) 67·86.* For the separation of tantalic and columbic acids the method of Marignac was used, which may be briefly described as follows. The mixed acids, after weighing, are fused with $HKSO_4$, washed with hot water to remove most of the H_2SO_4, dissolved in hot HFl. One-fourth their weight of $HKFl_2$ is then added. If crystals do not separate on cooling, concentrate to 7 c. c. per gram (of mixed acids) and let cool; K_2TaFl_7 then separates if tantalum is present in the solution. This salt is collected on a weighed filter, washed with cold water till the washings give no longer an orange-colored precipitate with solution of galls. Dry at 100° and weigh; continue the same process with the filtrate and washings, adding new portions of $HKFl_2$. One readily sees when the acicular crystals of K_2TaFl_7 mix themselves with the lamellar crystals of K_2CbOFl_5. Then redissolve the latter and collect the former on a filter. If the weight of both acids is known, Cb_2O_5 may be calculated by difference. On account of the suspected presence of titanic acid in the substance here examined the second crop of crystals of K_2TaFl_7 was redissolved in hot water and recrystallized. No more acicular crystals could be obtained in sufficient quantity to collect. For the same reason the bisulphate fusion of the mixed acids was treated with *cold* water. The filtrate and washing on boiling deposited a light precipitate, which brought into solution and tested with tin gave an unmistakable reaction for titanium. Moreover, after separation of tantalum the columbic and titanic acids remaining in solution were obtained by evaporating with H_2SO_4 and boiling with water and fused with K_2CO_3. Treatment of the fused mass with water left but very little residue, which further examination proved to be mostly potassium titanate.

In analysis No. 1, the two products containing titanic acid, obtained in this way, were fused with $HKSO_4$ which rendered the greater part soluble in cold water. This solution on boiling deposited what was assumed to be titanic acid, after weighing and subjecting to the further tests. It can hardly be expected that a very accurate separation was effected. By boiling ·5 gram of the mineral with H_2SO_4 mixed with a little HFl in a platinum crucible so rapidly as to exclude air decomposition was effected in a few moments. The diluted solution deoxydized an amount of permanganate of potash corresponding in one experiment to 1·90 per cent FeO, in another to 2·20

* Professor Smith remarks, "I refer to the metallic acids in the analyses in this paper as columbic acid from the fact that the tantalic acid which accompanies it is only in small quantities, and also because none of the methods proposed for separating the two acids have given satisfactory results in my hands."

per cent. Iron was therefore assumed to exist as protoxide and uranium as UO_2O. A calculation of the relative number of atoms from No. 1 gives the following:

Atomic weights.			
182	Ta	·134	·386 (Ta, Cb)
95	Cb	·252	
50	Ti	·020	
U 240	UO_2	·054	·268 (UO_2, Fe, Mg, Ca, Na_2)
	Fe	·030	
	Mg	·004	
	Ca	·158	
	Na_2	·022	
	H_2O		·255
	Sn?	·002	

Disregarding the small amount of tin or tungsten and deducting Ti with $\overset{II}{R}$ sufficient to form with it normal titanate, there remain $\overset{II}{R}$ ·248 $\overset{V}{R}$ ·386 H_2O ·255, whence $\overset{II}{R}:\overset{V}{R}:H_2O=2:3{\cdot}1:2$, a ratio closely approximating to that required by $\overset{II}{R}_2\overset{V}{R}_3 2H_2O$ or $\overset{II}{R}_2\overset{V}{R}_2O_7+2\overset{II}{R}\overset{V}{R}_2O_6+4H_2O$, in which $\overset{II}{R}$ represents one atom of a bivalent basic radical or two of sodium and $\overset{V}{R}$, Ta, or Cb. The investigations of Rammelsberg* lead to the conclusions that three columbates (in which Cb may be replaced by Ta) occur in minerals, viz: $\overset{II}{R}Cb_2O_6$, $\overset{II}{R}_2Cb_2O_7$, and $\overset{II}{R}_3Cb_2O_8$, corresponding to phosphates and arsenates; which, singly or combined with each other, with or without titanates., zirconates, thorates, etc., constitute mineral species. Hatchettolite appears to be composed of the first two with a small quantity of normal titanate.† It it perhaps questionable whether there is any significance in the fact that the amount of water present bears a simple ratio to the other constituents.

Some pieces from one side of the specimen from which material for analysis was selected had the specific gravity from 4·60 to 4·70 per cent and were rejected. They lost by ignition 4·97 per cent. Hatchettolite may have resulted from alteration of a mineral having essentially the same chemical constitution, as well as crystalline form, as pyrochlore, an alteration consisting of hydration and removal of alkaline fluorides.

II. *Samarskite.*

Samarskite from Mitchell Co., according to the analysis of the writer,‡ has the following composition:

* Jour. Chem. Soc., vol. xxv, p. 189.

† Rammelsberg (Jour. Chem. Soc., vol. xxv, p. 203) supposes that these three compounds may be isomorphous, and that they exist in the isometric crystalline form in pyrochlore.

‡ Dana's Text Book of Mineralogy, p. 340, March, 1877.

	(1)		(2)		Atomic ratio.	
Columbic acid	55·60	37·81	55·80	37·20	·2754	·3592
Tantalic acid		17·79		18·60	·0838	
Stannic acid		----		0·08	·0005	·4430
Yttria		14·52		14·45	·1896	
Cerium oxides*		4·10		4·24	·0382	
Uranium oxide (VO_2O)		12·63		12·46	·0433	
Manganese protoxide		0·80		0·75	·0106	
Iron protoxide		10·60		10·90	·1513	
Lime		----		0·55	·0100	
Water		----		1·12		
				100·35		

These results do not differ materially from the first published analysis of samarskite from the same locality by Miss Ellen H. Swallow, who found 54·96† per cent of metallic acids of the tantalic group, and expressed a wish that some one might undertake their separation‡ In my analyses, tantalum and columbium were separated by Marignac's method. Water expelled by ignition was collected by a calcium chloride tube. 0·5 gram of the very finely pulverized mineral was completely decomposed by heating with sulphuric acid in a sealed glass tube. The solution, properly diluted, decolorized an amount of potassium permanganate corresponding to 11 per cent of protoxide of iron. A repetition of this experiment confirmed the first result. It may therefore be concluded that no material amount of uranium is present in the lower state of oxidation (UO_2). The relative number of atoms of each element present is calculated from No. 2, uranium being assumed to exist as UO_3 or an oxide (UO_2O) of the bivalent radical UO_2 which it is reasonable to suppose acts as a basic radical with tantalic and columbic acids, as it does with phosphoric and arsenic acids in several natural compounds. $\overset{II}{R}:\overset{V}{R}$ is then 4430 : 3592 = 1·236 : 1 = 4·94 : 4 closely approximating 5 : 4 required by the formula $\overset{II}{R}_2\overset{V}{R}_2O_7+\overset{II}{R}_3\overset{V}{R}_2O_8$.

In chemical constitution this samarskite appears to approach Fergusonite being next to this mineral the most basic of the natural columbates and tantalates. The formula of Fergusonite, deduced by Rammelsberg from a large number of analyses, is $\overset{II}{R}_3(Cb, Ta)_2O_8$.

* The atomic weight of didymium was used in calculating the atomic ratio. This element is readily shown by spectroscopic examination of a solution. Only a minute quantity of cerium is present, the presence or absence of other elements of the cerium group was not ascertained.

† Dr. Smith's analysis, contained in the paper already cited, gave 55·13 columbic acid.

‡ Proceedings of the Boston Society of Natural History, vol., xvii, 424, 1875. See also this volume, p. 71.

ART. XIX.—*On the relations of the Geology of Vermont to that of Berkshire;* by JAMES D. DANA.

[Continued from page 48.]

IN the preceding part of this paper, the unity of the system of rocks occupying the limestone region of the Green Mountains has been demonstrated by reference to facts connected with the geographical arrangement and stratigraphical relations of the formations. One other well-known feature characterizes the belt from north to south, and requires consideration: namely—

3. THE ABUNDANT OCCURRENCE OF IRON.

The existence of iron in the rocks is known mainly from the beds of limonite along the region. This limonite, as is now well known, was made from the rocks *in place*, and hence it is testimony as to what the original rocks contained and still contain where unaltered. Its beds exist in Vermont at so many places that the geologists of the Vermont Survey represented it on their geological map of the State as a continuous band of limonite. And south of Vermont it occurs more or less in each of the towns over the limestone area, and in some of them in deposits of great depth, the most noted being in Richmond and West Stockbridge, Massachusetts; Salisbury and Sharon, in Connecticut; Hillsdale, Copake, Ancram, North East (near Millerton), Amenia, Dover, and Pawling, in New York. In order that this feature of the region may be appreciated, I mention here the more prominent facts connected with the ore-beds. In a general way, and for special localities, the subject has been often treated. The descriptions given in this place have particular reference to the regional characteristics of the beds in the limestone belt, as illustrated by their mineral nature, distribution, and stratigraphical relations; and they have been drawn mainly from my own observations.

(1.) *The mineral nature of the beds.*

Throughout the great limestone area, from north to south, the ore-beds are alike in the nature of the ore, its mode of aggregation, and its association with yellow ochre and clays. Moreover, in most of the beds to the north as well as south more or less manganese is present with the iron. Manganese ore (chiefly pyrolusite and psilomelane) has been observed in connection with ore-beds of the Vermont limestone area in Bennington, Chittenden, Pittsford, Brandon, Middlebury, Bristol; and the Vermont Report adds, "in the vicinity of most of the beds of limestone in the State." It has been observed also in various ore-beds of Berkshire and New York, though less abundantly than in Vermont. An analysis of ore from the Leet ore-bed, West Stockbridge, by Dr. A. A. Hayes, made in 1845, obtained red oxide of iron 76·18, oxide of manganese 5·04, phosphoric acid 2·36, water 10·80, quartz and gangue 3·40 = 98·78.* At the same time, phosphoric acid is very sparingly present; and there is only a trace of sulphur or none at all. The clay, while generally impure from the presence of iron ochre and other mineral material, is sometimes a white kaolin.†

(2.) *The geological distribution of the beds.*

(1.) The limonite deposits are alike throughout the limestone area in their interrupted occurrence and varying depths—even many miles often intervening between those of workable value, and all depths existing from zero to one hundred and fifty feet or more.

(2.) The ore-beds occur in the vicinity of all the rocks of the limestone area,—the limestone, clay-slate, hydromica slate, mica schist, gneiss and quartzyte. But, from north to south along the limestone area, they most abound where the schist is the hydromica slate, and hardly at all where it is common argillyte. The hydromica slate in Vermont prevails over the eastern half of the area, and, in Berkshire and farther south, over the western half; and accordingly the line of maximum ore-beds does not follow the general course of the limestone area, but is a little oblique to it, having more westing to the south. In Vermont it is with few exceptions not far from the western border of the eastern quartzyte range, as we learn from the Vermont geological map; the few exceptions occur near the center of the area, adjoining small central slate ridges, as in Dorset and on the borders of Wallingford and Tinmouth; and at the south end of the State in Bennington. These last are near the Taconic (or Great Central) slate-belt.

In Berkshire, beds exist sparingly in the eastern portion of the limestone area (as in the gneiss and mica schist region of Tyringham); the chief beds are in its *western* half in Richmond and West Stockbridge, a few miles east of the Taconic range. In Connecticut, they closely adjoin the Taconic range in Salisbury and Sharon; while in New York, they occur on

* I am indebted for a copy of this analysis to Mr. J. W. Hoysradt, President of the Company. Mr. Hoysradt states that no later analysis has been made; but he is of the impression that the ore now obtained yields less manganese and phosphoric acid.

† While limonite (in which the oxide of iron, Fe_2O_3, and the elements of water are in the proportion of 2 to 3) is the principal ore, there is also at Salisbury, as first shown by Prof. G. J. Brush (this Journ., II, xliv, 219, 1867), and probably also at other places, the related ore *turgite* (in which the same ratio is 2 : 1), and a little göthite (in which the ratio is 1 : 1); also occasionally a red ochre, which may be either turgite, or the simple anhydrous oxide Fe_2O_3. Besides the iron and manganese ores, there are also traces of cobalt and zinc.

the *west* of the Taconic range, in the towns of Hillsdale, Copake, and North East, besides along its eastern border in Dover, Amenia and Pawling. The axis of the band of maximum ore-beds appears hence to cross the axis of the limestone area in Bennington, Vermont; and to strike the Taconic range south of West Stockbridge, from which point, beds occur on both sides of the range.

(3.) *The stratigraphical relations of the beds.*

The ore-beds, to the north as well as south, occur near the junction of a stratum of limestone with one of hydromica or mica schist, the beds of both having usually a high dip (generally between 40° and 55°); or they have schist on both sides; and sometimes they are cut through by one or two beds of limestone or schist. Quartzyte often lies along the east side in Vermont; but a stratum of schist usually, if not always, intervenes between the quartzyte and limestone.

This geological relation of the beds was recognized, at localities in Vermont, Berkshire, and Connecticut, more than fifty years since, by the late Prof. Chester Dewey, then Professor of Geology and Mineralogy in Williams College, Williamstown. In the fifth volume of this Journal, 1822, in an article on the ore-bed of Bennington, he says (p. 251)—"It has been remarked that the great bed of ore is not *immediately* connected with any rocks. It seems, however, to be associated with limestone rocks, and the whole to lie between two strata of mica slate. It lies in the same [mountain] range with the ore of Salisbury, Connecticut, and has the same range of mica slate lying on both sides of it." The *in situ* position of the ore-beds is here brought out by Dr. Dewey, and a relation to the limestone is suggested. Two years later, in vol. viii, speaking of the ore-beds of Berkshire, he says (p. 30), that the beds "are near limestone, but on beds of clay." And "as mica-slate is found on both sides of them, they must doubtless be considered as lying in this rock, though the clay indicates that they are a later deposit than the rock itself:" in which the limonite beds are made a part of the mica slate, but not an original part.

The facts at many of the ore-pits of Berkshire and New York, as well as Connecticut, sustain the statements of Professor Dewey. The schist often forms part of the walls of the ore-pits, or stands in ledges near by; and when no rock is to be seen, the clays often show that they are the decomposed schist *in place* by their having its schistose structure, its dip and strike, and also its flexures, all corresponding precisely with the stratification of the rock of the region. The schist makes sometimes the eastern wall, and sometimes the western; and it is also found dividing the ore of the beds. Among the

New York ore-beds the relation of the schist is well exhibited in the Weed ore-pit in the town of Copake, and in the ore-pit, a mile and a half to the west of the village of Pawling.

Limestone strata outcrop near or within many of the pits. In Richmond, Mass., at the Cone ore-pit, a steeply dipping limestone stratum forms part of the northwest side; and at the Cheever ore-pit there is an outcropping bed a few yards to the west, conformable with the slate; at the Leet ore-pit, in West Stockbridge, limestone forms a ledge close by the pit. At the Miles ore-pit, in Copake, a bed of limestone was met with cutting through it, having the strike and dip of the region. The Vermont Geological Report states (p. 820) that a limonite bed in Western Bennington reposes on an impure ferruginous limestone, and it alludes to the similar position of the ore in other beds of the State.

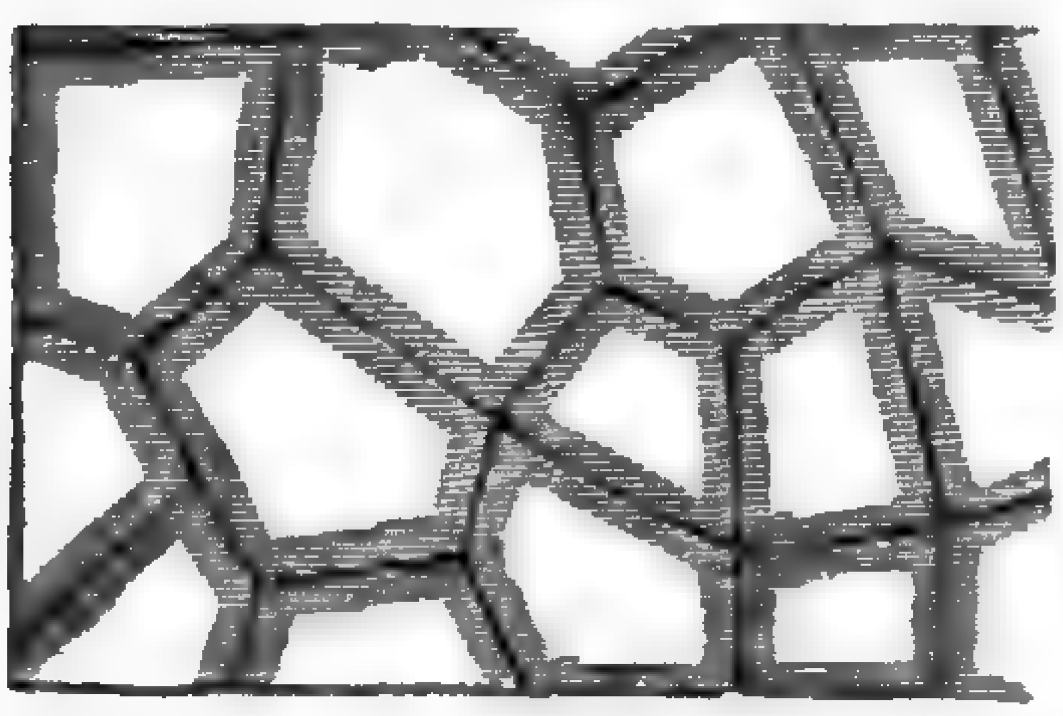
(4.) *The source of the ores and clays.*

Carbonate of iron (spathic iron, or siderite of mineralogy) occurs in masses, in connection with some of the ore-beds; and part of the limestone is ferriferous, that is, either a carbonate of calcium-and-iron, or else, a limestone containing more or less of carbonate of calcium-and-iron. And in consequence of the extremely easy oxidation of the iron of these carbonates, such beds, when air and moisture have access to them, are in all cases undergoing alteration to limonite. In some of the ferriferous limestone manganese replaces part of the iron.

The pure carbonate of iron has been found thus far only in western Berkshire. At the Leet ore-bed, one and a half miles west of the village of West Stockbridge, there projects from the east side of the pit, what is called the "white horse," which is a large ledge of compact light gray spathic iron, of a grayish white color, distinguished as "white ore." It has for many years been quarried and used in the furnace along with the limonite. This "white ore" is so close-grained as to be almost flint-like in aspect, and it evidently owes its preservation from change to this quality, which renders it impervious to water. Wherever there are cracks water and air have entered, and the cracks are widely bordered with limonite. Some pieces have a thin crust of limonite—a quarter to half an inch thick—showing some progress of the alteration even over the harder portions. There are botryoidal prominences of the iron-carbonate in cavities, which seem to be protected from the change by their smooth surface as well as firm texture. This mass of "white ore" is conformable in stratification with the limestone of a hill close by the north edge of the ore-pit; and hence it was probably part of a stratum that has disappeared, over the interval between them, by alteration. I have been informed by Mr. R. Van Buskirk, who is in charge of the mine, that this "white ore" has been taken also from the west side of the pit. There is also an outcrop of limestone in the ore-pit in which some of the layers are changed to limonite, while others above or below are unyielding—the presence of iron in any layers of the limestone (as an iron-calcium carbonate) determining their destruction.

At the Cone ore-pit, one and a half miles north of West Stockbridge, mining is done mostly through shafts; only at the north end is open mining going on so that the structure of the walls can be studied. At this end of the pit, limestone is in view having an eastward dip of 40° to 50°; and while some of the layers are not much altered, others are wholly changed to limonite. At my last visit (in 1875) the work was going on in this stratified material, the limonite portion being selected out for further separation by washing. Several layers had become wholly replaced by pure limonite, and one of those so changed was a yard thick. Some surfaces of the limestone were intersected by cracks, making areas three to six inches across, as represented in fig. 18; each crack having a border of limonite either side, an inch or so wide.

18.



The schist near by—hydromica slate—was in part firm, and in other places turned to soft grayish or yellow clay—an impure kaolin—which was silvery in surface from traces of the original mica of the slate. The quartz veins in the hydromica slate remain of course unchanged, in the ores.

The Cheever ore-bed, in Richmond, has also afforded some massive carbonate of iron, but less abundantly than the Leet ore-bed; and here, as already stated (p. 135), there is a limestone ledge near the pit.

Professor E. Hitchcock mentions the occurrence of massive carbonate of iron in Richmond, in his Report on the Geology of Massachusetts (1841), page 190, and gives an analysis showing that it contains 87·19 per cent of carbonate of iron, 5·21 carbonate of magnesium, 2·46 carbonate of manganese, 1·41 carbonate of calcium, and 2·81 of silica, alumina, etc. =99·08. The particular ore-bed in Richmond affording it is not stated, but it was probably the Leet ore-bed. In the Vermont Geological Report (1868), p. 236, Prof. E. Hitchcock gives an analysis of a dolomite from the vicinity of the Brandon ore-bed which afforded 3·61 per cent of carbonate of iron; and states that east of the bed another limestone was quarried for a flux which contained "10 per cent of iron" [carbonate ?].

The limestone has occasionally a little pyrite disseminated through it; and at one place east of the village of Great Barrington, the amount is large. But no one has reported its occurrence in the limestone about the ore-beds, and I have not myself observed it there. There is certainly not much of it.

The hydromica slate of the region contains several iron-bearing minerals: among them, pyrite (FeS_2) sparingly; pyrrhotite (Fe_7S_8) more sparingly; chlorite, often abundant, both to the north and south; garnet, often abundant in Berkshire and farther south; black mica, to the south; staurolite, rather common in Connecticut, in Salisbury and Sharon. In the decomposition of the schist all the minerals present must have contributed to the iron, for the clays contain none of them. It is probable that the schist where in near contact with the limestone also contained the iron-carbonate; but no positive evidence on this point has been obtained.

The beds all show that their formation was not dependent on erosion or transportation; and that the change to limonite required only the free access of air and moisture (with the traces of carbonic acid they ordinarily contain) to the iron-bearing materials. From some of the mines it appears that the best positions for the making of deep beds was off the mouths of valleys, or near slopes that carried down the rains for underground use. An iron-bearing carbonate would suffer rapid destruction under these conditions.

The facts which have been brought forward show that the ore-beds of Berkshire are essentially the same in nature, distribution and position with those of Vermont. The quality of the ore, the occurrence of the beds at intervals, greater or less, along the course of the limestone area, their stratigraphical relations to the limestone and schist, their origin in the oxidation of iron-bearing minerals present in the rock formations, and the concurrent decomposition of the enclosing rock or rocks—these conditions are alike for the whole area, from its northern end in Monkton, where is the most northern of the associated ore-beds, to the south extremity, near Pawling, N. Y., which place also has its large ore-bed. The facts sustain our proposition as to the geological unity of the formations. The fact that the belt of maximum ore-beds crosses obliquely the limestone area,—being near its eastern border to the north in Vermont, and near its western, west of the Taconic range, to the south,—affords additional demonstration of that unity, and suggests a close stratigraphical relation between the eastern and western sides and their formations.

The iron-bearing minerals include an iron-bearing limestone (carbonate of calcium in which iron replaces part of the calcium) both in Vermont and in Berkshire. The simple iron-carbonate has as yet been found only in Berkshire; but its ready oxidation is a sufficient reason for its not being exposed to view even where it is or has been a prominent source of the limonite.

Most of the points in the preceding view with regard to the origin of the limonite have been recognized by different geologists; and yet the view as a whole is not so well understood that the preceding explanations are superfluous. Professor Dewey seems to have nearly reached it, as shown on page 134, and perhaps he did quite. Professor C. U. Shepard, in his Connecticut Geological Report, published in 1837, page 146, refers the limonite to the oxidation *in situ* of the pyrite and other iron-bearing minerals in the mica or hydromica slate; and he remarks that garnet and staurolites are often present in such proportions in the slates of Salisbury and Sharon as to impart to them a highly ferruginous character. Dr. Percival, his associate in the Connecticut survey, held independently the same view.

In the year 1838, Dr. R. M. S. Jackson, of Pennsylvania, as stated, with commendatory remarks, by Prof. J. P. Lesley,* announced the conclusion, after a study of the iron ores of Nittany valley and other valleys in that State, that "the brown-hematite (limonite) ore of the valleys belonged to the stratified limestone beds, and had been set free by chemical and mechanical decomposition"—making the iron to have *existed originally in the limestone as the hydrated oxide.*

Professor Hitchcock, in 1861, in the Vermont Geological Report, after stating that the limestone contained sometimes ten per cent of carbonate of iron, and referring to the occurrence of iron carbonate in the West Stockbridge ore-bed, mentioned in his Massachusetts Report, says "it is obvious that the limestones may have furnished the whole, or a part, of the iron;" but he further adds that it is probable that "the ore was derived from both the rocks [mica slate and limestone], and possibly also in some cases from the quartz rock." But to this right conclusion is added the old error, that the iron had been taken "from the subjacent rocks and re-deposited in connection with clay, sand and gravel."

The different views of other authors might be here presented if this were the place for a full discussion of the subject.

The change of the hard schists to soft clay is one of the most striking facts observed in the ore-beds. But if the iron was derived mostly from iron-bearing carbonates, a powerful agent of change was present in abundance in the carbonic acid set free by the oxidation. This acid is the most prominent source of the destruction of granite and of the reduction of its feldspar to kaolin; and in the schist it would act similarly, robbing the feldspar and mica of their alkalies, the removal

* Historical sketch of Geological explorations in Pennsylvania and other States. 200 pp. 8vo. Harrisburg, 1876, p. 81.

of which with the addition of water, makes kaolin or a more or less pure clay. Silicates, like garnet, black mica and chlorite, would yield to the same agent, and so give up their iron for oxidation. Sulphuric acid also would have been concerned in the process wherever any pyrite existed, and have aided in the destruction. But the nearly total absence from the ore of sulphur (seldom over one-tenth of a per cent*) appears to be evidence that pyrite played a very subordinate part in the production of the limonite.

It is a question of interest—Whether the iron was in the state of carbonate when the deposits were originally made by sedimentary action, or, whether in some different state, from which it was converted into carbonate as one of the results of metamorphism. The facts on page 133 under section (2) may bear on this question. Where the truth lies it is not important now to enquire. The schists were originally marine mud beds, while the limestones were clear-sea formations, an era of one condition in that region having been followed by an era of the other. Between any two such eras there appears to have been an epoch of long-continued marshes, and, while it existed, drainage-depositions of iron, in some state of composition, took place over the marshes. And this feature characterized the area from north to south, though with great local differences depending on differences in depth of water and position. If the iron was deposited in those marshes as carbonate, this result was no doubt favored by the excess of carbonic acid in the Lower Silurian atmosphere and waters.

One corollary of importance seems to flow from the facts here considered. It is this: that, in some localities, beneath the richest part of a limonite bed in the direction of the dip, there *may be* iron carbonate of inexhaustible extent, and if so the regions will be good for iron ore long after the limonite beds are exhausted.

(To be continued.)

NOTE.—*Professor Dewey's determination, by chemical means, that the Taconic "talcose slate" ("magnesian slate" of Emmons) is mica slate.*—In a note to page 334 of the last volume of this Journal, the Vermont Geological Report is credited with the first announcement that the "talcose slate" of Western New England is mainly a mica slate in which the mica is a hydrous species; and on page 366 of vol. iv (1872) the analyses published in the Vermont Report are cited. It is due to the late Professor Dewey, who in early life worked in chemistry as well as in geology, mineralogy and botany, to state that in the *first* volume of this Journal, published in 1819, in an article on the geology of

* Analyses of the same ores, from similar positions, in Pennsylvania in Frazer's Geological Report, Harrisburg, 1876.

the vicinity of Williamstown, Mass. (Northwestern Berkshire), he observes that the rock of the Taconic range is mainly a "*very fine-grained mica slate*—a rock which had been called 'soapstone slate,' and appeared to be *talcose;*" "but," he adds: "I have been able to detect but a very minute quantity of magnesia in any specimens I have tried, though I obtained a considerable proportion of alumina."

In a later article (vol. viii, p. 8, 1824) he says: "The Taconic Mountain is a huge mass of mica slate." He also uses in the same article the term "talco-micaceous slate" for some portions of the rock, but still holds to the result of his chemical trial that the amount of talc was very small, and that it was strictly mica slate.

ART. XX.—*A proposed new method in Solar Spectrum Analysis;** by S. P. LANGLEY.

No observation of modern Physical Astronomy is more striking in its conception, than that which attempts to determine the motion of a celestial body, by the altered wave-length of its light, and none has attracted more general attention. It is popularly understood, I think, that the proper motion of certain stars in the line of sight, has been thus completely demonstrated, but those particularly engaged in such studies know how far astronomers have till very lately been from the certainty attributed to them. Only last April, Father Secchi presented a communication to the Comptes Rendus† in which he recalled the denial on theoretical grounds, by Van der Willigen, of the possibility of any such observation, pointed out the extreme danger of instrumental error in such spectroscopic work, and gave experiments of his own, to show that its causes were so numerous and so subtle that it was difficult to be certain of any result.

Without discussing the replies, which aim to show that lately precautions have been taken which it may be hoped are effective, it may be observed that there is another mode of investigating the reality of the phenomena, not liable to as many difficulties as in the case of the stars, though presenting a formidable one of its own. I mean, of course, the observation of the different wave-lengths of light coming from the east and west limbs of the sun, which, owing to that body's rotation on its axis, have equatorial velocities that together make up nearly two and one-half English miles a second. This speed, enormous in itself, is most insignificant compared with the velocity of light, and this relative smallness constitutes the difficulty in

* Communicated to the meeting of the National Academy, held in Washington, April, 1877.

† C. R., tome lxxxii, pp. 761–812.

attempting the solution of the problem by means of the sun, for the whole displacement due to it, is (as Professor Young has remarked in illustration), but one-seventy-seventh of the distance between the D lines, or between one-twelfth and one-thirteenth of one division of Angström's scale. Zöllner, Secchi and Hastings have believed that they, nevertheless, detected a change in the refrangibility of the light, and Vogel* using Zöllner's reversion spectroscope obtained a displacement of from ·08 to 0·15 of one of Angström's units. In August last, Professor Young gave the results of his own measurements with one of Mr. Rutherfurd's gratings, showing an equatorial velocity of 1·ᵐ42. Professor Young was unable to find any displacement of the atmospheric lines. This last research† being much more systematic than its predecessors, and given in satisfactory detail, has turned the weight of scientific opinion in favor of the view, that the change due to motion of the luminous body is fairly proven. It can hardly, however, be deemed superfluous to still offer upon so important a question, the results of an independent method of measurement, and one which renders errors from instrumental displacement, on the danger of which so much stress has been deservedly laid, in the sense in which the word is here used, not only unlikely but impossible.

In the course of a research upon the selective absorption of the solar atmosphere, I arranged in 1875, means for comparing homogeneous lights from different parts of the disc. The apparatus was too complex for description here, but it consisted essentially, in the provision of two pair of right-angled prisms of total reflection, so disposed in connection with a spectroscope, that the spectra could be formed side by side, of light from different parts of the sun, and of a photometric apparatus by which the relative intensity of the lights at different parts of these spectra could be compared. The results of this research, with an improved form of the instrument, will I hope be soon ready for publication. It was not intended, primarily, for the comparison of individual spectral lines, for which purpose optical arrangements, not very essentially different, had already been used by Lockyer, Hastings and perhaps others, but the investigation of Professor Young suggested to me another and cognate method of testing the principle of Doppler, to which this apparatus is especially applicable. The theory of the proposed method is very simple. Let two spectra be formed side by side, the one of light from one edge of the sun, the other of light from a point 180° distant. The instrument being in adjustment, if these points be in the neighborhood of the solar poles which are relatively at rest, all the lines

* Beobachtungen auf der Sternwache zu Borhkamp.

† American Journal of Science and Arts, vol. xii, Nov., 1876.

will be continuous in both spectra. But if the instrument is rotated till the light comes from points on the eastern and western sides of the sun, which are in relative motion, not only will the solar lines be discontinuous, in the two spectra; as though the one receiving light from the advancing or eastern side had been slid past its neighbor toward the violet; but any mal-adjustments of the instrument, which simulate this effect, can be with certainty detected by a means to be shortly described. The actual quantity by which we may anticipate from theory that the spectra are displaced, is, as has been observed, extremely small, and to produce the desired result we need not only very great dispersion in the spectroscope, but very delicate workmanship in the cutting and mounting of the prisms which are to bring the light to the slit, and in general it will be evident that more than common skill is to be desired of the instrument maker.

I wish to acknowledge the obligations I am under in these respects to Mr. F. Walther, of Philadelphia, the optician, and to Mr. William Grunow, the maker, of New York. Not to dwell on those difficulties of detail which always come between the conception and its embodiment in practice, I may say that more than six months have passed in experiment and modification till the instrument has attained its present form, in which I have been finally able within the past few days to see my anticipations justified. That it has been possible to me to undertake this research at all at present, is due to Mr. Rutherfurd, who has given me choice specimens of his gratings, which are so generally known and valued, that it is unnecessary that I should describe them.

It is desirable that a very clear mental picture should be present to the observer, of the *amount* of displacement he is to expect, for though it is well that he should be ignorant, if possible, of the anticipated direction, this knowledge of the amount will prevent him at the outset from confusing apparent displacements due to mal-adjustment of the instrument with those to which his attention should be directed.* I have taken advantage of a table prepared by Professor Pickering, showing the

* The following method of statement appears to present material for such a mental picture. In the 3d spectrum of the 17280 line grating the D lines, viewed under the magnifying power most favorable in my instrument to clear vision, appear like two sharply-defined parallel lines $\frac{1}{8}$ inch apart viewed by the naked eye at the distance of 10 inches. One of the units of Angström's scale appears to fill rather more than $\frac{1}{60}$ inch at the same distance. The displacement here due to rotation is as is remarked rather more than $\frac{1}{13}$ or ·08 of a unit, or, referred to the distance of distinct vision, very near $\frac{1}{600}$ of an inch. It is known that we can with the naked eye distinguish $\frac{1}{3000}$ of an inch or less, in the form of discontinuity of two lines on a vernier plate, which is essentially our present case. Owing to defective light and other causes, we cannot do quite this on the sun, as yet, but can still count on detecting by this method a discrepancy of somewhat less than ·03 units, which again is less than half the amount in question.

results of different instruments on the fine lines of the E group, to compare mine with them, and I observe that I can discriminate more, and more delicate lines, with either the 8,000 or 17,000 line grating than observers have been able to do with the most powerful spectroscopes of the common construction. Where Angström, using a grating of Nobert's, has delineated twelve lines, the grating supplied me by Mr. Rutherfurd shows thirty-one, and one of these pairs, though separated by but distances of one-sixth of a unit of Angström's scale, is yet clearly divided. The displacement to be expected from the solar rotation, under favorable circumstances, is about one-half of this, and hence if it exist, it is clearly within the power of the instrument to exhibit, since the two spectra are formed in juxtaposition as nice as that of a vernier plate to its circle, a circumstance under which, as every one knows, the eye judges of the continuity of lines with the most accuracy.

The instrument itself consists of the grating, with a collimating and observing telescope, each of one and one-quarter inch aperture and fourteen and one-half inches focus, with positive eye-pieces magnifying from ten to thirty times. The slit is constructed so that its jaws are bevelled to knife-edges, where they meet, at the outer surface, and these owing to the excellent workmanship, still close so as to admit no light when held up against the sun. Over this slit, with their bases almost in contact with it, and their united edges crossing it at right angles, are the first pair of reflecting prisms. They are cut from the same piece of glass, and so fitted that their junction-line shows no more in the spectrum than a particle of dust, and in fact, the division between the two spectra is with difficulty distinguishable from the ordinary dust lines. The other two prisms slide independently on ways, with verniers reading to thousandths of an inch, permitting them to be put in any part of a solar image of from one and one-half inch, to five inches in diameter. Over them is a hood, carrying a screen, which receives the image projected by the equatorial telescope. This focal image is nearly one and three-quarters inches in diameter, and any two selected portions of it pass through adjustable apertures in the screen. By the construction of the instrument they are equally distant from the optical axis, and in every other optical condition, as far as possible, similar, except as they may differ at their origin in the sun itself. It shows the difficulties of the method of research successfully employed by Mr. Huggins, and at Greenwich, that when the instrument is turned directly on the sun (i. e. so that each spectrum receives light from all parts of the sun's disc), the two sets of spectral lines will not ordinarily be continuous. Theoretically they should be, practically, we find they are not, owing to numerous latent causes of disturbance. A touch on the prisms, a movement of the slit, an adjustment of the eye-piece, will ordinarily disturb one spectrum relatively to the other, by a minute amount. But the whole change we are seeking is of a minuter order still; how then, can we discriminate it with certainty? In our ability to do this lies the advantage of the method I describe, which, granting sufficient dispersive power, makes impossible the instrumental error that has been dwelt on by Secchi and others with justice, as shaking confidence in the result. To see how we are authorized to use this word "impossible," let us bear in mind that the solar spectrum consists of two distinct kinds of lines, one caused by absorption in the solar, the other by absorption in the terrestrial atmosphere. These latter being formed by light from all parts of the sun are independent of its rotation.

The prisms are adjusted, till, on looking on the sun directly, the lines are all continuous in both spectra, then the instrument is put in the telescope and the slit placed at such a position-angle that the light in spectrum A comes from the vicinity of the north solar pole, that in spectrum B from the south. On looking in, we see a very long and narrow spectrum, filled with dark lines and exhibiting the chromospheric lines on both sides. It is divided by what appears to be a fine dust line, in two exactly corresponding parts, and is in reality two distinct spectra, as we see by the opposed chromosphere lines, but as the sources of light for both spectra are relatively at rest, all the dark lines are still continuous. But now (without disturbing any adjustment), revolve the whole 90° about the optical axis passing through the center of the solar image, so that spectrum A is formed by light from the eastern or advancing edge of the sun; spectrum B by light from the western or retreating one. A curious change has taken place. By a very minute but perceptible quantity, spectrum A appears to have been slid past its neighbor, toward the violet end, so that every solar line in the first is "notched" at its junction with the second, while at the same time, the telluric lines are as unaltered as the fixed lines of a micrometer web would be, by moving a scale about in the field. The effect is the same as though the spectra were tangible things, like two engine-divided scales, whose numerous delicate divisions (represented by the solar lines), were all in exact juxtaposition a moment before, and are all now just perceptibly displaced, as when a vernier plate is moved till a coincidence is made at a new stroke on the limb.

Moving the instrument 90° more, we come again into the axial line of the sun, and the coincidence should return: with still 90° more we are again in the equator, but now spectrum A is formed by light from the western edge, and this time it is moved the other way, as if it were a scale which had been slid by a very slight but distinctly perceptible amount toward the *red* end; while still the telluric lines retain their continuity, assuring us that no mal-adjustment has occurred.

It will be admitted that this change is, if real, excellent experimental evidence that the wave length is virtually different in light from the eastern and western limbs, as theory predicts. For, granting that the instrument is mal-adjusted in any unknown way or degree, any *instrumental* cause will affect solar and telluric lines alike, and we may in fact defy ingenuity to suggest an error of adjustment, which will modify one and not the other.

For the sake of clearness, I have assumed that we start with all the lines continuous in both spectra; in practice this condition is not easily assured: commonly some lurking error, will, without especial pains, cause them to appear broken upon a fixed source of light; but we disregard this, and consider, as we bring the instrument into new positions, only the *difference* of displacement of the solar and telluric lines. The simultaneous observations of this difference, in each of two spectra, is the essential condition relied on, not only in theory but in actual work.

It will be remembered that many lines in the spectrum are only seen when the sun is low. These are clearly due to absorption in our atmosphere. Many thousands, as we know, are due to absorption in the sun's atmosphere. There remains a large number of lines not coincident with any we produce at the electrodes of our battery, and always present in the spectrum. Of these we do know that they are either caused by the sun's atmosphere or ours, without always knowing which, for these can only be inferred to be telluric from their growing stronger as the sun sets,* and this, though easily determined in the case of a single line, becomes a task of great labor where we deal with thousands. It is evident, however, that after having used known telluric lines to determine the fact that the refrangibility of solar lines only is altered, we can reverse the process, and classify unhesitatingly hereafter, all lines as telluric which are unaffected by the changes that compel others to betray their solar origin. To merely see these two spectra with clearness, then, is to be enabled to pick out the telluric lines from the others, as though they were mapped before us. They are mapped in fact, and it becomes, under the proper conditions, a matter of simple inspection to determine them.

I hope then, it will not seem too assuming a title, if I speak of this as a new method in solar spectral analysis.

I have only to add, that in all my trials of this method, I have

* Or by experiment on artificial lights viewed through intervening atmospheres.

constantly so arranged each experiment, that I remained in intentional ignorance as to which spectrum came from the eastern, and which from the western limb, until I had determined the point by the different behavior of these solar and terrestrial lines, which I have been able to do thus far correctly in every instance. I believe, in fact, that the effect under proper conditions is so marked that the observer hereafter need not take pains to guard against the unconscious bias of his measurement toward a desired result. I have, in these preliminary experiments, however, thought it necessary to take precautions that no such prepossession, if it existed, might influence me unawares.

I ought to add that the proposed method is considerably limited, not only by the need of very powerful instruments (for these can be supplied), but by the need of very good observing weather, which unfortunately we have not at command when we want it.

Useful tests of the desired condition are the duplication of such lines as 1529 of Kirchoff's scale, and the more celebrated "1474," known as a close double since Professor Young's duplication of it last year.

I have not yet made any measurements of the displacement by this method, which appears to me as thus far described to be less adapted to quantitative results than that already employed by Professor Young, but capable by the use of the micrometer of giving exact numerical data. I ought to add, however, that Professor Rood, of Columbia College, has offered the valuable suggestion, that by the use of a double refracting prism, we can cause the spectra to overlap, thus not only overcoming some mechanical difficulties which I have not enlarged on, but obtaining at little trouble all the advantage of micrometric measurement. I regret that the instrument reached me so late that I have not yet been able to give a trial to this, from which I hope excellent results. Nor have I been able to introduce photography with other contemplated improvements, such as the simultaneous use of both right and left spectra of the same order, thus doubling the displacement; and the use of three reflections instead of two, on each ray before it reaches the slit, thus inverting the portion of each limb under examination, and bringing the very edges of the sun into juxtaposition, instead of a portion somewhat within the edge, as at present.

I have only to add in conclusion, that while the instruments used have been principally those of the Allegheny Observatory, to which institution my services belong, I should have been unable to carry out this research without certain indispensable adjuncts, the expense of which has been defrayed from an appropriation placed at my disposal by the trustees of the Bache fund.

Allegheny Observatory, April 14, 1877.

Art. XXI.—*Note on the Exactitude of the French Normal Fork; a Reply to the paper of Mr. A. J. Ellis;* by Rudolph Koenig, Ph.D.—[In a letter to the Editors.]

An attack, as strange as it was unexpected, has just been made in England upon the exactitude of the official French fork. Mr. Alexander J. Ellis, having found that the notes of a tonometer, composed of sixty-five harmonium reeds, constructed by Mr. Appunn, do not agree with this fork, has considered himself entitled to assert, in a paper published in the Journal of the Society of Arts (May 25, 1877) and in Nature (May 31, 1877) that the normal French fork La_3 gives, not 870 single vibrations, as has been hitherto supposed, but 878 single vibrations. Mr. Ellis, having established the further fact that the forks constructed by me are in perfect accord with the French La_3, does not hesitate to affirm that all these forks, including those even of my large tonometer, which he has probably never seen, and in any event has never examined, are necessarily inexact. Not having at my disposal the instrument used by Mr. Ellis, I confess that I find myself under some embarrassment in stating at once by what error of construction this instrument, in the hands of Mr. Ellis, has given results so extraordinary. Fortunately, I can refer to a letter from M. Helmholtz addressed to Mr. Appunn and published by the latter himself in a paper on the acoustic theories of M. Helmholtz. This letter speaks of an instrument of exactly the same character, and made by the same maker, and sufficiently explains the surprising discoveries of Mr. Ellis. "I have examined your tonometer several times," writes M. Helmholtz to Mr. Appunn, "and I am astonished at the constancy of its indications. I would not have believed that reeds could give sounds so constant as those given by your apparatus, thanks to your method of regulating the current of air. The instrument, it is true, varies a little with the temperature, as do also forks; and hence it can be used for determining the absolute number of vibrations, only when one can work in a room heated by a stove. By the aid of an astronomical chronometer, I have counted the beats, and believe that your seconds pendulum must have been slightly inexact, because, though the number of beats agree very well among themselves, the absolute number obtained is not 240 but 237 to the minute. The temperature, which was rather low during my experiments, may count for something; but even this influence may be eliminated by counting the beats to the end of a major third, which took me a quarter of an hour. In this way I have found for my Paris fork 435·01 vibrations, which agrees to the $\frac{1}{40000}$ nearly with the official number, 435 vibrations."

This letter proves that the entire number of beats in the octave of the tonometer tested by M. Helmholtz was $\frac{237}{60} \times 64 = 252{\cdot}8$, and that its fundamental note was 505·6 single vibrations instead of 512. On comparing this note of 505·6 single vibrations with a fork giving actually 512 single vibrations, Mr. Ellis would find the latter to be 6·4 single vibrations more acute and, without doubt, would consider it as giving 518·4 single vibrations. Now for my forks giving 512 single vibrations he has found 516·7 only, with the tonometer which he used. Whence it would seem that the fundamental note of this latter instrument had become more nearly exact than that of the tonometer examined by M. Helmholtz, since the number of its vibrations is 507·3. This note, however, still remains quite distant from its true value.

The fact that M. Helmholtz succeeded, with an instrument of this sort (and one too, even less perfect than that used by Mr. Ellis) in finding the number of vibrations of the official French fork to be exact, by first determining the correction needed for his instrument, is evidence that Mr. Ellis has neglected to determine a similar correction required for his tonometer. He has too hastily declared that these small tonometers with harmonium reeds are the most perfect and the most exact in existence. It would certainly have been much better if he had first given himself a little practice in the manipulation of acoustic instruments, before having treated so slightingly the results obtained by Lissajous, by Despretz, by Helmholtz, by Mayer, etc., etc., and before seeking to throw discredit upon the labors of a *constructeur* who had no reason to expect so unjustifiable an attack.

26 Rue de Pontoise, Paris, June 5th, 1877.

[NOTE.—In response to our request, Professor A. M. Mayer has furnished us with the following statement concerning the absolute number of vibrations of Koenig's forks. "During the months of March, April and May of 1876, I made many determinations of the number of vibrations of Koenig's UT_3 fork and found that it gave 255·96 complete vibrations in one second at a temperature of 60° Fahr. The following are the separate determinations of that series of which the above number is the mean: (1) 255·95, (2) 255·97, (3) 255·90, (4) 255·92, (5) 256·02, (6) 256·02. The fork's vibratory period is accelerated or diminished $\frac{1}{22000}$ part by a difference of temperature of $\pm$ 1° Fahr."—EDS.]

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Heat of Combustion of Oxygen and Hydrogen in closed vessels.*—THAN has modified the ice calorimeter of Bunsen so as to render it available for determining the heat of chemical action. As a first result with the new instrument—the exploding tube of which he calls a heat-eudiometer—he has obtained accurate determinations of the heat of combustion, in closed vessels, of electrolytic gas. Since, hitherto, according to him, this term has not been defined with sufficient exactness, Than uses "heat of

combustion," or more generally "total difference of energy" of a mixture of oxygen and hydrogen, as expressing that quantity of actual energy which is evolved when the gas at 0° and 760 mm. is completely converted, in a closed vessel into liquid water at 0°. As a mean of five experiments, the heat of combustion found was 2·02930 gram-calories, with a probable error of 0·0018. That is, one cubic centimeter of electrolytic gas at 0° and 760 mm. on burning to liquid water in a closed vessel, evolves 2·0293 heat units. Or, taking the atom of hydrogen as unity, a gram of hydrogen at 0° and 760 mm. uniting with the necessary quantity of oxygen in a closed vessel, and forming liquid water at 0°, produces 33·982 units of heat (gram-calories); a close agreement with the number obtained by Andrews, 33·970.—*Ber. Berl. Chem. Ges.*, x, 947, May, 1877. G. F. B.

2. *On Vapor volumes and Avogadro's Law.*—The law of Avogadro asserts that equal volumes of all substances in the gaseous state, contain the same number of molecules; from which it follows that the molecules of all bodies in the gaseous state are of the same size. Hence calling the volume of the hydrogen molecule 2, the volume of all other molecules will also be 2. While the great majority of volatile bodies conform to this law, there are some whose molecular volumes are apparently represented by 4, 6, or 8. Such bodies are phosphoric chloride, ammonium chloride, ammonium sulphydrate, chloral hydrate, etc. While those chemists who deny the universality of Avogadro's law, maintain that these bodies have actually the molecular volumes given above, those who assert this universality claim that the true molecular volume of these substances is two, as it should be, but that dissociation takes place at the temperature of the experiments, yielding two or more bodies, the molecule of each of which has a volume of two. Troost has submitted this point, in the case of chloral hydrate, to the test of experiment, in a very ingenious way, by introducing into the vapor of this body, a salt containing water, whose dissociation-tension is, as nearly as possible, equal to that of the aqueous vapor of the chloral hydrate. If the vapor of the chloral hydrate suffers dissociation and consists of equal volumes of chloral vapor and of aqueous vapor, then the salt introduced will give up no water; i. e., the vapor-volume will remain constant. But if chloral hydrate is volatile as such, its vapor is free from water and on introducing the salt it will give up water and the volume will increase till the dissociation-tension is reached. The salt chosen was potassium oxalate, $K_2C_2O_4+H_2O$, whose dissociation-tension at 78° is 53 mm. and at 100° 182 mm. The experiments were conducted in Hofmann's vapor density apparatus, in both alcohol vapor and steam. In both cases the result was the same; the volume increased on introduction of the oxalate. Hence Troost asserts that chloral hydrate is volatile without decomposition.—*Ber. Berl. Chem. Ges.*, x, 899, May, 1877. G. F. B.

3. *On Plato-diiodo-dinitrosyl and Triplato-octonitrosylic acid.*—By the action of an alcoholic solution of iodine upon potassium

or barium platonitrite, Nilson has obtained a new class of bodies which he calls platoiodnitrites. The mixture, which is at first dark reddish brown, becomes, on heating to 30° to 40°, clear amber-yellow, evolving abundance of gas, in which the characteristic odor of aldehyde is perceivable, and depositing on cooling the platoiodnitrite in crystals. The potassium salt forms large brilliant four-sided amber-yellow prisms, having the formula $K_2N_2O_4I_2Pt.(H_2O)_2$. Nilson assigns to it the rational formula

K---O---NO=:=I

>Pt, the relation of this body to the pla-

K---O---NO=:=I

K---O---NO=:=NO---O

tonitrite >Pt being very simple.

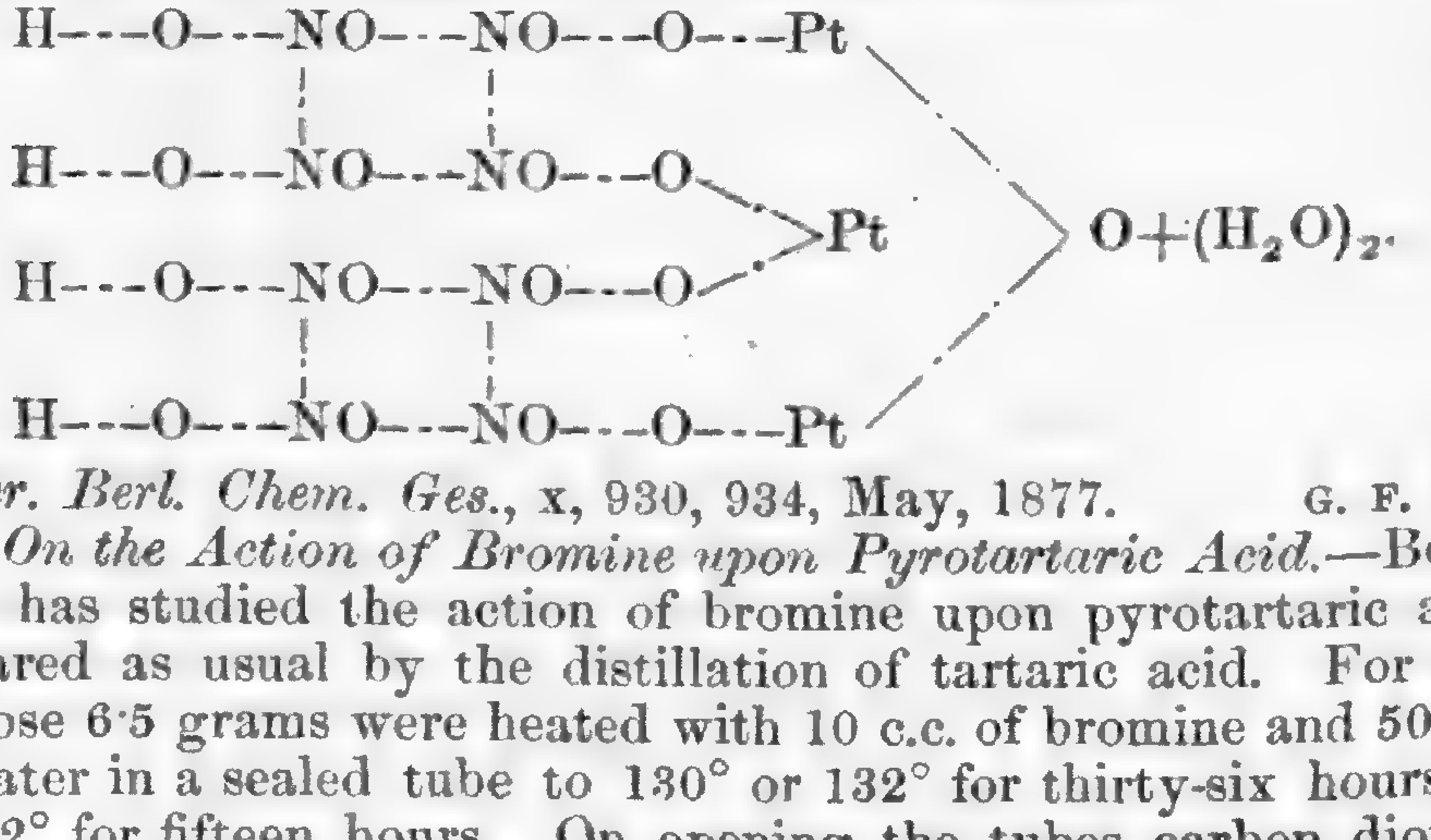
K---O---NO=:=NO---O

The reaction he represents thus:—

$$K_2(NO_2)_4Pt+I_2+(C_2H_6O)_3=K_2N_2O_4I_2Pt+C_2H_4O+(C_2H_5ONO)_2+(H_2O)_2.$$

The radical he names plato-diiodo-dinitrosyl.

Nilson has described also a new platonitrosylic acid, obtained while endeavoring to produce platotetranitrosylic acid by the method of Lang. For this purpose barium platonitrite was decomposed by sulphuric acid in the cold, and the solution was evaporated in a vacuum over sulphuric acid. At first red needles were deposited, corresponding to the acid of Lang; but on carrying the solution to dryness, a brownish-green brilliant residue remained, which was easily soluble in water, was strongly acid, was permanent at 100°, and which after drying over sulphuric acid, had the composition $H_4(NO_2)_8Pt_3O.(H_2O)_2$. Hence the unstable tetra acid, evolving one-third its nitrogen as nitrous acid, forms a remarkably permanent octo acid, the potassium salt of which is well crystallized. The author calls it triplato-octonitrosylic acid and assigns to it the rational formula:—



—*Ber. Berl. Chem. Ges.*, x, 930, 934, May, 1877. G. F. B.

4. *On the Action of Bromine upon Pyrotartaric Acid.*—Bourgoin has studied the action of bromine upon pyrotartaric acid, prepared as usual by the distillation of tartaric acid. For this purpose 6·5 grams were heated with 10 c.c. of bromine and 50 c.c. of water in a sealed tube to 130° or 132° for thirty-six hours, or to 152° for fifteen hours. On opening the tubes carbon dioxide was abundantly evolved, and the tube contained a dense liquid upon which rested an aqueous solution of hydrobromic acid. The heavy liquid, after washing with dilute potassium hydrate solution, was colorless and transparent, having an ethereal camphor-like odor,

irritating to the eyes, a sharp very sweet taste, a density of 2·93, and boiling about 200°, undergoing partial decomposition. On analysis it gave the formula $C_2H_2Br_4$. As it readily solidifies at −17°, it is thereby distinguished from acetylene tetrabromide, which remains liquid at −20°. From its reactions, the author regards it as tribrom-ethylene hydrobromate (or its equivalent dibrom-ethylene dibromide,) which solidifies in a freezing mixture and resembles it closely in other particulars. The third body known which has the formula $C_2H_2Br_4$, is tetrabrom-ethylene hydride, a crystalline body melting at 54·5°. The use of bromine in distinguishing the isomeric forms of pyrotartaric acid, is evident. —*Bull. Soc. Ch.*, II, xxvii, 395, May, 1877. G. F. B.

5. *On the Polybasic acids obtained by the action of Carbon dioxide on Phenol.*—The interesting synthesis of orthoxybenzoic (salicylic) and paraoxybenzoic acids by the action of carbon dioxide upon sodium-phenol and potassium-phenol, discovered by Kolbe, and the further discovery by OST, that a second and a third carboxyl group could be in this way introduced into phenol, forming respectively a phenol-dicarbonic and a phenol-tricarbonic acid, has led the latter chemist to study carefully the conditions of the reactions. For the tricarbonic acid, the process is conducted as for salicylic acid, the mixture being finally more strongly heated —to about 360°—until phenol ceases to come over. The purification is accomplished by converting the acid into barium salt, and then decomposing this by a large excess of hot hydrochloric acid; the acid separates in crystals on cooling. From 650 grams phenol, converted into sodium-phenol and heated to 270° for thirty-two hours (when 330 grams of phenol came over) and then for fourteen hours more with a gradually increasing temperature (during which 110 grams more of phenol distilled over), 20 grams phenol-tricarbonic acid were obtained. The dicarbonic acid is best obtained by using a mixture of three molecules of sodium-phenol and one of potassium-phenol, and heating to 320°. By reason of its insolubility in water, the acid is easily purified. From 50 grams phenol, 10 to 12 grams of pure phenol-dicarbonic acid were obtained, and 32 grams of phenol were recovered. Its formation from salicylic (orthoxybenzoic) acid and its conversion into paraoxybenzoic acid on heating, prove that the two carboxyls occupy the ortho and the para positions. As to the tricarbonic acid, Ost converted it into the chlor-acid by the action of phosphoric chloride, and then reduced this by sodium amalgam; thus obtaining trimesinic acid

$$C_6H_3\left\{\begin{matrix}COOH\\COOH\\COOH\end{matrix}\right.$$

identical with that obtained from mesitylene by Fittig. The phenol-tricarbonic acid is therefore oxytrimesinic acid. No further introduction of carboxyl into phenol was possible, the meta derivatives not being obtainable in this way; a fact true also of the nitro-derivatives.—*J. pr. Ch.*, II, xv, 301, April, 1877. G. F. B.

6. *On the Relation of Cystin to Sulphates in the Urine.*—NIEMANN has examined a case of cystinurea and has sought to

determine the quantitative relation between cystin and other constituents of the urine, in this disease. The most noteworthy fact observed was that the per cent of cystin stood to that of the sulphuric acid as 1 : 3·89, and that the two varied together. The quantity of uric acid was diminished, but that of the urea was not sensibly affected. The patient excreted from 0·4234 to 0·595 gram cystin per day.—*Liebig's Ann.*, clxxxvii, 101, May, 1877.

G. F. B.

7. *On Gauss's Theory of Capillarity.*—The virtual work of the molecular forces engaged in the phenomenon of Capillarity is divided, according to Gauss, into: 1, that which arises from the force of gravity; 2, that which arises from the forces between the particles of the fluid; and 3, that which arises from the forces between the fluid particles and the surrounding solid bodies. The contact line between different bodies is made apparent when the complicated integrals are reduced to simpler forms. Lippman separates a quantity from the general expression. This quantity is connected with the variation in the contact line. Lippman believes that he has made this included connection "for the first time" noticeable. He discusses the changed equations of Gauss which he has thus divided into two parts. By a consideration of the facts that the volume variation of solids and in compressible fluid bodies = 0, and that by the shifting of absolute movable particles of a homogeneous fluid without volume variation, no work is done—the original equations can be simplified. Lippman finally shows why we cannot assume that the rise of a liquid in a capillary column depends upon the attraction between the fluid and the unmoistened parts of the walls of the containing vessel.—*Beiblätter, Pogg. Ann.*, vol. i, No. 5, p. 275. J. T.

8. *Influence of Light upon the Electrical resistance of Metals.*—Dr. R. Börnstein, Assistant in the Physical Institute of Heidelberg University, claims that: "The property of experiencing a diminished electrical resistance under the influence of luminous rays is not confined to the metalloids selenium and tellurium, but belongs also to platinum, gold and silver, and in all probability to metals in general. The electrical current diminishes both the conductivity and also the sensitiveness to light of its conductor; and both of these, after cessation of the current, gradually acquire their former value.—*Phil. Mag. Supplement*, June, 1877, p. 1.

J. T.

9. *Chemical and Physical Researches;* by Thomas Graham. Collected and printed for presentation only. Preface and Analytical Contents, by Dr. R. Angus Smith. Edinburgh, 1876.—What Horace wrote of his own works

"Exegi monumentum æve perennius,"

is equally true of the product of all literary and scientific labor of the highest class, and no more worthy tribute can be paid to intellectual greatness than by carefully cherishing that monument, which the noble intellect during this earthly life erects to itself.

Such a recognition, though long delayed, the French Government bestowed both on La Place and on Lavoisier, by publishing magnificent editions of their works. A similar debt of gratitude the American Academy of Arts and Sciences has paid to Rumford; but we do not hesitate to say that the elegant volume before us, in which his two friends,—James Young and R. Angus Smith,—have embodied the "Chemical and Physical Researches of Thomas Graham," is the noblest tribute of all. To the scientific contemporaries of Graham, among whom it has been widely distributed, this volume is the most worthy memorial possible of the successful student of nature whom all honored, and of the man whom all who approached him loved. His modesty of character was in striking contrast with the self-assertion of the Roman poet who could write the famous verse we have quoted above; but no friend of Graham can doubt that this literary tribute would be far more grateful to him than the bronze statue which adorns his native city. Bronze can add no luster to intellectual greatness, and however much it may swell the false glory of the living, to the eyes of posterity it only renders the transient splendor the more vain. Such monuments have their value in so far as by keeping constantly before the people examples of true greatness they serve to educate a nation. But who does not know that the chief motive which erects statues of great men is national vanity, and when will nations learn that they can serve even this selfish aim far more effectually by promoting with pecuniary means the labors of their great scholars while living, and carefully cherishing their works when dead. Every student of science would have preferred that the memorial before us, worthy as it is of one of the noblest scientific scholars which England has produced, should have been a tribute of the nation rather than an offering of two devoted friends, and all must regret that a similar tribute has not been paid to Graham's great contemporary, Michael Faraday.

The great value of memorial volumes like the one which Graham's two friends have presented *gratuitously* to the scientific world is to be found in this,—that they add finish to the completed work of the great man, they commemorate, and exhibit its unity. The investigations of almost every successful student of nature are directed by a few controlling ideas, and although the parts may seem to his contemporaries to be disconnected, because the results are published at intervals, yet when the work is done, and is seen with the perspective which time gives, the plan appears; and no greater service can be done for the departed scholar than to bring together his scattered papers, and make evident to the world the great thoughts which give unity and dignity to the whole; and not only is the work of his life thus made to appear more worthy, but, what is more important, it is rendered more useful to science.

The trait we have pointed out is most conspicuous in the investigations of Graham, and the service we have commended has been most ably rendered to his deceased friend by Dr. Angus

Smith, in the admirable "Preface and Analytical Contents" of the volume we are noticing. It is this feature which in our estimate renders this volume a more worthy memorial than either of the works to which we have referred above. In a biographical notice prepared for the Proceedings of the American Academy of Arts and Sciences, and reprinted in this Journal, III, vol. i, p. 115, we have already expressed our appreciation of the remarkably unique character of Graham's work, and shown that it forms a large part of the experimental basis of the recent science of molecular mechanics; and we are glad to find that our estimate of these investigations has been so fully confirmed. There is but one observation which we desire to add.

Faraday and Graham were two of the most successful discoverers who in any age have illustrated the annals of physical science, and their success was wholly due to the power with which they wielded the inductive method of experimental research. Experiment guided by analogy ever has been, and ever must be, the fundamental condition of all progress in physics, and we regret to see a tendency to undervalue this mode of investigation as compared with the more rigid methods of mathematical deduction. The ability to devise crucial experiments, and to overcome the difficulties which the material conditions of every new physical problem present, is a talent of fully as high an order as that which can marshal differential equations and draw forth the truths which they involve; and this mathematical skill, all important as it is, and essential to the later developments of the science, would be powerless without the data, which experiment has supplied. We would therefore most earnestly commend to the attention of the students of physics, these experimental researches of Graham, as an example of what great results can be attained by purely and very simple experimental means. J. P. C., JR.

Newport, July 9th.

II. Geology and Mineralogy.

1. *Bulletin, Vol. iii, No.* 3, *of Hayden's Expedition.*—The publication of this Bulletin was announced in the preceding number of this Journal. The following are notes from the volume.

Professor Cope refers the Lignitic beds of the Judith River region to the Cretaceous, making the Eocene Tertiary commence with the Wahsatch group. These Judith River beds overlie the Fox Hills group, which is the Upper Cretaceous No. 5, of Hayden & Meek, a rusty sandstone separating the former (which he makes Cretaceous No. 6), from the black shales of the latter. These Judith beds have a thickness of 300 to 500 feet, and afford, above as well as below, various Dinosaurian remains. From the upper two-thirds of a section of 332 feet, Dr. Cope enumerates the following: *Lælaps*, 6 species; *Troödon*, 1; *Aublysodon*, 2; 12 others of the genera *Zapsalis*, *Paronychodon*, *Palæoscincus*, *Dysganus*, *Diclonius*, *Trachodon*, *Monoclonius*; also species of *Crocodilus*; of the Testudinate genera *Trionyx*, *Plastomenus*, *Polythorax*, *Comp-*

semys, *Emys*; of *Rhynchocephalia*, 4 species; *Batrachia Urodela*, 5; others of *Lepidosteus*, and *Ceratodus*.

Mr. Cope makes the Lignitic formation include the Judith River and Fort Union epochs, as defined by Meek, and regards the Laramie or Bitter Creek beds as representing other epochs.

Prof. White discusses the age of the Lignitic group in connection with his review of the species of fresh-water and land shells. He refers the Judith River and Laramie groups to the *Post-Cretaceous*, and recognizes the same five Cretaceous groups laid down by Hayden and Meek; but he makes the Cenozoic or Tertiary commence near the base of the Fort Union group, in the Upper Missouri region, and also near that of the Wahsatch in the Green River region; so that the Tertiary of the Green River region includes (beginning below) the Wahsatch (except its earliest part), Green River, Bridger and Brown's Park groups, all of fresh water origin; and that of the Upper Missouri River region, the Fort Union, Wind River and White River groups. The Laramie group and the lower portion of the overlying Wahsatch (some 500 or 600 feet) is the portion of the series about which the age, whether Cretaceous or Tertiary, is in dispute. The final change from brackish to fresh-water formations takes place at the close of this early part of the Wahsatch.

Dr. Peale describes mountains consisting partly of mixed eruptive and sedimentary rocks, occurring in Colorado. Among the examples of them there are the Spanish Peaks, two isolated mountains east of the Sangre de Cristo Range; two areas of low hills in Middle Park; Mount Guyot and Silverheels, northeast of South Park; four Elk Mountain areas, the Italian, White Rock, Snow Mass and Sopris; the Sierra la Sal, 120 miles west of the Elk Mountains, and others. The areas are isolated, and in regions of sedimentary rocks. The mountains consist partly of trachyte and rhyolyte, or of granite, into which the trachyte graduates, or less commonly of dioryte. The sedimentary rocks are intersected by dikes, and the beds have sometimes been carried up, broken off, overturned, and forced apart by intrusive sheets; or the liquid rock has forced its way through the strata and spread out with scarcely any displacements; or, on reaching the shales, it has pushed its way between the layers, lifting those above. The sediments adjoining are sometimes altered and even disguised, in other cases they are unaltered by the heat. The rocks penetrated and overlaid are in part the Cretaceous; and in one of the West Elk Mountain areas, Upper Cretaceous; the eruptions were certainly post-Cretaceous. In Park View Mountain and Spanish Peaks, Lignitic strata are intersected by trachytic dikes. Dr. Peale concludes that the eruptions are all of the same age; that they occurred after the elevation of the mountain ranges; and that the trachyte and other rocks have resulted from the fusion of metamorphic rocks lying beneath—the fusion being due to the heat occasioned by the movements and plication.

A Fourth edition of the "Lists of Elevations" by H. Gannett has been issued. It contains the Hypsometric map noticed on page 387 of the last volume of this Journal.

2. *The Coal Mines of the Western Coast of the United States;* by W. A. GOODYEAR, Mining Engineer. 154 pp. 12mo. San Francisco. 1877. (A. L. Bancroft & Co.)—The author of this volume has had a ten years' intimate practical acquaintance with the coal mines of California, Oregon and Washington Territory. His work gives a clear and full description of the coal fields (none of which are older than Cretaceous), and of the mines themselves as they exist to-day, together with statistics of production, information concerning the relative value for steam purposes of the various coals which come to the San Francisco market, and other cognate matters interesting not only to geologists and mining engineers, but also to all who are connected with the coal trade. The relative value of the different coal fields is considered, and the following conclusion reached: that the mines of California cannot be relied on for much more coal; that those of Coos Bay, Oregon, the only ones yet worked in that State, will not probably be worked with a profit many years longer; that "it is unquestionably to the mines of Washington Territory and of British Columbia that the Pacific coast must look hereafter, both for its chief domestic, and its nearest and most reliable foreign, supplies of a good article of coal."

3. *On the Origin of Kames or Eskers in New Hampshire;* by WARREN UPHAM, of Nashua, N. H. (Proc. Amer. Assoc., Buffalo Meeting, 1876).—Mr. Upham describes "kames" as existing along the lower part of the valleys of almost every river in the State of New Hampshire; and as being ridges several miles in length, or remnants of them, made up of sand and fine or coarse gravel, and in some places containing occasional angular bowlders. A single continuous "kame," 150 to 250 feet high, is said to extend in the Connecticut valley from Lyme, N. H., to Windsor, Vt., a distance of twenty-four miles. Mr. Upham describes the terraces as consisting of sand, clay and fine gravel, and as covering in places the kames, and therefore newer than the kames. Their origin is referred to depositions by sub-glacial streams of the material dropped by the melting glacier before its retreat.

4. *The American Palæozoic Fossils.* A Catalogue of the Genera and Species, with names of authors, dates, places of publication, Groups of Rocks in which found, and the Etymology and Signification of the words, and an Introduction devoted to the Stratigraphical Geology of the Palæozoic rocks; by S. A. MILLER. 254 pp. 8vo. Cincinnati, 1877. Published by the Author.—This title gives the contents of Mr. Miller's work. The Catalogue is the result of a large amount of labor, and will be of great service to students in Paleontology. The Introductory chapter is judiciously drawn up; and so also a preceding chapter on the construction of scientific names in Paleontology, by Prof. E. W. Claypole, of Antioch College. The Catalogue commences with the names of fossil Plants; and continues with those of Animals, beginning with the lowest. Among Vertebrates it includes only the fossil Fishes and Reptiles. A valuable addition to such a catalogue would be a table containing the titles of the works referred to.

5. *Heights of Mountains in Western Connecticut.*—The following is a list of some of the mountain elevations of Western Connecticut, as obtained by a survey made two or three years ago by Messrs. Fyler and Civil Engineer George M. Bradford, of Winsted, and the Hon. Robbins Battell and H. P. Lawrence, of Norfolk. It will be seen that Salisbury, the northwest corner township, has elevations much higher than that of Mt. Ivy in Goshen, which used to be called the highest land in Connecticut. The elevations here given are the heights above tide water:

Spaulding's Summit, Norfolk	1,336	feet.
Platt Mountain, Winchester	1,460	"
Chamberlain Mountain, Winchester	1,480	"
Ivy Mountain, Goshen	1,642	"
Riggs Mountain, Norfolk	1,565	"
Knapp Mountain, Norfolk	1,617	"
Moses Mountain, Norfolk	1,645	"
Dutton Mountain, Norfolk	1,672	"
Summer Mountain, Norfolk	1,672	"
Haystack Mountain, Norfolk	1,672	"
Gaylord Mountain, Norfolk	1,717	"
Bald Mountain, Norfolk	1,770	"
Winrow Mountain, Norfolk	1,770	"
Mt. Bradford, Canaan	1,960	"
Clipper Mountain, Canaan	1,810	"
Bald Peak, Salisbury	1,996	"
Buck Mountain, Salisbury	2,150	"
Bear Mountain, Salisbury	2,250	"
Mount Brace	2,300	"

"The last three heights are estimated." The report of the survey says: Mount Brace and Bear are 150 to 200 feet higher than the ground they stood on, [Bald Peak, Salisbury], and unquestionably in the limits of this State,—while there is some dispute as to whether the highest point of Mount Brace, which is considerably above the other two, is in this State, or just over the line in New York. The monument to mark the State line is on this mountain near the top, and it is exceedingly probable that the highest land in the State is *exactly* in the corner where New York and Massachusetts join Connecticut. Only this seems now certain, that there is land in this State that will vary little, if any, from 2,300 feet above the sea level.—*Hartford Times*, June 14, 1877. This high land is in the Taconic range and just south of Mount Washington.

6. *On some of the conditions influencing the projection of discrete solid materials from Volcanoes, and on the mode in which Pompeii was overwhelmed.*—Robert Mallett, F.R.S., has an important paper on this subject in the Journal of the Royal Geological Society of Ireland, vol. xiv, part 3, which was read before the Society a year since.

7. *The Geological Survey of Portugal.* — The recent publications of the Survey of Portugal include a memoir on the Caves of Casareda containing human remains, by J. I. N. Delgado; on the existence of Silurian rocks in the vicinity of Alemtejo, by the same; on the Quaternary of the hydrographic basins of Tejo and Sado, by C. Ribiero; on the supply of Lisbon with spring and river waters, by the same.

C. Ribeiro has also published a memoir on flint and quartz implements from the Tertiary and Quaternary of Tejo and Sado, in the Memoirs of the Lisbon Academy of Sciences.

8. *Earthquake of Jalisco, Mexico, and eruption of the Volcano Ceboruco.*—A detailed account of the Jalisco earthquake, of the 11th of February, 1877, shaking heavily the city of Guadalajara, and of Ceboruco, a volcano in the region, by a Government Commission, consisting of M. Iglesias, M. Bárcena, and J. I. Matute, is contained in the first volume of the Anales del Ministerio de Fomento de la Republica Mexicana, Tomo i, Febrero de 1877.

9. *West Rock at New Haven, Connecticut, not the termination of the Green Mountain range.*—The ridiculous statement,* that the Green Mountains terminate in West Rock, is still afloat in the School Geographies studied in and out of New England. The following correction of it appeared nearly sixty years since, in Amos Eaton's "Index to the Geology of the United States," (p. 103) a small volume published at Troy, New York, in 1820.

"It is very strange that several publications have located the southern extremity of this primitive range (the Green Mountains) in West Rock, New Haven, which is greenstone resting on red sandstone. Such random guesses given as facts are very injurious to the science."

III. Botany and Zoology.

1. *Some points of Botanical Nomenclature.*—The series of laws of nomenclature, revised and expounded by Alph. DeCandolle, and adopted at a Botanical Congress in France a few years ago,† naturally left certain practical points unsettled, or apparently so. A Belgian botanist, A. Cogniaux, asks some questions, all rising out of the way in which genera, their synonyms, and some species are succinctly dealt with or referred to in the Genera Plantarum now in course of publication; and he very naturally addresses these questions to M. DeCandolle. The latter replies, laying down the law: and the correspondence is printed in the ***Bulletin de la Société Royale de Botanique de Belgique***, 1876, pp. 477–485.

The difficulty upon which M. Cogniaux fell was not very formidable, but it is one which a botanical writer has to settle, and which ought, if possible, to be settled with unanimity, and upon intelligible principles. DeCandolle seizes the principle and applies it to the case. The settlement should be satisfactory to all who really accept the principle. It may well satisfy us; for the principle is one which for many years we have strenuously maintained in this Journal. The fact is, that the name of an author, or its abridgment, appended to the name of a genus, or to a specific name, is mere bibliography, stands in the place of a citation of author, work, page, etc. For some purposes the whole citation is needed: for others the first word suffices. "When Dr.

* See this Journal, III, x, 498, xi, 151, 1876.

† Reprinted, with comments, in this Journal, July, 1868.

Hooker, in the Genera Plantarum, characterizes a new genus, *Cerasiocarpum*, and states that it is founded upon the *Æchmandra Zeylanica* of Thwaites, but does not write *Cerasiocarpum Zeylanicum*, how is a succeeding writer to refer to this record? Shall he write *Cerasiocarpum Zeylanicum*, Hook. f.?" If this were the only kind of case coming under the rule, we should say it were best to do so,—that, although Dr. Hooker has not imposed the specific name in question in fact, he has done it by such direct construction, that, in the absence of all reason to the contrary, the name might be cited in that manner. But constructions grow; and this one may form the foundation of a superstructure which would stand very much in the way. Suppose, asks M. Cogniaux, the new genus consisted of two or more species, already published under other generic names, and these were in like manner enumerated, some with certainty, some with doubt; suppose that several species are referred to a newly proposed genus by their old names, without saying whether they are severally regarded as distinct species or not; suppose, to take an actual case, a genus is said to contain only "*two or three*" known species, while four or five species of authors under other genera are said to belong to it; suppose, to take a common case, the species of a newly-formed or newly-limited genus could not be transferred bodily from their former associations to the new without re-adjustment and alteration of some names; and finally, take *Peucadanum*, into which Bentham thrusts twenty or thirty received genera, some of them numerous in species, what is to be done? DeCandolle rightly answers these questions, first, by calling attention to the fact that, from the time of Clusius and Dodoens down to Linnæus, this suffix of authors' names is merely the commencement of, or in lieu of, a citation; that it is not a matter of homage or sentiment, or justice, but a matter of fact, i. e., of historical record. The guiding principle as to this record is, that we are not to make an author say that which he has not said. The fact is that Hooker has established the genus *Cerasiocarpum*, and has not said that the species referred to it should be called *C. Zeylanicum*. Probably that is the name which the plant should bear: possibly not. When some writer describes or enumerates it under that name, this will also be matter of record. This rule, which rigid consistency requires to be followed in such a case, is obviously the only safe one in all the following cases. It is the rule which we ourselves have endeavored to follow. It is attended by a certain amount of inconvenience in certain cases, but any serious departure from it is sure to introduce confusion and falsification of the record. But it is every way desirable that the founder of a genus should complete the nomenclature of the species at the time, whenever and so far as he can, instead of leaving it to others.

DeCandolle closes with a reminder that the same considerations apply to the raising or lowering of the grade of a name; for instance, that Endlicher should not have written *Ordo Swartzieæ*, DC., when, in the Prodromus, the rank assigned is *Subordo;*

also that, when a genus is reduced to a section of some other, we should not write after it the name of an author who established it as a genus, etc. Consistency and exact correctness require that the rule *suum cuique* should be followed even in these matters. But we do not agree in the requisition that the name of the author who first used a former generic name as that of a section, should always be appended. Sometimes it is not easy to ascertain this, or to know whether or not it has been yet so employed. And when known, we may in many cases, in print as well as in writing, innocently and safely omit the authority of a sub-genus or section, as we may that of a genus or species. A. G.

2. *Athamantha Chinensis* L.—This is a puzzle, of which a probable solution by Muhlenberg has recently turned up. The following is the character, etc., in the Species Plantarum, ed. 1, p. 245.

"*Athamantha Chinensis*, seminibus membranaceo-striatis, foliis supra-decompositis lævibus multifidis.

"Habitat . . . Chinensem dixit Barthram qui semina misit ex Virginia.

"Caulis angulatus, lævis, erectus, parum flexuosus. Folia Chærophylli, lavia. Umbella minus expansa, alba. Semina singula 5-alis longitudinalibus parvis; involucrum duplex."

In the second edition of the Species Plantarum it is added: "Statura Selini Monnieri."

In reading the botanical correspondence of Zaccheus Collins, which (as is already noted in this Journal) is preserved in the library of the Academy of Natural Sciences, Philadelphia, I found the following in a letter from Muhlenberg, dated Oct. 12, 1813.

"Among the specimens from Genessee, sent by Mr. Whitlow, there is an umbellate agreeing with *Athamantha Chinensis* L., which Linnæus had from Mr. Bartram, who had visited the Lakes. Can we find out whether in Bartram's time the name of Genessee was known, and how Bartram spelled it: perhaps *Chinesee*, and whether such a word might have been misunderstood? I have never seen Bartram's journal."

The journal referred to must be John Bartram's "Observations made in his Travels from Pennsylvania to Canada." 8vo. London, 1751. The name of Genessee is certainly older than Bartram's time.

If Muhlenberg's suggestion is the right one, as is probable, the plant is probably *Conioselinum Canadense.* Yet that hardly posseses an "involucrum duplex." There is, perhaps, a specimen in the Linnæan herbarium, which would settle this point. A. G.

3. *Repertorium Annuum Literaturæ Botanicæ periodicæ curarunt* G. C. W. Brohnensieg, Custos biblioth. Soc. Teylerianæ, et W. Burck, Math. Mag. et Phil. Nat. Doct. Harlemi, Erven Loosjes, 8vo.—We have before us tomm. II, 1876, and tomm. III, 1877, relating to publications of the years 1873 and 1874 respectively. Vol. I, it appears was brought out by Van Bemmelen, who sickened and died soon after its appearance. The present authors taking up the work, appear to have done it very conscientiously

and well. They put on record, in a systematic way, the titles of all the communications relating to Botany which are found in the periodicals and serials of the years in question. The contents are arranged under the heads of General Morphology, Special Morphology of the several classes and orders, Physiology, Plant-descriptions, Floras, Geography of Plants, Paleontology, etc., etc. A list of the periodicals used is given, an alphabetical index of authors, and another of Families and Genera. The work appears to be under the patronage of the Teylerian Society of Harlem. It makes a valuable supplement or continuation, so far as concerns botany, of the Royal Society's Catalogue, and has also the advantage of systematic arrangement. A. G.

4. *Sir Joseph Dalton Hooker and party on a Botanical excursion to the Rocky Mountains and California.*—Sir Joseph Dalton Hooker, President of the Royal Society, and Director of the Royal Gardens, Kew, arrived at Boston in the Parthia, on the 9th ult. He is accompanied by Major General Strachey, of the Royal Engineers, and of the India Board, the explorer and surveyor of Kamoun, etc. They proceeded at once to the Rocky Mountains of Colorado and Wyoming, in company with Professor Giay of Cambridge, and Professor Leidy of Philadelphia, escorted by Dr. Hayden, to whose Survey the party are temporarily annexed, while they make a botanical reconnoissance of the Rocky Mountain region, which may probably be extended to California.

5. *The Influence of Physical Conditions in the Genesis of Species;* by JOEL A. ALLEN. 32 pp. 8vo. (From the Radical Review, vol. i, No. 1, May, 1877.)—Prof. Allen has brought together in this paper a large number of facts—partly of his own observation—on the differences among the individuals of species connected with their geographical distribution. He draws his illustrations from birds and mammals. The differences are differences in size of body, size and form of peripheral parts, kind and intensity of color, and, to some extent, in qualities still more fundamental:—differences that had led to the establishment of many distinct species which now are known to shade into one another by hardly perceptible gradations. The author after pointing out many examples, argues that the direct influence of climate or geographical conditions--and not natural selection—is the chief source of the variations, a conclusion the facts clearly establish.

6. *Sir Wyville Thomson, and the working up of the "Challenger" collections.*—The May number of the Annals and Magazine of Natural History contains an article by Professor P. M. Duncan charging Sir Wyville Thomson with partiality and lack of patriotism in the distribution of the "Challenger" collections for description. Mr. Duncan refers especially to the Echini, Sponges, and Protozoa, a portion of which have been sent for description to America and Germany, which, according to him, belong of right to British naturalists.

If Sir Wyville Thomson has neglected any one's interests in the matter, he may be said to have disregarded his own, by sending part of the Sponges to Oscar Schmidt; for surely no one has a better claim than Sir Wyville himself, to whatever distinction may be gained in working them up as a whole. Mr. Duncan speaks of the destination of the Echini as a wrong done to Dr. Thomas Wright, and that of the Radiolaria as a slight upon Mr. Carter. Without discussing the merits of any English naturalist as compared with those selected, it certainly is no slight to any investigator of the Protozoa, that the Radiolaria should have been intrusted to Haeckel. And we may suppose that in sending the Echini to be worked up at Cambridge, Sir Wyville was strongly influenced by the fact that a larger amount of material for the comparison of recent Echini is to be found at the Museum of Comparative Zoology than in any other institution; which circumstance, added to Mr. Agassiz's familiarity with the subject, gives him unusual facility for the work.

More important, however, than any personal interest is the principle involved in this distribution. The same cosmopolitan spirit has guided Sir Wyville on previous occasions. A reference to past transactions shows not only that he has been consistent with himself, but that he could scarcely have acted otherwise if the best and fullest scientific results were to be obtained from the materials in question. On the return of the Porcupine in 1869, it was agreed between Sir Wyville Thomson and Mr. Agassiz, then acting for the Coast Survey under whose auspices similar deep sea dredgings had been made, that they should send their respective materials, as far as possible, to the same persons, and secure the best coöperation by choosing specialists of known ability regardless of nationality. We may add, that a few years later, when the collections of the Hassler expedition were ready for distribution, the same policy was continued with even greater disregard of national predilections than in the case of the "Challenger," the material being divided among sixteen specialists, twelve of whom were either Swedes, Frenchmen, Englishmen, or Germans.

We cannot regret that Sir Wyville Thomson in distributing the invaluable collections of the Challenger has persisted in the same course. In so doing he has selected, as far as possible, those investigators whose familiarity with the results of his own earlier deep-sea dredgings, and with those of the United States Coast Survey, gives them an unquestionable advantage in working up these later collections. In short, it seems to us, that in this final division, Sir Wyville has manifested the discriminating judgment which has made the Challenger expedition an exceptional one throughout; exceptional, not as Mr. Duncan thinks it should have been in its exclusively national character, but exceptional in well laid and admirably executed plans, conceived in a liberality of spirit which lays the whole scientific world under obligation.

7. *American Addresses, with a Lecture on the study of Biology;* by Thomas H. Huxley. 164 pp. 8vo. London, 1877. (Macmillan & Co.)—These addresses include those delivered by Professor Huxley in New York in 1876, noticed on page 399 of volume xii of this Journal (1876), and also his address on the occasion of the

opening of the Johns Hopkins University, delivered at Baltimore on the 12th of September, 1876, and a lecture on the study of Biology, in connection with the Loan Collection of Scientific Apparatus, South Kensington Museum, delivered December 16, 1876.

IV. Astronomy.

1. *Notice of the Meteor of June* 12, 1877; by Professor Daniel Kirkwood. (Communicated.)—On the evening of June 12, 1877, about fifteen minutes before 9 o'clock, a large meteor was seen in Indiana, throughout almost the entire extent of the State. The *Plymouth Democrat** of Thursday, June 14th, contains the following notice of the phenomenon:

"A remarkably brilliant meteor, of a bluish color, passed through the heavens from west to east, last Tuesday evening at about fifteen minutes past 9 o'clock. The movement of the meteor was much slower than is usual with such bodies, being visible for several seconds. It left no trace of its course, as some former meteors have done. Its elevation was about thirty degrees, and the space traversed was about twenty degrees, according to the opinion of a city paper."

The time here given, fifteen minutes *past* 9 o'clock, is certainly erroneous, as the meteor was seen *before* 9 both in Muncie and Bloomington. The altitude is probably that at which the body disappeared. According to the *Muncie Times* of June 13, the meteor as seen in Delaware County was in the north, moving from west to east, nearly parallel to the horizon, at an elevation of about 40°. Mr. F. M. Parker, a graduate of Indiana University, observed it carefully at Bloomington, Monroe County. When first seen it was about 15° east of north at an altitude of 17° or 18°; its apparent magnitude was one-fourth that of the moon; its motion eastward; the length of its visible track, about 20°; and it disappeared at an elevation of 12° or 13°. With the exception of the Bloomington observations the data are very uncertain. They justify the conclusion, however, that the meteor's motion was direct, and that its height above the earth's surface at the moment of its disappearance was more than thirty miles and less than forty.

Bloomington, Indiana, July 2.

2. *Micrometric measurement of Double Stars.*—A memoir on this subject, extending to 266 pages, by N. C. Dunér, is contained in the Acta Universitatis Lundensis, tom. xii, 1875–76.

3. We are glad to learn that Mr. Burnham has been granted again the use of the large telescope in the Chicago Observatory.

4. *Handbook of Descriptive Astronomy;* by George F. Chambers. 3d edition. Clarendon Press Series. Macmillan & Co. London: 1877. 8vo, 960 pp.—The first edition of this excellent work was published about ten years ago and is probably known to most amateur astronomers. In that edition there were

* Published at Plymouth, Marshall County, near the northern boundary of the State.

several very serious deficiencies. The present edition is much enlarged, and these deficiencies have been supplied. Some of the chapters are, from the increase of our knowledge, almost entirely new. The net increase in the volume is not less than 200 pages. The work is, as its title implies, strictly *descriptive*. The author has in general avoided all theoretical discussions. The law of universal gravitation and the nebular hypothesis are alike omitted. The same is true of spherical astronomy and all methods of computation except the very simplest. The volume is therefore a handbook of the known facts of Astronomy, stated with the least possible amount of mathematics. It is not designed or fitted to be a textbook, but it is not unsuited to general reading, and the amount of information crowded into its pages makes it extremely convenient for reference by the teacher and almost indispensable to the amateur observer.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Abstract of a pamphlet entitled Reflections sur les Chronometres*, par J. A. ROUYAUX, Enseigne de Vaisseau. Translated by Lieut.-Com. C. H. DAVIS, U. S. N.*

Part I—Contains an exposé of numerous inconveniences in the direct application of formulæ to chronometers at sea, and a resumé of the advantages to be derived from an application of the formulæ to the *differences of rates* observed daily at sea.

Part II—Contains a demonstration of some properties of lines of equal rates and temperatures (lignes isothermes et lignes isomarches).

As a necessary corollary follows an examination of the results furnished, during a cruise of thirty months, by the chronometers of the *Decrès*. This examination, which in general confirms the views of Yvon Villarceau, reveals a nearly new fact: the influence which the action of the screw propellor may have on chronometer rates. A final note contains the analytical demonstrations involved in the work.

Part I.—The object of all researches on chronometer rates is a double one. 1. By a comparison of dates and temperatures, with corresponding rates, to find a law which governs these variables. 2. This law found, to apply it in such a way as to determine the rate for a given date and temperature. The common method of proceeding is, by means of careful observations, to determine rates as often as possible, the temperatures being observed at the same time. When a sufficient number of observations has been accumulated, to form a number of equations of condition, and from them determine the values of the coëfficients in the formula chosen as best applicable to the case in point. Another method

* This abstract of one of the latest contributions to an important subject is given with a view to make public a research which would perhaps have little currency in this country, and without committing the translator to the views therein expressed, from some of which his own investigations have led him to differ.

is to record the rates observed, with corresponding temperatures, in the graphic form of curves.

The inconveniences of these two methods as applied to chronometers on board ship are:

(1.) The length of time necessarily involved in the preliminary investigation: for in order to have a sufficient number of equations of condition there must be great differences in the observed temperatures, and these differences will only appear with change of seasons.

(2.) There must frequently occur, on board a cruising ship, interruptions of the regular observations.

(3.) In consequence of these interruptions the observations may be badly distributed on the scale of temperatures.

(4.) Skill is necessary in the observer.

(5.) The observations so laboriously collected and studied represent only the *Harbor rates*, whereas the practical navigator is directly concerned with the *Sea rates*, and it is well known that these two sometimes differ widely.

The navigator on considering these many and important inconveniences will be led justly to conclude that so much labor is practically useless, and will trust as implicitly to the regularity of his chronometers, as to the demonstrations of a formula based on such uncertain conditions.

It is proposed, therefore, to apply the formula, not to the rates themselves, but to their differences, or what is the same thing to the second differences of daily comparisons. These differences, when three chronometers are used, may be obtained daily, without regard to the actual value of the rates, both at sea and in port.

The length of time may be diminished, as observations are furnished every day; the interruptions in the observations will not occur; the observations will be better distributed on the scale of temperatures; talent of observation will not be necessary; two chronometers will be followed at once; and finally the perturbations of sea rates appear directly.

There is one decided inconvenience in this method, the importance of which it is impossible to deny, viz: that the result practically useful to the navigator is the variation of *the rate itself*, which must still be sought by the ordinary methods, because this method only furnishes the variation in *difference of rate.* The ordinary methods may however be facilitated by a study of the difference of rates, and are of themselves insufficient to control the regularity of sea rates or the validity of the proposed formulæ.

Since the rate of a chronometer may be regarded as a function of the two variables, time and temperature, it may be expressed by the development of a series (Taylor's theorem), and Mr. Yvon Villarceau was the first to apply this solution to the problem. His formula is the general one for all chronometers. It is shown that the formula may be applied to express the *difference of rate* of two chronometers, exposed to the same temperature, at the same times.

Part II.—Several properties of chronometer-rates are implicitly contained in the formula of Yvon Villarceau. The importance of these properties is that they are *necessary* and *sufficient* consequences of the formula, and are consequently verified or not verified at the same time as the formula, and are capable of replacing it either as proof of an admitted law, or as a control on the regularity of rates. Their practical utility consists in the fact that their graphic construction is much easier than that of the formula.

Without entering into their mathematical demonstration these properties may be briefly stated as follows:

(1.) All the rates corresponding to the same temperature are distributed on a parabola having its axis parallel to the axis of rates.

(2.) The points corresponding to the same value of rate are all situated on a conic, and all the conics obtained for different values of rate have the same center and are similar.

[It must be borne in mind that the points corresponding to equal temperatures are points on the curve of rates, and the points corresponding to equal rates are points on the curve of temperatures.—*Translator.*]

By giving to the curves of temperatures and rates the same axis of time these properties will appear in a graphic construction of the curves.

A study of the chronometers of the *Decrès* is given to show the influence of vibrations caused by the screw of a steam vessel on the rates of chronometers on board.

A practical way of correcting rates at sea, by the application of the formula to their differences, is as follows:

Suppose that the normal values of the rates a, b, c, . . . and their differences $b-a$, $c-a$, . . . have been determined, for a given time and temperature [by any adopted formula].

If time and temperature alone affected the rates these determinations might be adopted as the correct *sea rate.* Compare the differences thus deduced with the second differences in the daily comparisons actually observed for the corresponding date. To deduce variations in the rates themselves we may reason as follows:

(1.) If none of the differences $b-a$, $c-a$, . . . have varied it may be admitted that the rate itself has not varied. Because, if the rate has varied it is almost impossible that the perturbations da, db, dc, . . . should all be equal and of the same value.

(2.) If one or several of the differences have not varied it may be admitted that the rates on which they depend have not varied. For in order that a difference $b-a$ should remain constant, while b and a both change, it is necessary that $da=db$, which is improbable.

(3.) If all the differences have varied there is no longer any probable rule to govern the corrections. In this case the change is probably due to the action of the screw, and if the effect of this action is once determined, it may be the same in a second case.

E. S. H.

2. *Earthquake wave of May 9th and 10th.*—This wave, some account of which is given on page 77, reached New South Wales

(according to a report from the Pacific Steamer, Australia) on the morning of the 11th of May (Australian time). At 5^h 20^s A. M. the tide guage at Fort Denison recorded the first of the series of waves. The oscillations continued through the day and reached their maximum at 2 P. M. the height then being three feet six inches. Telegrams from New Zealand report that similar waves were felt on the east coast, from the Bay of Islands to the bluff, commencing at 5 o'clock A. M. The maximum height was six feet.

3. *Tides of the Arctic Seas.*—These tides are mathematically discussed by Prof. S. Haughton in papers published in the Proceedings of the Royal Society, the last of which (Part vii) was read on the 17th of February last.

4. *Massachusetts Institute of Technology, Boston.*—In connection with this excellent institution, laboratories for the instruction exclusively of women were open for occupancy on the 23d of October last, and have been in successful operation through the winter and spring. The design is to afford facilities for the advanced study of Chemical Analysis, Mineralogy and Chemistry as related to Vegetable and Animal Physiology and to the Industrial Arts. The laboratories are excellent in arrangement and are furnished with all needed apparatus. The laboratory is under the charge and instruction of Professor John M. Ordway and Mrs. Robert H. Richards. The terms are $200 a year for a full term of eight months, six days per week. Students are also taken for one or two days per week.

5. *Transfer of the Shepard Collections to Amherst College.*—The scientific resources of Amherst College have recently been greatly increased by the acquisition of the large collections of minerals, meteorites, fossils, plants, etc., of Prof. C. U. Shepard. These collections have been for more than twenty-five years deposited in the Amherst College Museum; and while there they have been ever increasing in extent through the zeal and liberal outlay of Professor Shepard, until finally they had reached a value, according to his estimate, of full seventy thousand dollars, excluding the collections in zoology, botany and archæology. From good will to the Institution, with which Professor Shepard has long been connected, the whole are now transferred to the college for little more than half this sum. The collection of meteorites ranks fourth in the world, and no institution in this country possesses a superior collection of minerals.

6. *Imperial Academy of Sciences of St. Petersburg.*—This Academy has published Part I. of a detailed index volume to its publications, covering 490 8vo pages and including the articles in foreign languages.

7. *National Academy of Sciences.*—The Academy has recently published vol. I, of Biographical Memoirs, 344 pp. 8vo, containing memoirs of J. S. Hubbard, J. G. Totten, B. Silliman, E. Hitchcock, J. M. Gilliss, A. D. Bache, J. H. Alexander, W. Chauvenet, J. F. Frazer, J. H. Coffin, J. Torrey, W. S. Sullivant, J. Saxton, H. J. Clark and J. Winlock. Also volume I, of Proceedings of the Academy. 120 pp. 8vo.

8. *Bulletin of the Bussey Institution*, Vol. ii, Part 2. 80 pp. 8vo. Boston, 1877.—This number contains the following papers by F. H. Storer: (1) on the composition of certain Pumpkins and Squashes; (2) record of results obtained on analyzing seeds of Broom Corn; (3) record of analyses of several weeds that are occasionally used as food; Chemical composition of Blue Joint grass (*Calamagrostis Canadensis*) as contrasted with that of Reed Canary grass (*Phalaris arundinacea*); (4) remarks on American Fodder rations with hints for the improvement of some of them; (5) results obtained on growing Buck-wheat in equal weights of Pit-sand and of Coal-ashes; and the following by W. G. Farlow: Notes on some Common diseases caused by Fungi.

9. *Dynamics, or Theoretical Mechanics;* by J. T. BOTTOMLEY, M.A., F.R.S.E., F.C.S. 142 pp., small 8vo. New York, 1877. (G. P. Putnam & Sons.—This little work forms one of the volumes in "Putnam's Elementary Series." The fundamental principles of mechanics are presented with clearness and precision, without the introduction of difficult mathematics, and it is thus an excellent book for the class of students for whom it was prepared.

Eighth Annual Report of the State Board of Health of Massachusetts, January, 1877. 498 pp. 8vo, with several maps. A Report of high scientific value. The chief topics are: Pollution of streams; sewerage; sanitary condition of Lynn; registration of deaths and diseases; growth of children; disease of the mind (by Dr. C. F. Folsom); health of towns.

Science Lectures at South Kensington. The Steam Engine, by F. J. Bramwell. 62 pp. 12mo, with illustrations. London and New York, 1877. (Macmillan & Co.)

OBITUARY.

SANBORN TENNEY.—Sanborn Tenney, Professor of Geology and Natural History in Williams College, Williamstown, Mass., died suddenly, on the eleventh of July, at Buchanan, Michigan, while on his way to Chicago, the point of rendezvous of a Williams College exploraing party to the Rocky Mountains, of which he was the projector and leader. Professor Tenney was the author of valuable text-books on zoology and geology.

DR. STEPHEN REED.—Dr. Reed died on the twelfth of July at Pittsfield, Mass., aged seventy-six years. His name has been long connected with geological discovery in Western New England, and mainly through his account of a long train of bowlders across part of central Berkshire, which attracted Lyell and other geologists to the spot and has obtained a prominent announcement in all writings on North American drift.

C. F. WINSLOW, M.D.—Dr. Winslow, formerly of Boston, died recently in Utah, aged sixty-six years. He is the author of a work entitled "Cosmography, or Philosophical views of the Universe," published at Boston in 1853, also later of one on "Nature and Force;" and, besides, of short papers on some Earthquakes, in this Journal, and on the discoveries of human remains in California, and some other subjects.

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[THIRD SERIES.]

ART. XXII.—*On a new Process for the Electrical Deposition of Metals, and for constructing Metal-covered Glass Specula;* by Professor ARTHUR W. WRIGHT, Yale College.

IN a paper by the writer, published in this Journal, January, 1877, an account was given of a method of producing metallic films upon the inner surface of exhausted glass tubes, by the action of a succession of energetic electrical discharges. The thickness of these films could be varied, from a tenuity such that the coating barely gave indications of a metallic luster, and scarcely dimmed the intensity of transmitted light, to the point where perfect opacity was attained, by simply continuing the action of the current for a shorter or longer time. They were produced by forming the negative electrode of the metal to be deposited, exhausting the tube, and passing through it the current from an induction coil. The metallic coatings thus obtained, as seen from the exterior, were very brilliant, but the condition of the inner surface was not readily observed, and the nature of the process made it seem probable that they possessed a dull or even a frosted surface. With a view to obtain the films in a fo[illegible]etter suited for examination, a modification of the appa[illegible]was contrived, by which they could be deposited upon pieces of plane glass. At first this object was attained by inserting narrow slips of glass into the tube by the side of the electrode, in the manner suggested in my former paper, and very good results were gained. But, as the nearer portion of the plate[illegible]eceived a larger share of the metal, the thickness of the de[illegible]was not uniform, and it was found necessary to construct a special apparatus, in which the relative positions of the plate and the electrode could be varied, so as to give the latter an equal action upon all parts of the surface to be covered. The plan employed was as described in the following paragraphs.

A rather thick-walled glass globe about seven centimeters in diameter, blown upon the end of a tube twenty-five centimeters long and fifteen millimeters in diameter, was used to form the receiver. The top of the globe opposite the tube was cut off, so as to form an opening forty millimeters in diameter, and the edge ground flat, in a plane perpendicular to the axis of the tube. The end of the latter was drawn somewhat smaller in a gas-flame, and a glass stop-cock attached to it with cement. A little way above this, a platinum wire was fused into the glass to serve as the positive electrode. The cover of the vessel was made by cutting from a similar globe a portion corresponding in size to the part removed, but with the neck attached, the two pieces being carefully ground so as to fit closely. When they were placed together, a little cement applied to the outside along the line of juncture rendered the joint perfectly air-tight. The tube or neck of the cover was five centimeters long, and was also somewhat reduced at the extremity by drawing it smaller. Into this was cemented a small and thick-walled tube extending to a point near the center of the globe. A platinum wire was placed in this tube, and was fused in at the top, enough being left projecting to form a small loop for the attachment of the wire from the coil. The inner end of the wire terminated at about one centimeter from the lower end of the glass tube. Into the latter was slipped a wire of the metal to be deposited, which, in all cases, was the negative electrode,—the part within the tube being long enough to make good contact with the platinum wire, and being bent somewhat so as to cause it to retain its place by friction. In some of the experiments a different cover was used, made from a glass funnel, the neck of which was left somewhat longer to afford more room for the swinging electrode, as described below, and the tube carrying the latter was fitted into the top by grinding so as to make an air-tight joint.

For the support of the plate, a small watch-glass, about three centimeters in diameter, was employed, to one edge of which a thread of glass was fused by a blow-pipe flame, and then bent so as to form a loop by which it could be suspended like the pan of a balance. A small hook of glass was also attached to the side of the thick tube carrying the electrode, and upon this the pan was hung, the loop being so formed as to allow it to swing freely in all directions. The pan, when in place, was about fifteen millimeters below the end of the tube from which the electrode projected, the latter being adjusted to the proper distance by sliding it up or down in its support as occasion required. By slightly inclining the globe the extremity of the wire could thus be readily brought over any point of the plate. In some of the experiments the plate was stationary, being held in a little tripod of glass threads, or simply laid upon the bottom of the globe. In these cases the tube holding the electrode was jointed near the top, the two portions being connected by a hook and loop of platinum or magnesium wire. It could thus be made to traverse all parts of the plate by giving suitable movements to the globe.

When adjusted and closed the receiver was attached to the Sprengel pump. By means of a small air-pump of the ordinary construction, connected with this by a stop-cock and flexible tube, the whole apparatus was exhausted as far as possible and then dry hydrogen admitted, this being repeated two or three times in order to remove the air and moisture. The process of exhaustion was then completed with the mercury pump. The degree of rarefaction required varied somewhat with the metal to be deposited, but was rarely above 2·5 millimeters. For platinum the best results were obtained, when it was from 1·5 to 1·75 millimeters. The use of hydrogen is not in all cases necessary, as some of the metals can be deposited perfectly well with only air in the receiver. This is especially the case with gold, but platinum, although ordinarily not easily combined with oxygen, becomes tarnished with a film of what apparently is the blue oxide, unless the air is removed. The electrode itself was formed of a small wire, usually not more than one-fourth of a millimeter in thickness, bent at the end into a circle three or four millimeters in diameter, the plane of which was perpendicular to the straight portion of the wire entering the glass tube, and parallel with the surface of the glass plate situated beneath it. Its distance from the latter was generally about three millimeters, though considerable variations were possible. When it is farther away the process of deposition goes on much more slowly, though the results are in most cases quite as good as when it is nearer. After the process of exhaustion was completed, the stopcock was closed, and the apparatus removed from the pump, for greater convenience of manipulation in applying the current.

The electrical apparatus employed consisted of an induction-coil capable of giving sparks four or five centimeters in length, and a battery, the power of which could be varied according to circumstances. It consisted usually of pint Grove cells, from three to six in number, not completely filled, or charged with rather weak acid, and a plunge battery of five cells, of which one, two, or more were used, as occasion required, the whole being joined in a continuous circuit. By immersing the plates of the plunge battery more or less, as well as by varying the number in the circuit, the strength of the current could readily be changed within the limits desired. The various metals required currents of different strength, and the power best suited to each had to be determined by trial. It was found advisable in most cases to regulate it so that the temperature of the electrode was below that of a red heat, or such as barely to redden it. Of course with the more fusible metals it was necessarily much lower than this. The metal is actually volatilized by the discharge, as is shown by the fact that the characteristic lines of its spectrum may be seen with a spectroscope, and the film is formed by the condensation of its vapor upon the cooler glass surface. For the production of films with brilliant surfaces, the strength of the current must not be great enough to give the discharge a disruptive character, as this separates some of the metal in the form of powder.

The primary object of the experiments was to obtain films of the different metals upon thin pieces of flat glass for the purpose of investigating some of their optical characters. The apparatus proved to be perfectly successful in its operation, and beautiful films of gold, silver, platinum, and bismuth, were obtained with ease and certainty. As has been mentioned, it seemed probable that the surface of deposit would be dull, but the first trial showed that this anticipation was incorrect, and the films when removed from the receiver exhibited surfaces of exquisite perfection and the most brilliant polish. They can only be compared to the surface of clean liquid mercury, far surpassing in luster anything that can be obtained by the ordinary methods of polishing.

This circumstance suggested at once a valuable application of the process in the production of specula for optical purposes, and the subsequent investigations were directed to this end. The mirrors first made had been formed upon disks of thin glass, such as are commonly used as covers for microscopical objects, those being selected which were most free from defects, and had the best surfaces. By means of a very delicate assay balance, the weight of the glass disks, both before and after receiving the deposit could be obtained to the one hundredth part of a milligram, and hence it was easy to calculate the thickness of the metallic layer in any instance. By this means the relative transparency of the different metals can be determined, and the relation between the amount of light transmitted and the thickness of metal traversed by it. The more particular consideration of these and some other matters of interest as bearing upon the optical characteristics of the metals is deferred to another place, and it is only necessary to mention here the results of some measurements which were made in order to determine the limiting thickness of a film in regard to the transmission of light, that is, the thickness of a film which would allow only an inconsiderable proportion of the incident rays to pass through. As the metallic luster is developed gradually with the increasing amount of metal, showing conclusively that light actually penetrates these substances to a certain depth, it was important to ascertain whether the thickness of the layer, sufficient for a virtually complete reflection of light, would be great enough to affect perceptibly the figure of a mirror of glass upon which it was laid down.

Experiments for this purpose were made with gold and platinum, and the process of deposition was continued until the films appeared to have just reached the condition of complete opacity. On removing them from the receiver, however, it was found in both cases that a very small amount of light was still transmitted, as, on holding them close to the eye, a brilliant object, like the sun or a bright flame, could be seen through them. The thickness of the gold layer was found to be 0·000183 mm., that of the platinum 0·000174 mm., or approximately one-fourth the length of a wave of light at the red end of the spectrum. The gold, although thicker than the platinum, transmits perceptibly more light, showing that it is the more transparent of the two metals. As the films employed for mirrors may be much thinner than the amount mentioned without an appreciable diminution of the intensity of reflected light, it is evident that the figure of a perfectly wrought glass mirror will not be changed, when the metal is uniformly deposited, to such an extent as to affect its performance unfavorably. A platinum film of one-fifth the thickness of the one described forms a brilliant mirror, transmitting but a very small percentage of light. The perfect control of the process obtained by the use of the movable electrode will even make it possible to apply the method of local correction for the improvement of a defective figure, or to parabolize a spherical mirror by depositing the metal in a layer increasing in thickness toward the center, though, of course, it would be better to avoid a somewhat tedious operation by securing the perfect form of the glass beforehand.

Of the metals that are suitable for the formation of specula, platinum appears to be the most valuable. For while, when well polished, it is but little inferior to silver in reflecting power and freedom from color, it does not become tarnished by oxidation or the action of sulphurous gases, and when dulled by atmospheric deposits the surface can be cleaned by washing with water or with acids, which is an important advantage. By the method here described it can be deposited upon glass surfaces very easily, and a mirror of the most perfect surface produced at once, without the necessity of a single touch to complete it. Several such mirrors have been made in the course of these experiments, by the use of concave glass lenses, with the most satisfactory results. The metal film adheres strongly to the glass, and when of sufficient thickness appears to be very firm and hard. In mirrors silvered by the ordinary method, trouble is often experienced from the insinuation of moisture between the glass and the metal, resulting finally in the separation of the latter. In those prepared by the new process the adherence of the film is so close as to render such an effect impossible. As a test of this, a small silvered speculum was placed in a beaker of water where it remained for two weeks, and besides this was wetted and dried repeatedly, without showing the slightest tendency to suffer the penetration of the moisture. Similar results were also obtained with platinum and gold films.

With silver the process likewise succeeds well, but it is more difficult to obtain good surfaces than with gold or platinum. The metal is volatilized with extreme ease by the action of the current, and the energy of the discharges must not be too great. Of several trials made with this metal the most successful was one in which not only the degree of exhaustion of the receiver was less than had been employed in other cases, being only to three millimeters, but the electrode was more distant from the plate, and the battery weaker. The action proceeded slowly in this instance, but with the result of producing an excellent film. With a stronger current the deposit is rapidly made, and has a fine luster, but the surface has a yellowish color. This is perhaps partially due to a slight degree of oxidation, but also appears to be owing in part to the deposition of a portion of the metal in the form of fine powder, the vapor of the silver as it streams from the electrode toward the more distant portions of the plate becoming partially condensed, and falling on it in minute particles. That such a result would follow from this cause was shown by some of the experiments in which a rather strong battery was employed. The whole interior surface of the globe was in a short time covered with the powdered metal, appearing an intense purple where thinnest, and shading gradually to deep blue where thickest, the color being the same by both transmitted and reflected light. The metallic luster was wanting, though it was readily developed when a portion of the powdery coating, which was easily removed, was rubbed against the surface of the glass with some pressure. The defect was, to a considerable extent, remedied by surrounding the electrode with a small glass tube projecting some three millimeters beyond it, so as to clear the surface of the plate by an interval of only one or two millimeters. This had the effect to cut off the lateral portion of the discharge, and to confine its action to a limited area immediately below the extremity of the wire.

The yellow tarnish is removed with the greatest ease by gently rubbing the surface with soft chamois leather and a little rouge, and the metal is so hard, that, when this operation is performed with care, the polish is not at all, or but very slightly, affected. Even then, however, the metal is not perfectly white, having still a very faint yellow tinge. It is well known that silver is not a perfectly white metal, for light which has undergone repeated reflections from polished surfaces of this metal appears yellow or reddish-yellow, though this color is not perceptible when the light has undergone but a single reflection. But the real cause of the yellowish tint may possibly be found in the very tenuity of the films, which when prepared in this way have a beautiful and intense blue color by transmitted light. When not too thick, the amount of blue rays which they suffer to pass, may be sufficient to cause, by their abstraction, a perceptible tinge of yellow, the complimentary color, in the reflected rays. If this were really the case, the coloration should grow weaker with an increase of thickness, and disappear when opacity is reached. Some of the results obtained seem to favor this view, and the probability of its correctness is strengthened by the facts related in the next paragraph, but further experiments are needed to decide the question satisfactorily.

One result of the investigation has been to show that the color of the light which has passed through a layer of metal varies somewhat with the thickness of the film. This was known to be the case with gold, and experiment has shown it to be true of platinum and bismuth also. Thus the latter in a very thin film appears a clear bluish-gray, while a much thicker film appears brownish. Platinum in a thin layer has a grayish tint, which varies, as the film is made thicker, to a peculiar brownish shade, somewhat like that of sepia, passing into brownish yellow, and finally becoming a deep yellow, even inclining somewhat to orange. in the thickest films obtained. Now this color is almost exactly complimentary to that transmitted by silver, and the possibility suggested itself of making a mirror which should be perfectly white by reflected light, by depositing first a thin stratum of silver and over this another of platinum, the relative thickness of the two being properly regulated by observing the color of the transmitted light. An experiment made with a circular disk of flat glass was perfectly successful, the platinum being readily deposited upon the silver, the yellowish tint of which it entirely removed, producing a white and brilliant reflecting surface. By transmitted light the film, as it was anticipated would be the case, has a pure neutral tint, with no perceptible color of any kind.

The value of such a combination for specula is evident, for though until careful measurements are made, it cannot be asserted that the absolute reflecting power is increased, the whiteness of the layer, and the protection afforded by having the surface covered with an unalterable metal, are very substantial advantages. In constructing large mirrors it will probably also be found to result in a material saving of time, the silver being so much more rapidly and easily deposited than the platinum. The process can also be used with great advantage for the construction of solar eye-pieces for telescopes, since the compound film can be deposited directly upon the surface of the lens, and made thick enough to reduce the intensity of the light as much as may be desired. An image, nearly or quite colorless could thus be obtained, and the disturbance of the rays should be less than that produced by the interposition of a dark glass of the ordinary kind.

As has been mentioned, some experiments were made with bismuth, and a mirror of excellent surface was obtained, but the metal is inferior to platinum in brilliancy, and has a decided color. The great facility with which films are obtained with it might recommend its use for mirrors in some cases, but for most purposes other metals are to be preferred. Attempts to produce mirrors of iron and nickel were but partially successful, as it was difficult to prevent tarnishing by oxidation. Some good iron films were obtained, however, which were very brilliant. They were exceedingly hard, and adhered to the glass with such tenacity that at first it seemed as if they had been fused into it. But when the film was dissolved off by an acid the glass was found not to have been acted upon at all. A singular characteristic of the iron in this condition is its chemical inertness. Films prepared more than six months ago and freely exposed to the air, which for a part of the time too, was excessively charged with moisture, have not shown the least alteration. Nitric acid placed upon one of them for a short time produced scarcely any effect, and nitro-hydrochloric acid acted upon it with about the same readiness as it does upon platinum. This may be due to the extreme thinness of the film, in consequence of which, even the exterior atoms of the iron, being within the range of the molecular action of the glass, are held by a force tending to oppose and neutralize the attraction of reagents that ordinarily attack the metal energetically.

It is not at all necessary that the object upon which the metal is deposited should be of non-conducting material. This is shown by the fact that the process continues to go on after the glass has become covered with a perfectly continuous layer of metal of considerable thickness. The success of the experiment of covering a silvered glass with platinum is additional evidence of the same fact. In order more fully to test the question whether a deposit could be made upon a solid piece of metal, a small silver coin was placed in the pan under an electrode of gold. It was covered in a few minutes with a beautiful coating of the latter metal, which was found to be very hard and to adhere perfectly, having also, in every respect, its proper color and luster. At the beginning of the process, while still thin enough to allow light reflected from the silver to pass, it had a greenish color, producing a curious effect.

As an example of the applicability of the process to practical purposes, it may be of interest to mention the results of some experiments in the construction of a small Gregorian telescope, the specula of which were covered with platinum by the method described, and with entire success. The larger mirror has a diameter of a little less than four centimeters, and both this and the smaller one, so far as the nature of the surface is concerned, appear absolutely faultless. As only common lenses were employed in its construction the performance of the instrument is not remarkable, but it is sufficiently good to warrant the assurance that the method will be serviceable for the production of specula of exquisite quality for optical purposes. The size of the apparatus, which, for convenience in experimenting, was necessarily small, did not permit the introduction of larger mirrors than this, but there seems to be no reason for doubting that much larger specula can be successfully made in this way. The amount of time required for obtaining the platinum covering of this mirror was about three hours, during which the coil was kept in continuous action, with a battery power equivalent to four or five small Grove cells. Mirrors of larger size would of course require a longer time, but with suitable apparatus a much stronger battery and larger coil could be used, which would materially accelerate the operation. A plate two centimeters in diameter can be covered with platinum in twenty or thirty minutes sufficiently thick to form a good speculum. For gold or silver the time would not be more than from ten to fifteen minutes.

Many useful applications of this process may be found, and its use is not limited to those metals which have been mentioned here. Moreover for many of them no other available process is known by which they can be deposited in a uniform layer and with a brilliant reflecting surface upon glass. A very thin layer of platinum, or still better of silver and platinum together, could be used with great advantage in the *camera lucida* and similar instruments. Very perfect mirrors for galvanometer needles, and for delicate torsion apparatus, can be expeditiously formed in this way, and by the use of very thin glass, or the most delicate films of mica, they may be made of almost inappreciable weight. For the mirrors of heliostats, and other reflecting instruments in which a metallic surface is necessary, the specula produced by this method will be especially valuable. For telescopes, the beautiful process of Liebig and Foucault, for forming silvered glass specula, is recommended by the ease with which it is applied, and the rapidity of its operation. But the perishable nature of the delicate silver film, and the difficulty of securing a firm and permanent adherence, are serious disadvantages. These are entirely avoided by the use of an unalterable metal like platinum; and though for instruments of the largest size the process here described may be found impracticable, for those of more moderate dimensions there is every reason for believing it may be employed with complete success. The labor and time required for its application are indeed drawbacks; but there is compensation for this in the important circumstance that the mirror comes out of the receiver with a surface of inimitable perfection, which would in fact only be injured by any of the ordinary methods of polishing.

Yale College, August 8, 1877.

ART. XXIII.—*A new and ready method for the Estimation of Nickel in Pyrrhotites and Mattes;* by MARGARET S. CHENEY, and ELLEN SWALLOW RICHARDS.

WE had occasion several months since, to make a number of determinations of nickel in mattes where, for commercial reasons, the element of time was of considerable importance. Our attention was thus called to the various processes which have been recommended for the separation of nickel from iron, and we have submitted these processes to comparative tests, but no one of them seemed perfectly satisfactory for our purpose.

The method most commonly used, perhaps, depends upon the separation of iron as a basic acetate. (Fresenius, page 363.) This method requires considerable analytical skill and practice in its use. The large dilution and subsequent evaporation necessary render the operation a tedious one, even without the repeated re-precipitations which are indispensable to a complete separation.

The method based upon the behavior of neutralized solutions at the boiling point (Fresenius, page 362), which we personally prefer to use, is open to the same objections. The process of separating the iron by ammonium hydrate, even with all the precautions recommended by various authors, has given very unsatisfactory results in our hands. By far the best success was obtained in the use of the method given by Frederick Field, in the Chemical News, vol. i, page 5 (1859). The method is as follows:

"In the case of nickel and iron, the nitrates are evaporated nearly to dryness, and, after the addition of water, oxide of lead (litharge) is added, and the whole boiled for ten minutes or a quarter of an hour. The iron is entirely precipitated, the nitrates of nickel and lead remaining in solution. After filtration, which can be effected with great readiness, dilute sulphuric acid is added, and on standing for sixteen hours the sulphate of lead is filtered off, and the nickel precipitated and estimated in the usual manner."

This process uniformly gave good results as to the separation of iron and nickel, all the nickel being left in solution. The presence of lead in the solution was somewhat undesirable, the results being too high if the nickel was weighed as oxide, and much more caution was required in the battery precipitation. All these methods require two or three days, and the quantity of the ore or matte to be operated upon is limited, usually two to four grams.

Among the numerous tests made for a more ready way were those depending upon the solubility of the sulphates in alcohol and upon the behavior of the oxalates, but no satisfactory results were reached. Finally a systematic series of tests was made with the phosphates, in the course of which it was found that phosphate of nickel is completely soluble, while phosphate of iron is almost insoluble in acetic acid, in the presence of an excess of phosphate of soda. Upon this fact, which we had not found mentioned in any work that we had consulted, we based the following process.

The ore or matte is dissolved in hydrochloric acid with the addition of a little nitric acid. All the metals of the arsenic and copper groups, if present, are separated by means of hydrogen sulphide with the usual precautions. The filtrate is boiled to drive off the excess of hydrogen sulphide, the iron is oxidized by nitric acid, and ammonium hydrate is added until a permanent precipitate begins to form, but not until complete precipitation is effected. Acetic acid is then added until the precipitated ferric hydrate is redissolved and the liquid is of a deep red color, though not transparent. To this boiling hot solution ordinary phosphate of soda is added in excess, and the nearly white precipitate is filtered and washed with hot water containing acetic acid. The filtrate is heated nearly to boiling and caustic potash added until the odor of ammonia is distinctly perceptible. The apple-green precipitate of phosphate of nickel is partially washed, dissolved in a little *dilute* sulphuric acid, the solution rendered strongly alkaline by ammonium hydrate and the nickel precipitated by the battery.

If the ore contains more than three per cent of nickel, it is necessary to dissolve the precipitate of phosphate of iron in hydrochloric acid, dilute this solution somewhat, render it nearly neutral by ammonium hydrate, add twenty-five or thirty cubic centimeters of acetic acid, and re-precipitate by phosphate of soda. The filtrate is added to the first filtrate. If the solution has been rendered alkaline before the addition of acetic acid, or if an insufficient quantity of phosphate of soda has been used a small amount of iron will remain in the solution, not enough, however, to interfere with the battery precipitation of the nickel. The solution of phosphate of soda should be a saturated one, and, if it is heated separately, the troublesome boiling of the bulky precipitate is avoided. By the aid of the filter pump this precipitate is readily filtered in spite of its unpromising appearance.

The advantages of this method are: 1st, the concentration of the solution. It may contain ten to fifteen grams of ferric oxide in a half liter, instead of one gram as in the basic acetate method, and thus larger quantities of a poor ore may be operated on. 2d, A great saving of time. The nickel may be weighed in eight or ten hours from the time the ore is pulverized and ready for solution. This saving of time is mainly due to two causes. First, less care is required in case of precipitating as phosphate than as basic acetate. Second, in precipitating phosphate of nickel by caustic potash it is not necessary to concentrate the solution nor to expel all the ammonia as is the case in precipitating as hydrated oxide. An unexpected advantage is the more ready battery precipitation of the nickel from the solution of the phosphate.

Two of the so-called quart carbon cells, each half filled with the solutions (bichromate of potassium and sulphuric acid) were found quite sufficient to precipitate the nickel completely in two hours. If a strong current was used, the nickel was precipitated in a black, spongy form.

A solution containing ·375 grams Ni as chloride, and 1·183 grams Fe as chloride was made up to 250 c. c.

	Found.	Theory.	per cent.
100 c. c. of which	·1486	·150	99·06
100 c. c. "	·149	·150	99·33
50 c. c. "	·0748	·075	99·73

To the first portion, the phosphate of soda was added first, and the acetic acid afterward.

		per cent.	
Matte No. 1 gave	(phosphate method)	6·77	Cheney.
	" "	6·86	Richards.
	" "	6·48	
Matte No. 2 "	(neutralized solution)	2·08	Richards.
	" "	2·37	
		2·15	Cheney
Matte No. 3 "	(phosphate method)	7·22*	Richards.
	" "	7·41†	Hardman.
	(basic acetate)	7·79	Hardman.
Pyrrhotite No. 1	(basic acetate)	·32	Hardman.
	" "	·29	
" "	(phosphate method)	·33	Cheney.
		·25	
Pyrrhotite No. 2	(phosphate method)	·725	Richards.
		·686	

Massachusetts Institute Technology, Woman's Laboratory, June, 1877.

ART. XXIV.—*Notes on the internal and external structure of Paleozoic Crinoids*; by CHARLES WACHSMUTH.

(Continued from page 127.)

5. *The construction of the summit and its value in classification.*

THE construction of the ventral disc or actinal side of the calyx has heretofore received less attention than almost any other part of the Crinoids, and thereby an important aid to classification has been overlooked. I think it affords a clear and most important distinction between recent and ancient Crinoids, and shows that they fall naturally into two great divisions or groups. This view, although it does not agree with the opinion of other authors, who, in their classifications, have placed a number of Paleozoic genera in the same group with the recent Crinoids, is, as I hope to show, well founded.

Dr. F. Roemer, in the Lethæa Geognostica, 1855, p. 227, divides "*the true Crinoids*, which are supported by an articulated or jointed column" into two divisions:

a, Crinoids in which *the ventral side consists of a soft skin.*

b, Those in which *the ventral side is covered by solid immovable plates.*

Rœmer includes with the former group, *Pentacrinidæ, Apiocrinidæ, Eugeniacrinidæ, Encrinidæ, Cupressocrinidæ* and *Cyathocrinidæ.* This division seems to have been based on mere conjecture, since a membranous ventral surface has been observed only in the Pentacrinidæ and the recent Crinoids generally,

* Mrs. Richards lost a portion of the washings by the breaking of a beaker.

† This was Mr. Hardman's first trial of the phosphate method and not enough phosphate of soda was added to produce a *white* precipitate.

though it is probable that *Eugeniacrinus* and several allied genera had that summit structure. In the Apiocrinidæ and Encrinidæ however, the general construction of the dorsal or abactinal parts, the massive plates, both of calyx and arms, indicate rather a closer relationship with the ancient Crinoids and suggest the existence of a solid dome. The latter becomes more probable since a solid vault has been discovered in *Belemnocrinus.* This genus is in its generic formula and general form almost identical with the recent *Rhizocrinus*, which on the contrary is covered by a soft peristome. Both are closely related to *Apiocrinus; Belemnocrinus* particularly has the same heavy body plates and the small visceral cavity, and it appears to me that *Apiocrinus* is more nearly allied to the Paleozoic type than to the recent *Rhizocrinus.*

The *Cupressocrinidæ* and *Cyathocrinidæ* are the only groups from Paleozoic formations which Rœmer places in his division *a.* Dr. Schultze, who adopted Rœmer's classification, included in the *Cupressocrinidæ* the genera "*Synbathocrinus* Phill. and *Phimocrinus* L. Schl.," in which he is undoubtedly correct, for stronger reasons even than he himself perceived. These two genera agree with *Cupressocrinus* not only in the simplicity of their arms, but also in the so-called "consolidating apparatus," which he describes and figures in the latter. The apparatus is placed horizontally in *Cupressocrinus*, upright and turbinate in the two other genera. When the consolidating plates in *Synbathocrinus* are preserved, the ventral side appears to have two separate apertures, a lateral proboscis and a central mouth. And so the genus was originally described. This is, however, a misconception. By removing carefully all the arm joints from a specimen of *Synbathocrinus*, I discovered the central aperture perfectly covered with a number of small plates, and to this summit, as it might be called, were attached narrow lateral extensions, composed of alternating pieces, which passing downward, covered the little grooves that lead to the arm furrows. The consolidating apparatus here forms in fact a part of the solid vault. It is reasonable to conclude, that in the allied genera *Cupressocrinus* and *Phimocrinus*, so closely related to *Synbathocrinus* otherwise, the central opening was closed, and that the consolidating plates were further overlaid with plates forming the floor of a passage in connection with the arm furrows and visceral cavity. The small plates which extend out to the arms are in the specimen but partly preserved and the connection with the arm-furrow is interrupted, but there can be no doubt that the channel underneath contained the food groove and ambulacral canal which I have described in *Cyathocrinus.* The covering of the central opening of *Synbathocrinus* resembles in a remarkable degree that of the central aperture of the *Blas-*

toids, and it seems to me highly probable that the consolidating plates are homologous with the partly hidden deltoid pieces of the latter.

Among the Cyathocrinidæ, Rœmer included genera of widely different types. Besides the typical one, he enumerates nine genera, only two of which, *Heterocrinus* and *Graphiocrinus*, have the characteristics of the *Cyathocrinidæ*, and both of them evidently possess a solid dome, as is proved by their heavy proposcis. All the remaining genera belong to other groups. *Macrostylocrinus* resembles *Ctenocrinus* Bronn, and *Cytocrinus* Rœmer so closely, that they may yet prove to be identical. Rœmer, however, places *Ctenocrinus* with *Glyptocrinus* among the Crinoids with a solid dome, and *Macrostylocrinus* among the *Cyathocrinidæ*. *Macrostylocrinus* is allied to *Melocrinus*, and has undoubtedly a similar summit structure. The same may be said of *Schizocrinus* and *Dimerocrinus* which are not at all related to *Cyathocrinus*.

The genus *Cyathocrinus* was originally described by Professor Phillips and Mr. Austin as having a separate mouth and vent, which was considered by these authors and others to be its chief distinction from *Poteriocrinus*. Accordingly, all species with a proboscis or solid dome, though otherwise agreeing with *Cyathocrinus*, were referred to *Poteriocrinus* or some allied genus. Meek and Worthen, however, proved in the Geological Report of Illinois, vol. v, p. 325, that in perfect specimens, the central opening is closed. The covering of *Cyathocrinus* is exceedingly interesting, and throws light upon the summit structure of many genera. I shall herein refer frequently to Meek & Worthen's excellent figures, vol. v, Plate IX, figs. 13 and 14.

Looking only at fig. 14, one would at first naturally suppose there must have been, during the life of the animal, two distinct openings in the vault. But on examining it more critically and comparing it with fig. 13, it will be found that fig. 14 represents simply the consolidating apparatus as figured by Rœmer and Schultze in *Cupressocrinus*, placed here exactly as in that genus, and consisting of five large pieces, alternating with the upper edges of the first radial plates. The plate of the anal side is larger than the others and forms the base of the inner side of the proboscis. The five pieces which connect with each other laterally, extend inward for some distance, but not so far as to meet in the center where there is a semi-circular or heart-shaped opening. Along the sutures, between the five plates, a comparatively large furrow from each arm base extends inward and leads to the central opening. Examining now fig. 13 we find the general aspect of the ventral disc entirely changed. The lateral opening has been transformed into the base of a proboscis, and the consolidating plates are partly covered, leaving but a small uncovered space in the form of a delta in the interradial areas. The central opening is vaulted over by a number of various sized pieces, the largest one occupying the side toward the proboscis. The shallow groove between the sutures of the consolidating plates is arched by a double series of alternating plates, forming underneath a passage for the ambulacral canal and food groove. The vault, thus closely resembling that of *Synbathocrinus*, was in all probability arranged on a similar principle in *Cupressocrinus*. The same plan, with slight modifications, prevailed in *Poteriocrinus*, *Scaphiocrinus* and all genera with an *inflated or balloon-shaped ventral sac.* Among the latter, the center of radiation is frequently found to be pushed toward the anterior side, so that owing to the great size of the sac at its junction with the dorsal cup, it does not occupy the center of figure.

Among all groups of Crinoids, the *Cyathocrinidæ* undergo the least amount of change in the course of time. They are represented in the lower Silurian by several genera, and *Cyathocrinus* is the only genus recognized in the Permian. In all intermediate formations, we find Crinoids with five basals, five subradials and five radials, and it is worthy of note that the *Cyathocrinidæ*, in the structure of their vault, bear closer resemblance to the recent Crinoids than almost any other group, and seem to hold an intermediate position between modern and Paleozoic types. If the alternating plates, covering the furrows, could be turned back at the vault by the animal, as the Saumplatten of the arms, then the food groove of these Crinoids was open throughout, as in recent forms. This might possibly have been the case in *Cyathocrinus Iowensis*, but I even doubt it here, as the corresponding plates in other closely related species, though arranged upon the same fundamental plan, present rather an aspect of true vault pieces. The *Cupressocrinidæ* and *Cyathocrinidæ* thus fall naturally into a group by themselves, having the vault supported by consolidating plates, and covered by an immovable arch of small plates.

The next group is one in which of all Paleozoic Crinoids the vault is least known, including *Taxocrinus*, *Forbesiocrinus*, *Onychocrinus*, *Ichthyocrinus*, *Lecanocrinus*, and probably other genera. The *Taxocrinidæ*, for such I will call them, have hitherto been described as being covered with some soft material instead of solid plates, even by Dr. Schultze, though he describes and figures a *Taxocrinus* with a long heavy plated proboscis, which could not have been supported upon a soft skin.* In this

* I believe Dr. Schultze is mistaken in referring his *T. briareus* to *Taxocrinus* as it lacks all the characteristic features of the genus. Its rather large subra-

group, the plates of the radial series are indented on their upper margins more or less deeply for the reception of a protuberance from the lower side of the succeeding plate. The indentation of the upper margin does not extend throughout the thickness of the plate, and in *Forbesiocrinus*, it is filled by a superficial patelloid plate, which is separately articulated and sometimes anchylosed with the outer margin of the plate above. This peculiarity exists not only in the arm plates, but is conspicuous in the radials, thus producing apparently an articulate structure of the whole skeleton and indicating some degree of flexibility in the body as well as the arms. The interradial portions appear sometimes depressed, and in other cases swollen or bulged out, showing that they probably yielded to a moderate expansion or contraction of the body walls, due to the mobility of the radial parts which likewise involves a flexibility of the summit. I have not been so fortunate to find the summit of any of these genera perfectly preserved, but I feel convinced from what I have observed, that it did not consist of a soft skin. In *Onychocrinus*, the genus which possessed evidently the greatest expansive power, the radial plates are frequently found spread out horizontally, and I have found toward the inner or ventral side of the radials, rather large imbricating plates, to which smaller ones are attached which connect with the plates of the interradial series, and which decrease in thickness inwardly. In several specimens I found the inner part or center of the disc covered by a number of thin, very small plates, whose arrangement could not be made out, but it is highly probable from their size and shape, that they formed a kind of scaly integument which was pliant and flexible, thus facilitating a contraction or expansion of the dorsal portions.

The close relationship existing between *Onychocrinus*, *Forbesiocrinus* and *Taxocrinus*, renders it almost certain that their summit was similarly constructed. In *Ichthyocrinus* the peculiarities in the radial portions are less strongly marked, and the genus has no interradial plate, but as it agrees otherwise so nearly with *Taxocrinus* that it is sometimes difficult to separate them, we may feel sure that this *Silurian* genus forms no exception to the general rule, but that its mouth was covered as in other Paleozoic Crinoids.

That the summit in several genera has not been discovered is no proof that it consisted of soft material. During the eighteen years that I collected at Burlington, I obtained several hundred of the most perfect specimens of *Cyathocrinus*,

dials, the large first-radials as compared with the succeeding radials, the single anal plate upon which the heavy proboscis rests, indicate that it belongs to *Cyathocrinus* or some allied genus. His *T. gracilis* may prove to be *Graphiocrinus* or *Scaphiocrinus* (?).

some of them as perfect in most of their parts as if dredged from the ocean, but only two specimens have been discovered in which the summit was preserved, and only a single *Scaphiocrinus.* That this could happen at a locality where even the finest tissues of the most delicate internal organs are preserved, is somewhat astonishing, but yet it can be accounted for by the fact that the pieces which cover the central opening, as also the small alternating plates forming the ambulacral canal, are very thin and that they rest but partly upon the consolidating plates, being thereby rendered insecure and liable to removal by any accident, even with very small force. Moreover the arms of the *Cyathocrinidæ* are generally attached, and the ventral disc thus hidden from view. In specimens in which the arms are destroyed, their destruction almost invariably involved that of the entire ventral side, and so delicate are these parts, that even when the arms are well preserved and so situated as to expose the dome, the plates are nearly always gone, or are found in a confused mass inside the calyx.

I come now to another group in which on the basis of the summit structure, such apparently diverse forms are included that I am under the necessity, very unwillingly, of making a name for it. It includes the families *Actinocrinidæ*, *Platycrinidæ*, *Rhodocrinidæ*, *Melocrinidæ*, and the genera *Schizocrinus*, *Dimerocrinus* and *Macrostylocrinus*, which Rœmer has ranged among the *Cyathocrinidæ*, and I call it provisionally the *Spheroidæ*, from the form of the calyx which is generally somewhat spherical. This large group, embracing over one hundred genera and ranging from the base of the Silurian to the top of the Subcarboniferous, is capable of accurate definition, is easily distinguished, and fortunately the summit is very commonly found well preserved in most of the genera.

The summit is composed of heavy, frequently nodose plates, closely cemented together, so as to form a *free arch* (not supported by consolidating plates), which rests like a hemisphere upon the dorsal cup. The plates of the summit, which at first sight exhibit great apparent diversity, are arranged throughout upon one and the same fundamental plan. Beginning with genera that have but few vault pieces, we find in them the median portion occupied by one large center plate, surrounded by six others, four large ones of equal size, and two smaller ones. The four large plates join laterally and are often placed directly to the center piece. In very large species and sometimes in very old specimens, the plates are separated by small polygonal pieces, but easily recognized by their size. Two of the four plates lie above the interradial series adjoining the anterior ray, the two others, one at each side, are placed between the two lateral rays. The two smaller plates are separated from each other by anal plates or by the proboscis. These seven pieces which I will call the "*apical plates*," are easily recognized by their greater prominence and size in species with comparatively few summit plates and a lateral anal aperture; but their identification is more difficult in species in which a subcentral proboscis is placed between the two small plates, and the whole vault looks like an immense proboscis. In these forms, the four large plates, together with the two smaller ones, are pushed toward the anterior side of the specimen, while the center plate rests with one side against the proboscis.

There are other summit plates following a radial direction, which are either attached to the apical pieces or separated from them by a belt of small polygonal plates. Their number, which varies greatly in different species, depends upon the number of primary arms that spring out directly from the body, no matter how often the arms branch afterward. In species with only two arms to the ray, each ray has two rows of corresponding plates in the dome, one large bifurcating plate forms the upper row, three plates the second row; two of the latter are brachial plates, the third one is an inter-brachial plate separating the two arms. In rays with three arms, there are eight plates in three series. The upper series consist of one large bifurcating plate which evidently corresponds with the third radial of the dorsal side. The second series, corresponding to the secondary radials, is composed of two plates, the plate toward the division with two arms being as large as the plate of the upper series, and the one toward the single arm much smaller. The third series is formed by three brachial and two interbrachial plates. In species with four arms to the ray, both radial pieces of the second series are large, and from each of them there originate two brachial pieces. As a general rule, the summit plates increase in proportion to the number of primary arms of a species in the same manner and on the same principle as the plates of the dorsal side. Every radial from the third radial upward has a corresponding plate on the ventral side, and additional interbrachial plates between corresponding brachial plates above the arms. Therefore in adult specimens, with some little practice, the number of arms can be ascertained nearly as well from the dome as from the dorsal side. The number of vault pieces is enormous in some genera, especially if the radials branch off alternately, as for instance in *Strotocrinus*, where some species have 120 to 180 arms. In looking at a full grown specimen, with its many hundred apparently irregularly arranged vault pieces, one would scarcely expect to be able to discover that this construction, in nearly all the Paleozoic Crinoids, is based upon a definite plan, and that plan the same as prevails below the arms.

That this is the case may be successfully demonstrated in the *young Strotocrinus* which has comparatively fewer summit plates.

The young specimen, in genera with numerous arms, has fewer arm openings than the adult, though both have the same number of arms. This is best observed in the young *Strotocrinus.* Here, the basals, primary radials, first anal and first interradial pieces are comparatively large, while the higher series of interradials are yet absent or but slightly developed. The radials of the higher orders, which in adult specimens form a part of the body, are in young specimens free arm plates, unsupported by any interradial or interaxillary pieces. The arms, therefore, which spring directly from the body in adult specimens, in the young branch alternately right and left after emerging from the body, the spaces between the bases of the branches being subsequently filled by the upward growth of the body, so that the branching, instead of occurring in the free arms, seems to be completed in the body walls. So, for instance, the young *Strotocrinus umbrosus* has at first but four arm openings to the ray, at a later period it is found to have eight, and in the adult state twelve, being a separate opening for each arm.*

The rule, that the number of summit plates increases in proportion to the number of primary arms, holds good with reference to the young specimen. The young *Strotocrinus* has fewer plates than the adult individual (the difference being in proportion to the state of growth), and these are arranged in the same order, and are as easily recognized as those of the simplest species of this group. The apical and principal radial pieces are larger than the intervening interradial plates which, exceptionally in this genus, attain by age the same size as the apical and radial pieces. *The interradial plates* of the vault occupy the intermediate spaces between the radial areas. As their number depends greatly upon the age of the individual, they vary often in the same species. In species with but few arms, we find comparatively few interradials, and those are generally smaller than the other plates. The latter is especially true in young specimens, as also in small species. Sometimes, as for instance in some *Megistocrini* and all *Rhodocrinidæ*, the greater part of the summit is covered by large numbers of small polygonal plates which form regular belts around the apical and radial plates. The species of these genera, though

* A young *Strotocrinus*, unless the arms are attached, cannot be distinguished generically from an adult *Actinocrinus proboscidialis*, and as both have the same peculiar ornamentation with the same number of arm openings, they differ but slightly in specific characters. *Actinocrinus proboscidialis* is the typical species of a small group of beautifully ornamented Crinoids, and is evidently the forefather of all *Strotocrini*, which idea seems to be further confirmed by the geological succession. The former group occurs only in the *Lower*, and *Strotocrinus* only in the *Upper* Burlington limestone.

being comparatively of large size, have generally but two primary arms, and consequently for each ray but one radial dome plate which is here placed at some distance from the arm bases. In the *adult Megistocrinus* the radial as well as apical plates are extremely large and stand forth conspicuously, and each one separately, among the surrounding minute polygonal pieces. In the *young Megistocrinus*, however, and in the *Rhodocrinidæ* generally, the apical pieces and the radial plate are placed side by side, being surrounded by the polygonal plates. The form and size of the principal summit plates, the distribution and number of the interradial pieces, afford most excellent characters for distinguishing many genera. In *Agaricocrinus*, all apical and radial pieces are large and tuberculous, the few interradials are small. In *Dorycrinus*, the center plate and first radials are spiniferous or nodose. In *Amphoracrinus*, the four large apical pieces are spiniferous or tuberculous, the radials nodose. In *Platycrinus* and *Hexacrinus*, the apical plates are very prominent, often tuberculous, the radial portions are somewhat constructed like the rows of small alternating plates of the *Cyathocrinidæ*. In *Batocrinus*, all summit plates are nodose and almost of equal size.

The apical plates can be distinguished in other groups as well as in this. They surmount the vault of *Synbathocrinus* and *Cyathocrinus*, cover the central opening of the Blastoids, and can be traced in many of the Cystideans. This, with the further fact that they are so largely developed in young specimens, that they cover and protect some of the most important organs of the inner cavity, shows their great importance, and leads us to infer that they were the first solid parts developed on the ventral side in young Crinoids. The center piece corresponds evidently with the basals of the dorsal side, the surrounding plates to the subradials (the two smaller plates, separated by the anus forming together one large one), which on the other hand were undoubtedly the first developed parts of the dorsal side, and the parts which are the most highly developed in the Cystideans.

The above groups, representing the three principal plans upon which the vault is constructed, embrace, according to my views, not only all those Paleozoic genera which were supposed to be covered by a membranous surface, but nearly all Paleozoic Crinoids that are known. There are some few genera, as for instance *Eucalyptocrinus*, with a very peculiar superstructure at the ventral side, whose affinities I have not been able to determine. There is the genus *Calceocrinus* which differs so widely from all other known Crinoids by its distinct bilateral symmetry and unique structure, that it forms evidently a very distinct group by itself. There may be still others, differing in their summit structure from the general plan; but I have yet to discover a single Paleozoic genus in which a special oral aperture has been identified, or in which the existence of a solid vault has been disproved, or cannot be traced by analogy. Thus it may be possible that the solid vault was essential under the conditions which prevailed in the earlier geological ages.

Closely related as the recent Crinoids are to their Paleozoic ancestors in some points, the solid vault of the latter cannot in the remotest degree be homologized with the soft peristome of the former. The solid dome forms, as I think I have proved, a continuation of the radial and interradial series of the dorsal side and serves merely as a covering and protection for the organs underneath. It is in every sense of the word aboral and forms a part of the abactinal system, which being already reduced in the *Pentacrinidæ* and *Comatulidæ* to a narrow tentacle furrow, recedes in Paleozoic Crinoids one step further and disappears within the solid walls of the body. The actinal system here consists externally only of the arm furrows, whence it continues underneath the vault. These Crinoids therefore are evidently of lower development and belong to an inferior type.

The ventral peristome of the recent Crinoids serves as a madreporic apparatus, introducing the necessary water for respiration. It is capable of expansion, and does expand when water or food is introduced into the inner cavity, and contracts when refuse matter is expelled. These are functions which the solid vault could not have performed, and there must have been consequently important modifications in the internal economy of these animals. Comparing the large size of the calyx of the *earlier* Crinoids with the small cup and large long arms of the *recent* types, we find in the former an approach to the *Cystideans*, as also a striking resemblance to the nascent *Pentacrinus* before its arms are fully developed. In the older forms, the radial plan is almost overshadowed by the bilateral arrangement of the vault, which reminds of the bilateral symmetry in the earlier stages of other Echinoderms. All these facts tend to prove, that the *Paleozoic Crinoids*, embracing therein all *true Crinoids in which the actinal side is closed*, represent the young stage of growth of the living types. They bear evidently the same relation to the *Pentacrinidæ* and *Comatulidæ* as the *Perischoechinidæ bear to the Echini, as the Cystideæ and Blastoideæ bear to the Paleozoic Crinoids.* They unquestionably form a *distinct group* of Crinoids, and I therefore propose for it, from the fact that its representatives lived almost exclusively in Paleozoic times, the name: "*Paleocrinoidea*" *as a suborder of the Crinoids.*

Whether *Encrinus*, *Apiocrinus* and allied genera of the Jurassic time are to be brought within this suborder, depends upon the construction of their vault, which cannot at present be determined. Should they prove to have a solid dome they would be included here, and this might detract slightly from the technical exactness of the name *Paleocrinoidea.* Still as its characteristic types were so prevalent and constituted so important a part of the life of Paleozoic ages and the Mesozoic forms are comparatively so insignificant in variety and abundance, the term would nevertheless be significant and appropriate.

I shall not attempt to separate the *Paleocrinoideæ* into families, as I think our present knowledge is hardly sufficient for such a work, but I feel convinced that it must be based mainly upon the diversities in the structure of the vault, not upon the construction of the dorsal cup, nor upon the structure of the arms or column, upon which former authors have founded such divisions.

The discoveries which have been made within the last few years, both in recent and extinct Crinoids, are really wonderful, and lead us to expect large additions to our knowledge in the future. I observe in the February number of this Journal, that Professor Thomson has discovered at great depth two new genera of *Apiocrinidæ*, one of them resembling in superficial structure the genus *Poteriocrinus.* This may throw new light upon the physiology of the extinct types and solve some of the questions herein suggested. Other discoveries will follow. The labors of the Zoologist will supplement the researches of the Paleontologist and through their properly united efforts, we may hope in time to comprehend the structure of the *Paleocrinideæ* almost as perfectly as if they were yet living in our oceans.

ART. XXV.—*On some Phenomena of Binocular Vision;* by JOSEPH LECONTE.

X. *The structure of the crystalline lens and its relation to Periscopism.**

THE following thoughts were suggested by the recent memoir of Dr. Ludimar Hermann "On the passage of luminous pencils obliquely through lenses, and on a related property of the crystalline lens of the (human) eye,"† in connection with my own recent publication "On the comparative physiology of Binocular Vision."‡

It is well known that the crystalline lens of the mammalian eye increases in density and refractive power, from the surface to the center; so that it may be regarded as composed of ideal

* Read before the National Academy of Sciences, April, 1877.

† Archives des Sciences, vol. lii, p. 66. ‡ This Jour., vol. ix, p. 168, 1875.

concentric layers, one within another increasing in density and in curvature until the central nucleus becomes a very dense and highly refractive spherule.

Evidently this structure must have some important use in vision or it would never have been formed; but the question of its design has never been satisfactorily settled. It is usually regarded as intended to correct spherical aberration. It certainly is useful in this way, *when the pupil is greatly expanded.* But in strong light, when the pupil is greatly contracted and therefore only central rays reach the retina, *correction is not needed*, because, even in a homogeneous lens, *aberration*, under these circumstances, is *inappreciable.* It is natural, therefore, to cast about for some other purpose subserved by this very curious and universal structure.

Very recently Dr. Hermann (loc. cit.) has discovered another optical property conferred upon the lens by this structure—a property which he regards as of great importance in perfect vision, and which, therefore, he thinks, entirely explains the design of the structure. It is the property of *forming images of objects lying on the margins of the field of view, far more perfect than could be formed by a homogeneous lens* of the same focal distance. And since, as he supposes, perfect images of marginal objects necessitates distinct vision of these objects, he calls a lens having this structure *periscopic.*

By mathematical discussion he shows that, in a homogeneous lens, while the central rays *from radiants near the middle of the field of view*—i. e., of pencils nearly parallel with the axis of the lens—are brought to a perfect focal point, the central rays, from *marginal radiants*—i. e., of very oblique pencils—form crossing caustic lines. The refraction in the former case is *stigmatic*, in the latter *astigmatic.* Therefore the picture formed by such a lens is distinct in the central parts and very indistinct on the margins. Now this well known defect of a homogeneous lens Dr. Hermann shows is certainly in a great measure, probably entirely, *removed by the structure peculiar to the crystalline lens.* For in the case of a lens composed of concentric laminæ increasing in density and curvature to the center, the astigmatism of oblique pencils is greatly diminished, and if the laminæ be infinitely thin, probably entirely removed. The picture formed by such a lens would therefore be perfect in all parts, even to the extreme margins. *The crystalline lens, therefore, by its structure is endowed with the property of forming distinct images of objects lying even on the extreme margins of the field of view—of forming perfect images on all parts of the retinal screen even to the extreme anterior margins.* It is this structure, according to Dr. Hermann, which gives the eye its enormous field of view, compared with that of optical instruments. This then is the purpose of this structure. *It gives periscopism to the eye.*

Such is a brief statement of Dr. Hermann's discovery, and his deductions therefrom. This discovery I regard as very important, but his deductions in regard to periscopism of the human eye cannot be received without important modifications. For it can be shown that so far as periscopism is concerned, the peculiar structure of the lens is of little, if any, value in man, *for want of a corresponding suitable retinal structure.*

In order to show this, it is necessary carefully to distinguish two kinds of indistinctness of vision, viz: that which results from *indistinctness of the retinal image*, and that which results from *imperfect perception* of the image. The former has its cause in the properties of the lens, the latter in the organization of the retina. We may have a very perfect perception of an imperfect image, and on the other hand we may have so imperfect a perception of an image that we cannot tell whether it is perfect or not. If, for example, I hold the point of my pen very close to one eye (shutting the other), and look at the sky, the pen point is very indistinct, because the retinal image is indistinct; but my perception is perfect. I *can observe with great accuracy the exact degree of indistinctness.* This is an example of one kind of indistinctness of vision. But if I hold my pen far to one side, on the extreme verge of the field of view, say 90° from the direction of the optic axis, the pen is again indistinct, far more so than before, but from an entirely different cause, viz: *imperfect perception* of the retinal image. My perception, in fact, is so imperfect that I cannot tell whether the image is distinct or not. This is an example of the other kind of indistinctness of vision.

Now of these two kinds of indistinctness, the latter is by far the greater. Objects on the margin of the field of view are perceived as objects, and nothing more; their form cannot be distinguished—they attract attention, but we must turn the optic axis on them or near them in order to tell what they are. For example, held at arm's length and 90° from the usual line my pen is seen only as an elongated object; at 60° the shape is still indistinguishable—neither the point, nor the hole through the back, can be seen at all, though projected against a bright sky. Only at 30°–40° these begin to be distinguished. Even within a few degrees of the optic axis the *perception* of form is still very imperfect. In this case, however, the indistinctness is wholly the result of imperfect perception, not of imperfect image. I cannot perceive whether the image is perfect or imperfect—whether the outlines are blurred or sharply defined.

It is evident, therefore, that the retina of the human eye is so organized (and as I have shown in my previous article,* it is

* Loc. cit.

important that it should be so organized), that the perception of its images, good or bad, is most perfect in the central spot, and thence becomes less and less perfect toward the anterior margin, where it finally becomes extremely imperfect. Evidently, therefore, with this extremely imperfect marginal perception, extremely perfect marginal images would be entirely useless. *Periscopic structure of the lens is useless because periscopic perception of the retina is wanting.*

True periscopism, i. e. the power of distinct vision over a wide field without changing the direction of the optic axis, is therefore a product of two factors, viz: 1st, a periscopic property of the *lens*, i. e. of *making* distinct marginal as well as central images; 2d, a periscopic property of the *retina*, i. e. of distinctly *perceiving* marginal as well as central images. Now, Dr. Hermann has left out the second factor, and thus identified periscopism of the lens with periscopism of the eye.

I think it quite certain, therefore, that the property of making distinct marginal images, and therefore the characteristic lens structure, *in so far as it subserves this purpose*, is useless in *man*. Yet it seems equally certain that this property is a very important one. Where then shall we seek its use, and what is its significance in man? I believe we must seek its use in the lower animals, where it originated. In man it must be regarded as an example of *a structure which has outlived its usefulness.*

We have already shown in our last paper (p. 170), that true periscopism, or distinct vision over a wide field, is a necessary condition of safety in many of the lower animals. In accordance with the law of evolution, therefore, an ocular structure, suitable for this purpose, must be gradually formed and perfected. This ocular structure, as we have just seen, consists of two parts, a *lens* structure to produce perfect marginal images and a *retinal* structure to produce equal perception of all images, central and marginal. Both of these were developed in the highest degree in many of the lower animals, as for example in the ruminants. But in the highest animals, and especially in man, as we have shown in the paper referred to, this equal distribution of perception is inconsistent with fixed attention and thoughtful observation, and therefore with the development of the higher faculties of the mind. The uses of distinct marginal perception, viz: breadth of distinct view, are sacrificed to the higher uses of distinct central perception alone, viz: fixed thoughtful attention to the object regarded alone. Thus with the development of the *central spot* of the retina, *distinct marginal perception* is lost; because the uses of the latter are inconsistent with the higher uses of the former. But the other factor of periscopism, viz: the property of forming distinct marginal images, is retained by inheritance; because though no longer useful in this way, it is in nowise hurtful and may even be useful in other ways.

But I have also (loc. cit.) shown the close relation between the development of the central spot and the consequent loss of periscopism, and the development of true binocular vision. Hence it is evident that, in going up the vertebrate scale, just in proportion as the central spot is developed, and the position of the eyes is adapted for binocular vision, the characteristic structure of the lens, in so far as it is designed to produce perfect marginal images, becomes useless. There may be, however, and probably are, other uses, (e. g. correction of aberration), which this structure subserves and which would tend by natural selection to keep up the structure. It would be extremely interesting in this connection to compare the lens of the human eye with that of the eye of the ruminants. In so far as it subserves the purpose of periscopism the characteristic structure ought to be less marked in the human eye, since its retention is due to inheritance alone, and not to natural selection. If it is not less marked there would be strong reason to suspect that periscopism is not the most important purpose of this structure.

Berkeley, Cal., Jan., 1877.

ART. XXVI.—*On Ethylidenargentamine - ethylidenammonium Nitrate;* by W. G. MIXTER. *Contributions from the Sheffield Laboratory of Yale College.* No. XLIX.

LIEBIG, in his researches on aldehyde,* examined the precipitate obtained by mixing concentrated solutions of aldehyde-ammonia and silver nitrate. His analysis of it shows an atomic relation of silver 1, carbon 4, and hydrogen 11. He failed to estimate nitrogen and hence did not obtain a formula, but concluded from the deportment of the compound with acids and alkalies that it contained aldehyde, ammonia and nitric acid.

I have not succeeded in getting a good product for analysis by mixing simple aqueous solutions of aldehyde-ammonia and silver nitrate. Decomposition began before the substance could be washed with alcohol. This decomposition is, however, prevented, by using ammoniacal solutions. The substance is soluble in one and one-half parts, or less, of concentrated ammonia water, and is still less soluble in pure water. In the first experiment with ammoniacal solutions, the ammonia was rapidly removed by a blast of air, and from equal weights of aldehyde-ammonia and silver nitrate, two crops of very small white crys-

* Liebig's Ann., xiv, 147.

tals were obtained, which were washed with alcohol, and dried over oil of vitriol. The carbon and hydrogen were determined by burning with lead chromate, the nitrogen by Schiff's method with copper oxide and displacement of air by a slow stream of carbonic acid, and the silver by simple ignition. The following results were obtained from the two crops above mentioned:

	1st crop.	2d crop.	Mean.	Atomic ratio.	Calculated for $C_4H_{10}N_3O_3Ag$.
Carbon	18·32	18·33	18·33	3·9	18·75
Hydrogen	4·31	4·16	4·23	10·8	3·91
Nitrogen	16·63	16·65	16·64	3·	16·41
Silver	42·06	41·99	42·03	1·	42·18
Oxygen			18·77	3·	18·75
			100·00		100·00

These results give a formula different from $NO_3Ag\ 2(C_2H_3ONH_4)$, which is given in Watts' Dictionary, vol. i, p. 108, as probably representing the substance. Taken together with Liebig's analysis, they also indicate that the same body is formed in both aqueous and ammoniacal solutions.

$C_4H_{10}N_3O_3Ag$ differs from two equivalents of aldehyde-ammonia and one equivalent of silver nitrate by two molecules of water, thus: $2(C_2H_4ONH_3)+AgNO_3-2H_2O=C_4H_{10}N_3O_3Ag$. This view of the chemical process is supported by the reactions of aldehyde with benzamide and aniline, in which water separates, and also by the following experiment: 29·2 grams of a mixture of silver nitrate and good crystals of aldehyde-ammonia, in the proportion of one equivalent or 17· grams of the former, to two equivalents, or 12·2 grams of the latter, were dissolved in 40 c. c. of concentrated ammonia-water. The solution was evaporated in a weighed dish, first by a blast from a laboratory bellows and finally over oil of vitriol until the weight was constant. The residue weighed 25·445 grams. The weight, according to the above formula, should have been 25·600 grams. The difference of 0·155 grams between the experimental result and theory may be ascribed to the slight decomposition the substance had undergone in drying, which was shown by the small black residue it left when treated with ammonia-water.

When an ammoniacal solution of aldehyde-ammonia and silver is evaporated at 20° to 30°, hydrous monoclinic transparent crystals separate, which do not change rapidly on damp days, but become opaque with loss of water in dry weather. Together with the hydrous crystals, small poorly defined triclinic crystals form which do not become opaque in dry air. The latter are transparent and colorless, or more frequently have a resinous tinge. Dr. E. S. Dana has studied the crystalline form of both the hydrous and anhydrous crystals, and gives his results in the following paper, Art. XXVII. The hydrous crystals can be picked out before losing their luster if the atmosphere is damp, and the anhydrous crystals are easily distinguished after the former have become opaque. The following results were obtained on good monoclinic crystals which had been dried over oil of vitriol, and on transparent anhydrous crystals:

	Monoclinic dried crystals.	Triclinic crystals.	Calculated for $C_4H_{10}N_3O_3Ag$.
Carbon	18·55	18·62	18·75
Hydrogen	4·08	4·12	3·91
Nitrogen	16·58	16·64	16·41
Silver	42·03	41·97	42·18
Oxygen			18·75
			100·00
Specific gravity,	2·13	2·28	
Melts with rapid decomposition at	130°–135°	125°–130°	

To determine whether the monoclinic substance lost any ammonia on drying, nearly two grams of crystals, not entirely free from the triclinic body, were heated to 100°, in air which traversed a caustic potash drying tube before reaching the substance and then passed a weighed tube filled with fragments of caustic potash. The substance lost in weight exactly what the latter tube gained, and the water thus estimated corresponded to 4·20 per cent. The following results were obtained by drying well selected monoclinic crystals in a desiccator at 20° to 30°:

0·383	gram	lost	4·28	per cent.
0·343	"	"	4·26	"
0·437	"	"	4·23	"
1·0504	"	"	4·24	"

After the 0·383 gram had obtained a constant weight in the desiccator it was exposed for half an hour to 60° without further loss; in three quarters of an hour at 100° the loss increased 0·0025 gram and the crystals had become brown. These water determinations lead to the troublesome formula for the monoclinic hydrous crystals, of $8(C_4H_{10}N_3O_3Ag)+5H_2O$, which represents 4·21 per cent of water.

Both kinds of crystals are soluble in water, very soluble in ammonia water, almost insoluble in alcohol, sparingly soluble in ammoniacal absolute alcohol, and both give a silver mirror when their aqueous solutions are heated, and but a trace of silver remains in solution after continued boiling. With hot potash solutions both forms give the same odor that is perceived when aldehyde-ammonia is treated with potash. Dilute acids set aldehyde free, and warm oil of vitriol evolves nitrogen peroxide fumes. Both turn brown at 100°, the monoclinic crystals remain brittle, but the triclinic substance becomes gummy at

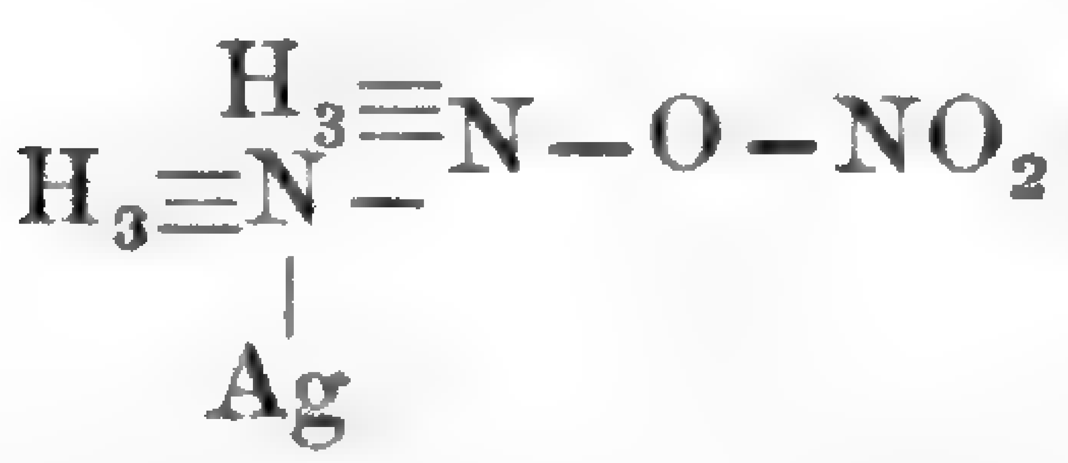
100° after some time. The triclinic crystals decompose rapidly a few degrees lower than the monoclinic. Both kinds appear to be permanent in dry air. On recrystallizing the monoclinic variety some triclinic crystals appear, and the triclinic form yields on recrystallization some monoclinic crystals.

As to the constitution of the bodies their reactions make evident that they contain the ethylidene and nitro groups. They are plainly analogous to the ammonio-silver nitrate, which crystallizes from a mixture of silver nitrate with excess of ammonia water as all contain (exclusive of crystal water) 3 atoms of nitrogen and 3 atoms of oxygen to 1 of silver. We may therefore, regard them as amines, and may show their relation to ammonia-silver nitrate as follows:

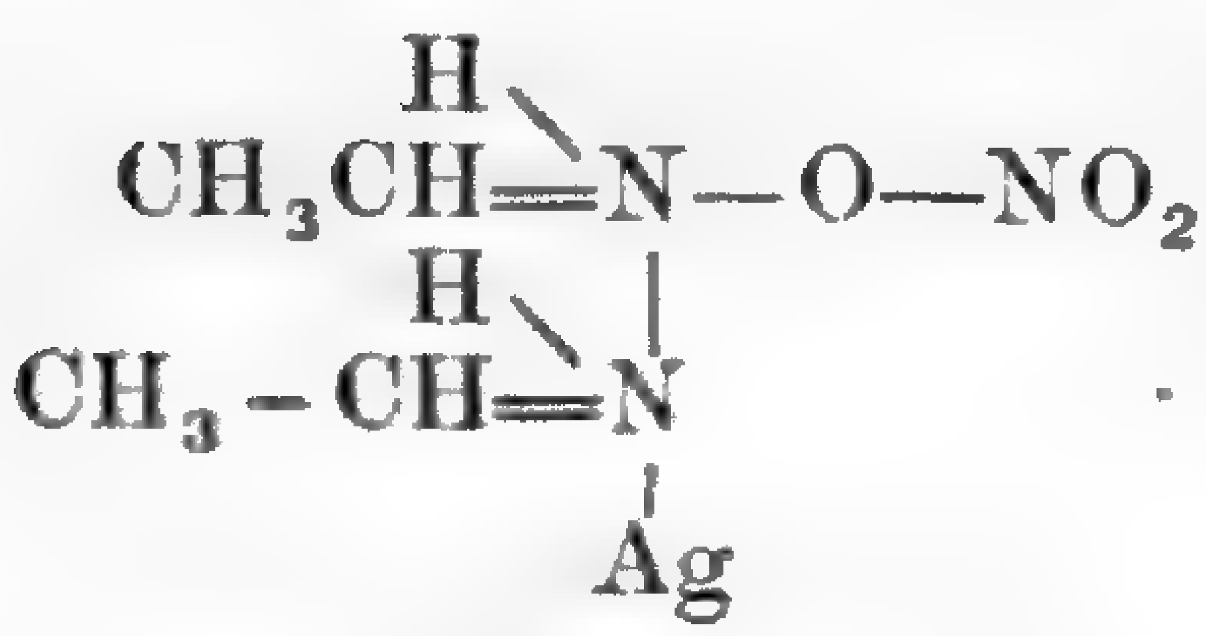
$$\left.\begin{matrix} H_3N \\ H_3N \end{matrix}\right\} AgNO_3 \qquad \left.\begin{matrix} CH_3{-}CH{=}NH \\ CH_3{-}CH{=}NH \end{matrix}\right\} AgNO_3$$

In accordance with the requirements of the now received theories, these bodies may be formulated as substituted ammonium nitrates, viz:

$$H_4{\equiv}N-O-NO_2,$$ ammonium nitrate.



argentamine-ammonium nitrate.



ethylidenargentamine-ethylidenammonium nitrate.

ART. XXVII.—*On the crystalline form of the hydrous and anhydrous varieties of Ethylidenargentamine-ethylidenammonium Nitrate*; by EDWARD S. DANA.

A. *Hydrous Ethylidenargentamine-ethylidenammonium Nitrate.*

THE hydrous variety of ethylidenargentamine-ethylidenammonium nitrate, described by Professor Mixter in the preceding article, crystallizes in the *monoclinic* system. The observed planes (see figs. 1, 2) are as follows:

c (001), *d* (111), *g* ($\bar{1}$11), *e* (011), and rarely *b* (010).

From the measurement of a considerable number of crystals the following were obtained as the fundamental angles:

$$c\,(001) \wedge e\,(011) = 69^\circ\ 2'$$
$$c\,(001) \wedge d\,(111) = 78^\circ\ 35'$$
$$d\,(111) \wedge d'\,(1\bar{1}1) = 60^\circ\ 50'$$

From these angles the elements of the crystals were calculated, viz:

$$\acute{c} : \bar{b} : \breve{a} = 4{\cdot}32645 : 1{\cdot}65788 : 1{\cdot}00000$$
$$\beta = 89^\circ\ 43'\ 52''$$

Other important angles, calculated from the same data, are as follows:

$$c\,(001) \wedge g\,(\bar{1}11) = 79^\circ\ 2'$$
$$g\,(\bar{1}11) \wedge g'(\bar{1}\bar{1}1) = 60^\circ\ 56'$$
$$d\,(111) \wedge g\,(\bar{1}11) = 114^\circ\ 17'$$
$$d\,(111) \wedge e\,(01\bar{1}) = 66^\circ\ 18'$$
$$g\,(\bar{1}11) \wedge e\,(01\bar{1}) = 65^\circ\ 5'$$
$$d\,(111) \wedge e'(0\bar{1}\bar{1}) = 122^\circ\ 56'$$
$$g\,(\bar{1}11) \wedge e'(0\bar{1}\bar{1}) = 122^\circ\ 48'$$
$$d\,(111) \wedge b\,(010) = 59^\circ\ 35'$$
$$g\,(\bar{1}11) \wedge b\,(010) = 59^\circ\ 32'$$

The measured angles agreed quite closely with the calculated angles when the character of the planes was such as to admit of satisfactory observations. This will be seen from the following examples, being the angles measured on different crystals for $d \wedge d'$ and $c \wedge c$:

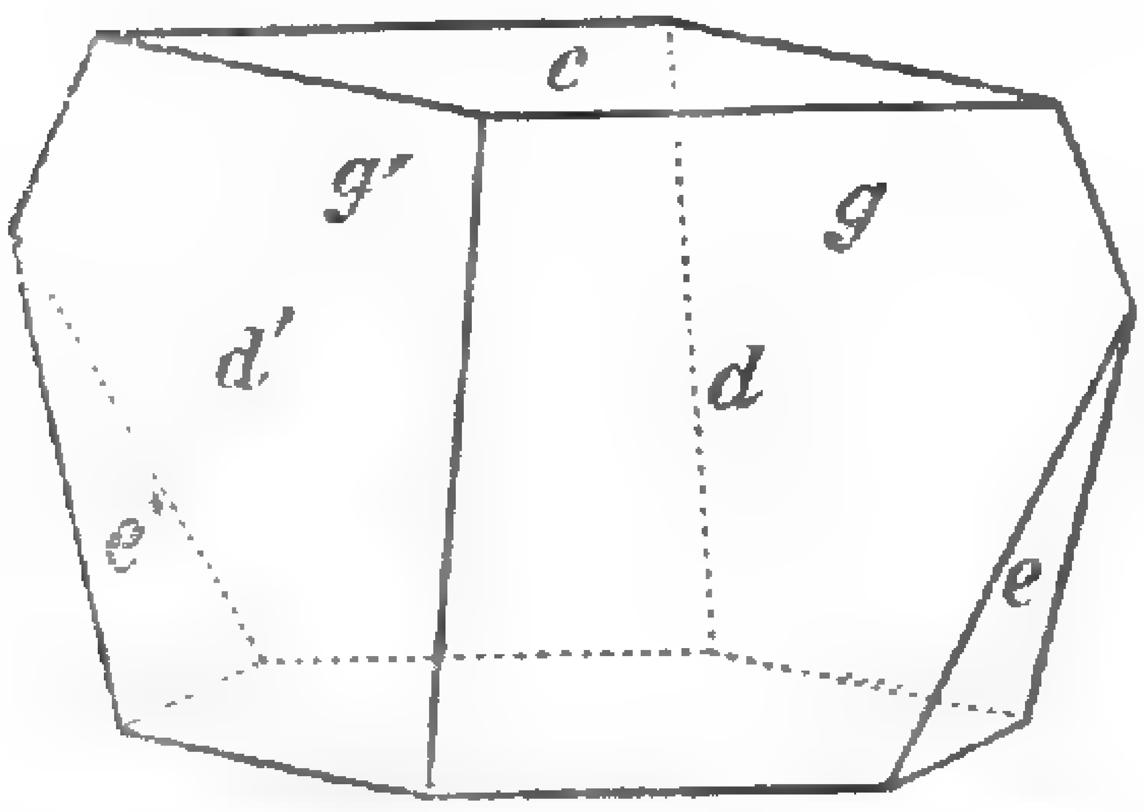
$d \wedge d' = 60^\circ 50'$, $60^\circ 47'$, $60^\circ 46'$, $60^\circ 47'$, $60^\circ 51'$, $60^\circ 52'$, $60^\circ 50'$, etc.
$c \wedge d = 78^\circ 35'$, $78^\circ 39'$, $78^\circ 40'$, $78^\circ 33'$, $78^\circ 34'$, $78^\circ 40'$, $78^\circ 38'$, $78^\circ 36'$, etc.

In many cases, however, the planes were by no means satisfactory, being generally polished and yet far from smooth, and hence the reflections given by them were more or less uncertain. The planes g, g' were quite uniformly striated, and hence the measurements made upon them were always unreliable. The following angles were all obtained from a single crystal; the wide variations from the calculated angles observed in some cases are due to the cause named:

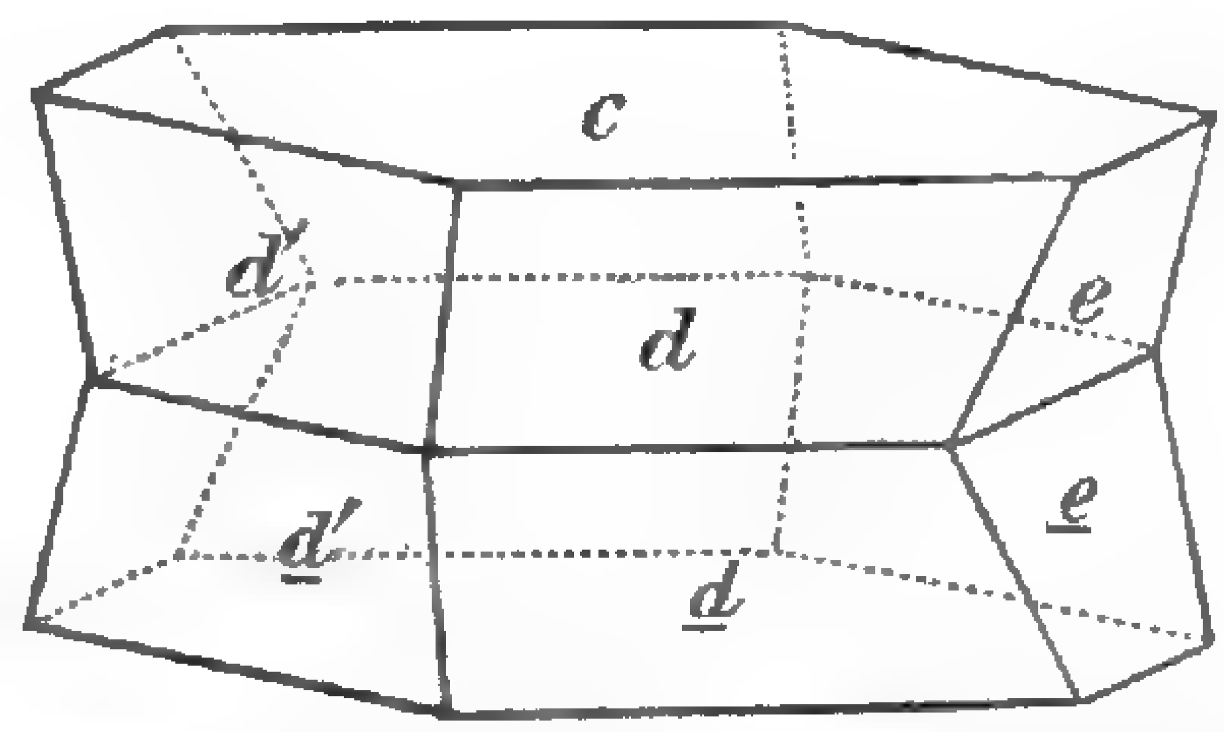
$\{ c \wedge d = 78^\circ\ 27'$	$\{ d \wedge g = 114^\circ\ 12'$	$d \wedge d' = 60^\circ\ 46'$
$\ \ c \wedge d' = 78^\circ\ 38'$	$\ \ d' \wedge g' = 114^\circ\ 7'$	$g \wedge g' = 60^\circ\ 46'$
$\{ c \wedge g = 78^\circ\ 10'$	$\{ d \wedge c = 65^\circ\ 52'$	$\{ g \wedge e = 65^\circ\ 41'$
$\ \ c \wedge g' = 78^\circ\ 30'$	$\ \ d' \wedge c' = 66^\circ\ 23'$	$\ \ g' \wedge e' = 66^\circ\ 33'$
$\{ c' \wedge e = 69^\circ\ 3'$	$\{ d \wedge e' = 122^\circ\ 51'$	$\{ g \wedge e' = 122^\circ\ 57'$
$\ \ c' \wedge e' = 69^\circ\ 2'$	$\ \ d' \wedge e = 122^\circ\ 30'$	$\ \ g' \wedge e = 123^\circ\ 33'$

The crystals examined were quite small, averaging from one to two millimeters in length. The are generally rhombic

1.



2.



(fig. 1) at one extremity, and hexagonal in outline on the other; occasionally, however, from the extension of the clinodomes they take the form of hexagonal tables (fig. 2). The hemihedral character of the crystals, shown in the figures, is a marked feature which they all possess. No trace of either of the missing pyramids or clinodomes was in any case discovered; a few isolated crystals of apparently holohedral development were without exception found by optical means to be twins, though showing no reëntrant angles. Other twins had the form of fig. 2. The twinning-axis is here a normal to the basal plane.

The cleavage is highly perfect parallel to the base (c), and the crystals have a pearly luster on this face.

The examination of the optical properties of the crystals proves that, though the angle of obliquity is small (89° 44′), they unquestionably belong to the *monoclinic* system, and, on the other hand, that they are not triclinic.

A natural crystal, or still better a cleavage section, viewed in the polariscope in a direction normal to the basal plane (c), shows the biaxial interference figures most satisfactorily. The axes, however, do not lie in the center of the field, but slightly on one side in the direction of the pyramids d, d'; thus showing that the plane of the optic-axes is not quite normal to the base. The *horizontal* dispersion is also very strongly marked.

A section cut parallel to the clinopinacoid and examined in the polariscope of Groth, shows that the acute bisectrix for blue rays makes an angle of 8° with a normal to the base (c), being inclined forward (see fig. 1) toward d, while the same angle for red rays is $5\frac{1}{2}$°.

The apparent optic-axial angle in air was obtained with considerable exactness:

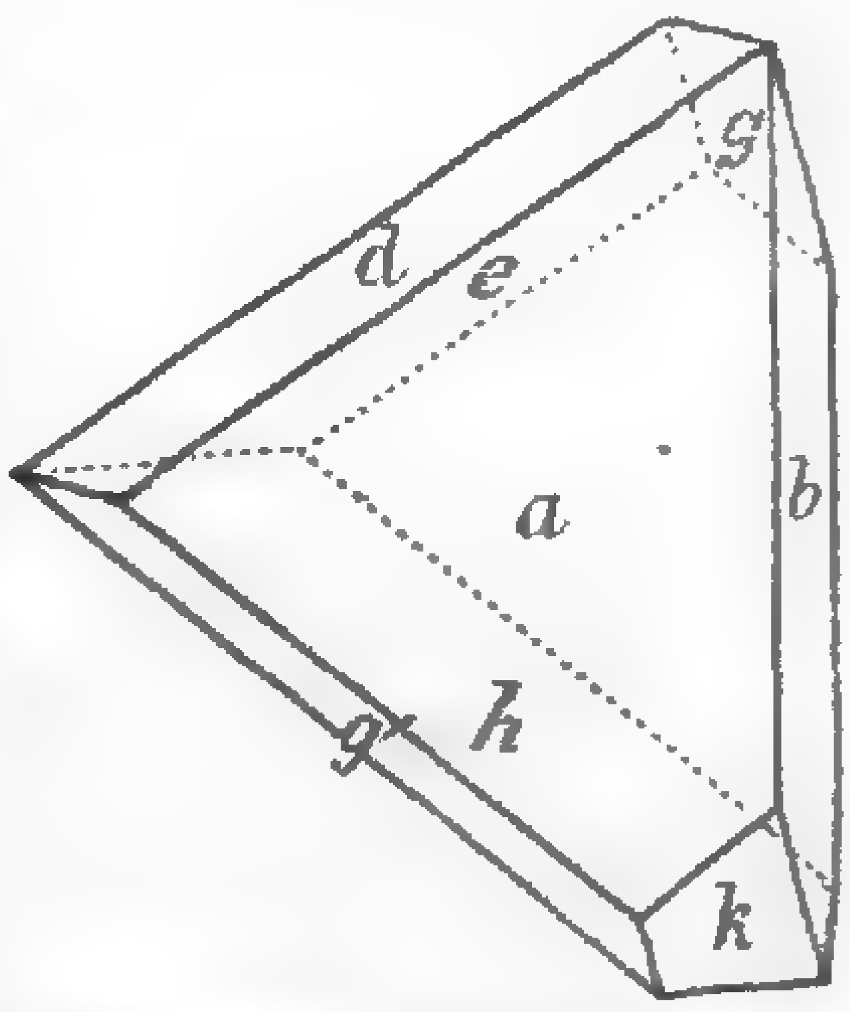
$2E = 68° 23'$ for red rays, $= 67° 30'$ for blue rays. The ordinary dispersion is consequently $\rho > \upsilon$; the dispersion of the bisectrices, on the other hand, $\upsilon > \rho$. The character of the double refraction is *negative*.

The twins (see fig. 2) gave interference figures of great beauty, both sets of axes being visible, situated symmetrically on either side of the medial line. The apparent angle between the two axial planes, measured in the usual way, was found to be 31° for blue and 25° for red. The true angles corresponding to these, obtained with the stauroscope, are 16° and 11° respectively. The first-mentioned angles, however, are not sufficiently accurate to serve for the calculation of one of the indices of refraction.

B. *Anhydrous Ethylidenargentamine-ethylidenammonium nitrate.*

The crystals of the second, or anhydrous, variety of this compound belong to the *triclinic* system. Unfortunately the material which Prof. Mixter has thus far been able to put into my hands has been much too imperfect to allow of exact determination. The crystals are small and the planes uniformly rough and uneven, so that the measured angles with an occasional exception cannot be relied upon within less than 30′.

3.



The crystals are quite uniform in habit, and figure 3 represents as closely as possible the common form. The crystal is placed in the position given in order to exhibit the close approximation to the *monoclinic* form. *e*, *g*, *h* are planes of the lower side, and *a′* is opposite *a*.

The angles measured on one crystal are as follows:

$a\,(100)\wedge d(1\bar{1}1) = 57°\ 20'$ $a\,(100)\wedge g(\bar{1}11) = 65°\ 10'$

$a'(\bar{1}00)\wedge h(\bar{1}\bar{1}\bar{1}) = 58°\ \ 2'$ $a'(\bar{1}00)\wedge e(\bar{1}\bar{1}1) = 64°\ \ 4'$

$g\,(\bar{1}11)\wedge e(\bar{1}\bar{1}1) = 65°44'$

These angles point to a form having an obliquity in a vertical direction of about 5°, but very slightly inclined in a horizontal direction. The measurements for a (100)$\wedge$$b$ (010) gave in the best case 90° 10′, and again 90° 20′. The variation from 90° is here within the possible error of observation, owing to the imperfect character of the planes; the question was not decided, consequently, until a stauroscope examination showed that the plane of vibration for the light was not normal to b (010), but made an angle of about 18°, thus proving the *triclinic* nature of the crystals.

The measured angles, as has been stated, are not sufficiently reliable to give the axial ratio calculated from them any especial value; the approximate values of the axes are, $\acute{c}=1{\cdot}45$, $\bar{b}=1{\cdot}93$, $\breve{a}=1$. The hemihedral character of the crystal figured is true of all the crystals, and the examination in the stauroscope failed to show any evidence of twinning. The crystals were not suited for any further optical examinations.

ART. XXVIII.—*On the relations of the Geology of Vermont to that of Berkshire;* by JAMES D. DANA.

[Continued from page 140.]

CONCLUSIONS AS TO THE RELATIONS OF VERMONT AND BERKSHIRE GEOLOGY.

THE conclusions, which flow from the fact, illustrated in the two preceding numbers of this Journal, that the limestone areas of Vermont and Berkshire are geologically one, may be presented under the following heads:

1. Chronological conclusions: or the equivalence and age of the formations.
2. Lithological conclusions.
3. Orographic conclusions.

And, as a sequel to this discussion, I propose, next, to present stratigraphical facts bearing on the geological relations between the area which has been under consideration and the country lying to the southward and eastward of it, in Connecticut and New York.

I. CHRONOLOGICAL CONCLUSIONS: OR THE EQUIVALENCE AND AGE OF THE FORMATIONS.

1. *Age of the Limestone series as a whole.*—From the facts brought forward it is manifest that the limestone, schists and quartzyte, making up the limestone series of Vermont and Berkshire, are *continuous* formations, and that they are *conformable* throughout. Hence we have proof that the conclusions deduced for Vermont, from Mr. Wing's discoveries, are true also for Berkshire: namely, that—

(1.) The limestone series is *made up wholly of Lower Silurian formations;* that is, of formations not older than the Primordial or Cambrian, nor newer than the Cincinnati or Hudson River group.

(2.) All these formations were upturned and metamorphosed together at one mountain-making epoch, no epoch of disturbance having intervened; and that upturning occurred after the laying down of the most recent of the formations in the series.

2. *Age of the Taconic slates, and of the limestone immediately adjoining.*—The Taconic mountains of western Berkshire are a direct continuation of the "Great central slate-belt" of Vermont. The two make one range and one rock-formation, and consist of the same kinds of rocks similary upturned. They are alike also in dividing off a western band of limestone from the main limestone area—that extending through West Cornwall in Vermont, and that of Hillsdale, Copake and Millerton, in New

York. In Vermont the Taconic slates (those of the central slate-belt) *overlie* the adjoining limestone in one or more synclinals, as plainly shown in Mount Dorset, Danby Mountain, Equinox Mountain, Spruce Peak in Arlington, and Mount Anthony in Bennington; and in Berkshire they have the same position, as observed in Graylock and Mount Washington. Hence in both States *the Taconic slates overlie, or are younger than, the adjoining limestone.*

In Vermont, as Mr. Wing has shown, the limestone nearest the slate contains, in several places, Trenton fossils (*Trinucleus*, etc.), and at West Rutland, Chazy fossils (*Maclurea*, etc.) if not also Trenton; and the slates are, therefore, as has been already stated, *younger* than the Trenton limestone of that region and belong probably to the Hudson River or Cincinnati group. If this be true in Vermont, the Taconic range in Berkshire, since it is part of the same slate-belt, consists of rocks younger than the Trenton, and is therefore either of the *Upper Trenton or of the Hudson River or Cincinnati group.*

It may be questioned whether the Graylock Spur should be included with the Taconic range, since it stands to the east of it. But the resemblance in its rocks to those of the Taconic range, coupled with its position stratigraphically *above the adjoining limestone*, just as in Mount Anthony, Equinox Mountain, Mount Eolus and other peaks in the slate-belt of Vermont, make it almost certain that the age of one is the age of the other, as first observed by Emmons.

The Berkshire *limestone* of the band adjoining the Taconic range is mostly, if not wholly, non-magnesian, like that of Vermont. Hence its constitution, as well as its position, makes it altogether probable, that it is Trenton or Chazy, as in Vermont. The limestone *west* of the Taconic range in Hillsdale, Copake and farther south, must also be Trenton or Chazy since this is true for that similarly situated in Vermont; and, moreover, it is the west side of one and the same synclinal flexure, the limestone on the east side of the Taconic range passing beneath and coming up again on the west side.

3. *The Limestones and Schists of the Eastern half of the limestone area.*—Like the Taconic slates to the westward, these more eastern rocks in Berkshire are a continuation of those north of them in Vermont. The quartzyte is not all in one range in either State; but, whether in one or several ranges, it is alike from north to south in belonging especially to the more eastern part of the limestone area. Hence whatever is true of the age of the quartzyte in one State is almost certainly true in the other.

Further, whatever the range of age in the more eastern of the limestones of Vermont, the same is the probable range of that in Berkshire and farther south. Like the Vermont limestone then, the Berkshire limestone of the middle and eastern half of the area may include the Calciferous, Quebec, Chazy and Trenton formations, and perhaps also the Primordial; but, since there are no fossils to fix the precise age, the areas of these different formations in Berkshire cannot be separately distinguished.

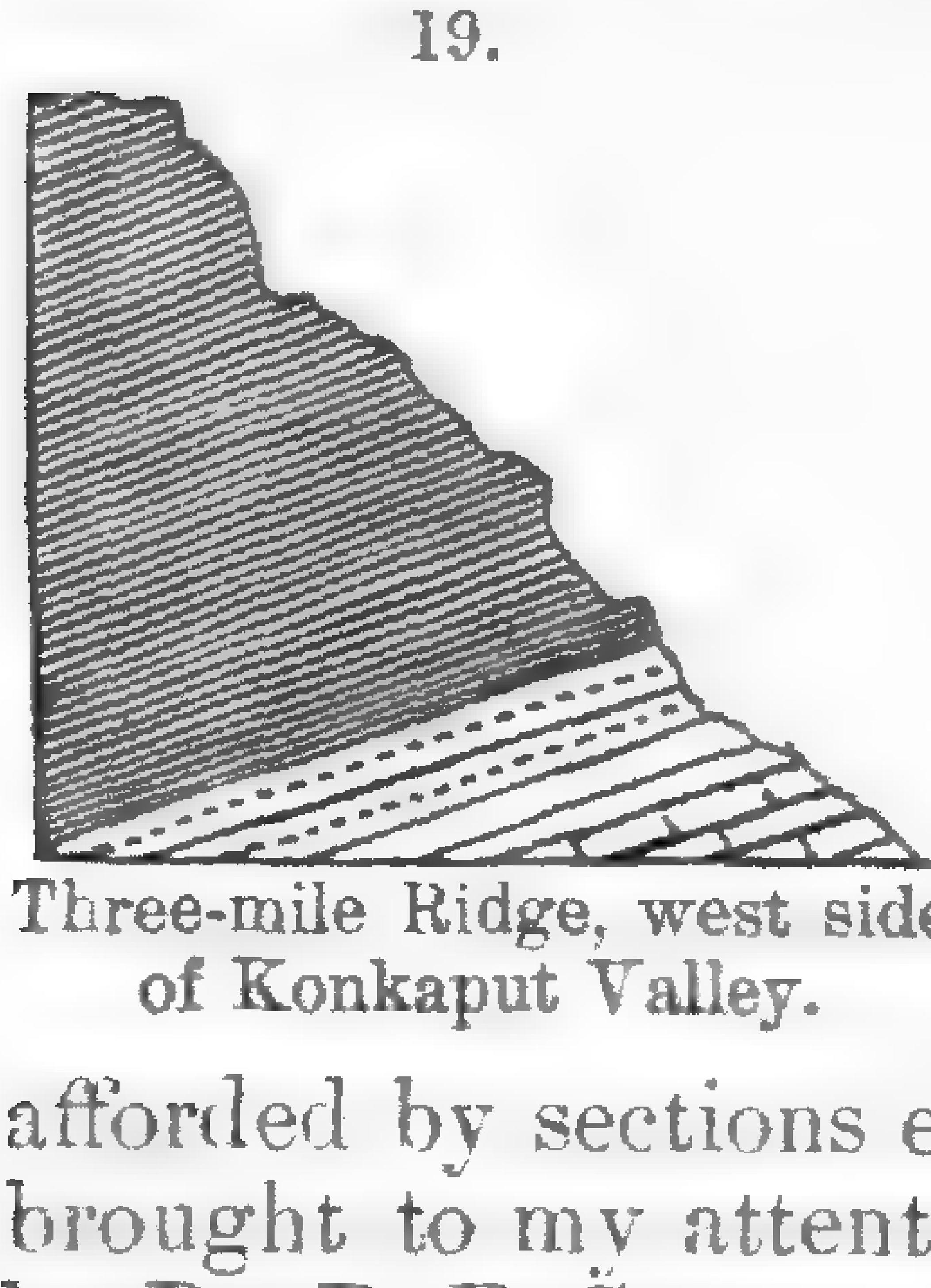
4. *The age of the Quartzyte formation, and its relation in position to the adjoining limestone.*—The quartzyte formation includes, as has been explained, strata of quartzyte and schists—sometimes one, and sometimes the other, predominating. The special age of the formation is in doubt, equally with that of the eastern limestones. There may be quartzytes of different periods of the Lower Silurian; and so with the schists. The question of age can be positively answered only by the discovery of decisive fossils in the quartzytes of Vermont; and so many imperfect forms have already been brought to light (besides the unsatisfactory worm-burrows, and Fucoids or worm-tracks) that we may feel sure the future will clear away the doubts. A word is added beyond (p. 207) on two of the forms thus far discovered.

One important point—the position of the quartzyte with reference to the associated limestone—is well illustrated in Berkshire. Mr. Wing, in his explanations of the Vermont sections (pp. 410, 411 of the last volume of this Journal), makes this limestone to *overlie* the quartzyte, and to be the equivalent of the "subcrystalline limestone" which overlies the Red Sand-rock on the west side of the limestone area—the quartzyte being in his view the same rock with the Red Sand-rock. It is to be noted, however, that the sections themselves do not indicate whether the limestone is overlying or underlying, and may be explained as well on one supposition as the other.

In Berkshire, beyond all reasonable doubt, *the eastern quartzyte formation overlies the adjoining limestone.*

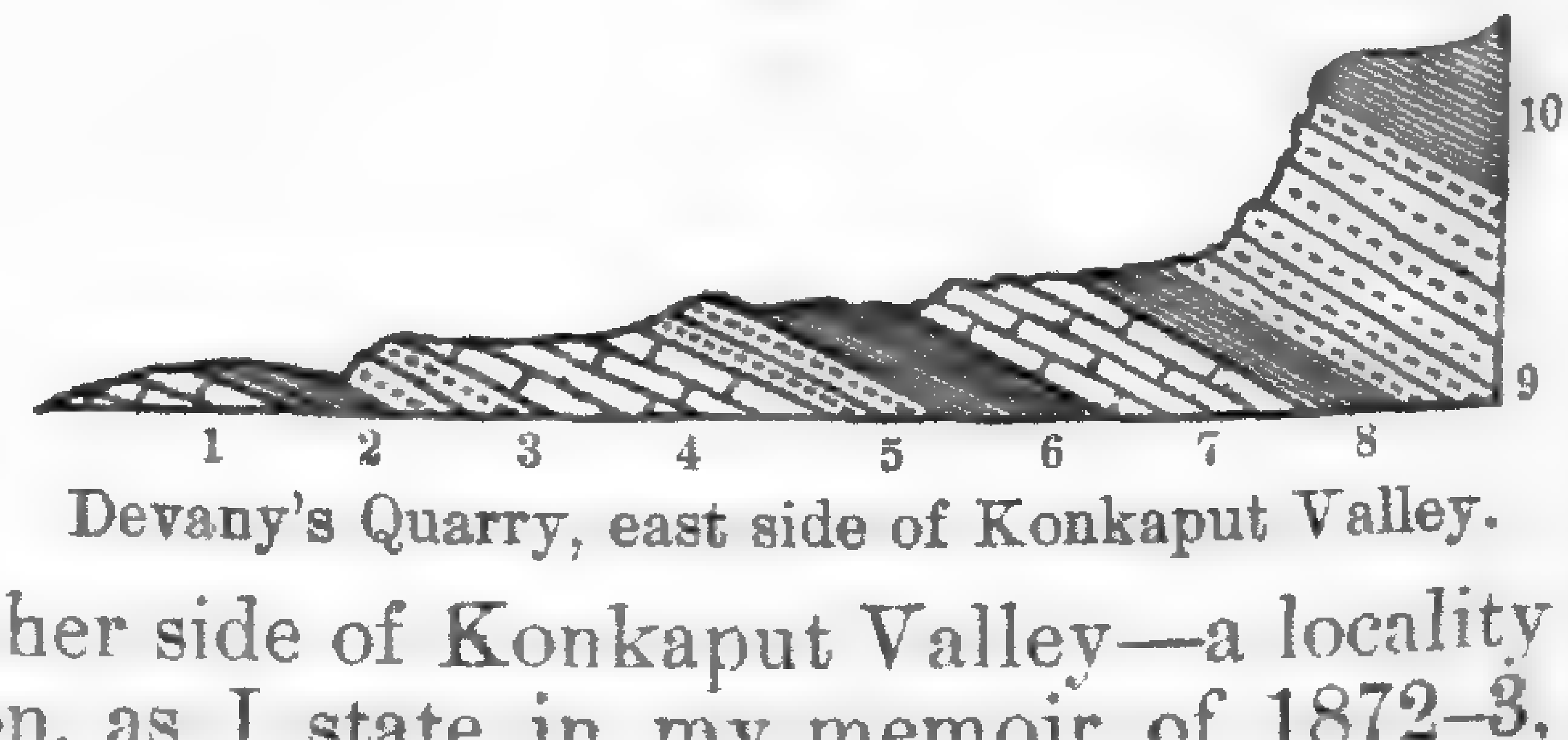
The most distinct and positive proof of the superposition of the quartzyte over limestone that I have observed is that

19.



Three-mile Ridge, west side of Konkaput Valley.

20.



Devany's Quarry, east side of Konkaput Valley.

afforded by sections either side of Konkaput Valley—a locality brought to my attention, as I state in my memoir of 1872–3, by Dr. R. P. Stevens. The figures of the sections of Devany's

Bluff and Three-mile Ridge, which face one another on opposite sides of the valley, are here repeated from page 45 of this volume. In each of the sections, quartzyte strata and overlying schists of great thickness rest on the limestone which outcrops in the valley. The dip is small (8°–25°, p. 46). The limestone is plainly at the bottom; and *it is stratigraphically* so, unless there has been a flexing of the strata and an overturned fold at the place. Nothing in the region suggests that there has been such an overthrow: the facts, on the contrary, prove the flexure which the strata have undergone to be a gentle one. As has been stated, the two ridges stand opposite one another, not quite a mile apart. In the eastern, the dip is 20°–25° to the northeastward; in the western, about the same to the northwestward. The series of rocks from below upward, limestone, quartzyte, schist, of one side, is repeated in the other, and the schist of the west side has a thickness of several hundred feet like that of the east. All the conditions are those of a low anticlinal spanning the valley; and one whose axis dips gently northward, and whose sides flare southward or southward and eastward. The valley south of Devany's Bluff widens much to the eastward and has its lakes with limestone about them.

Besides this, the rocks of the gentle anticlinal are continued in the high land either side in a broad shallow synclinal—the high land synclinals and the anticlinal valley between covering a breadth from east to west of ten miles. (*a*) In the synclinal to the *west* (between the Konkaput valley and Great Barrington), the schist has first a dip northwestward of 8° to 25°, but, after three-fourths of a mile, the dip is eastward 20° to 25°, and finally 40° to 50°, just east of Great Barrington. (*b*) In that to the *east*, the dip is 5° to 25° to the northeastward, over the high land and mountainous region all the way east from Devany's bluff to the village of Monterey; but on the northeastern side of this high land, at the village of Tyringham, and at South Lee, it is to the southwestward. A section between Monterey and Tyringham, east of north in course, shows the change of dip. The limestone about Monterey dips 25° to the northwest; along the highest part of the road, the gneiss and mica schist of the hills outcrop and have the same dip and strike; descending to Tyringham, five miles to the north, the dip diminishes, and for the last mile is reversed, being to the southwestward; finally, at Tyringham, the limestone comes into view again overlaid by the same kinds of gneiss and mica schist, with a dip of 15° to 25°.

Thus, both *east* and *west* of the Konkaput anticlinal there is as gentle a synclinal; and hence the idea of an overturn cannot be reasonably entertained. It appears to be a general rule, for the eastern or quartzyte part of the limestone area as well as the western, that *the valleys are eroded anticlinals*, and *the ridges* *or areas of high land are synclinals*, a rule exemplified extensively in the continuation of the Appalachians from Pennsylvania to Alabama, where the facts are little obscured by metamorphism. The position of the limestone *beneath* the quartzyte and schists along the Konkaput is then the original position.

This underlying of the thick quartzyte and schists by limestone appears to be a fact in many other parts of the Berkshire region, as in Monument Mountain, in quartzyte ridges east of Tom Ball, and elsewhere, though these examples are not as free as the above mentioned from other supposable explanations. The evidence is complete with or without them, that *the quartzyte and the associated schists in some prominent cases in Berkshire, if not all*, overlies limestone. In such cases, accordingly, the limestone is the older formation of the two; and this is as true for Vermont as for Berkshire. And where so in either State the quartzyte and the associated schists constitute *synclinals or monoclinals—not anticlinals.*

There is another argument favoring the view that the quartzyte is in *synclinals.* It may be questioned whether lofty anticlinals of quartzyte are a possibility. The quartzyte was originally a deposit of sand, or a sandstone, of great thickness. Now such a sand-bed or sandstone, raised into a close and lofty anticlinal flexure so as to have, as in Vermont, and in some parts of Berkshire, a dip of 40° or 50°, would be sure to have been very profoundly broken by the strain; and thus broken, it would have been exposed to erosion and destruction, and even to removal so as to leave a valley in its place, as has been the usual fact in the Appalachians; while, if bent up into a synclinal, whether shallow or deep, the pressure would tend to promote compactness, consolidation, and preservation. Hence the existence of the quartzyte formation in lofty ridges is strongly against its being in anticlinals.

If then the quartzyte ridges are not anticlinals, *the limestone is the inferior stratum.*

Again: if the quartzyte is Primordial, the underlying limestone is inferior Primordial. Consequently, the quartzyte formation should be elsewhere found separating this inferior Primordial limestone from the limestones of the Calciferous, Quebec, Chazy and Trenton periods. But the fact is that this limestone which underlies the quartzyte is in many places in Vermont continuous with the rest of the limestone formation, one area of limestone stretching from the quartzyte quite to the Taconic slate-belt where are Trenton and Chazy fossils in it. We naturally inquire—how under these circumstances can it be that the quartzyte formation belongs any where between the Trenton and that inferior limestone? Is it not necessarily superior to all the continuous Lower Silurian limestone formation? But if thus superior, the quartzyte is not Primordial; it is not the equivalent of the Red Sandrock; it is even related in age to the Taconic slates; these overlying a western portion of the limestone and the quartzyte formation an eastern. If so, *the eastern quartzyte formation is of the age of the later Trenton, or the Cincinnati group, both in Vermont, Berkshire and Connecticut.*

It will be remembered that the axis of the iron-ore belt is situated in the vicinity of the quartzyte in Vermont, but in the vicinity of the Taconic range in Berkshire; and even west of the Taconic range for the region south of the latitude of middle Berkshire (this vol., p. 133). Thus the quartzyte and the Taconic slates have the same geological relation to the iron ore belt; and this again suggests the idea that the two are of the same age—both of the Cincinnati or Hudson River group if one is.

These remarks make apparent the difficulties and doubts surrounding the question as to the age of the quartzyte, doubts which only new discoveries of fossils can wholly set aside.

The collections of Yale College contain specimens of the "Modiolopsis" and "Orthoceras" reported by the Vermont Report as occurring in the Quartzyte, which were received by me from the late Professor Adams, many years since, when he had charge of the earlier uncompleted survey of that State. There is but one specimen of each—not enough for a decided opinion about them. Quite recently I have seen other specimens in the Amherst College Museum. One is a piece of quartzyte with many casts of one valve of the so-called "Modiolopsis;" and another contains several of the "Orthoceras;" and I have found that both are unquestionable fossils. The former is the shell of a small lamellibranch about six and a half lines long and five broad. The so-called *Orthoceras* is a slender conical tube filled with quartzyte; and it was apparently without septa—no remains of them being present within; the specimen in the Yale collections has a length of 0·6 in.: a diameter, at the larger (broken) end, of 0·24 in., and, within a twentieth of an inch of the smaller rounded end, of just half this. It appears to be a *Theca*-like species. The lamellibranch seems to indicate, as Professor James Hall concluded, that the quartzyte is not Primordial, and that it must be later in age.

The facts that have been reviewed have established: (1) The Lower Silurian age of the limestone series as a whole; (2) the unity of position, and of epoch of uplift, of the series; (3) the very probable Trenton and Chazy age of the limestone adjoining the whole of the Taconic slate-belt or range; (4) the equally probable Upper Trenton or Cincinnati age of the Taconic rocks. But the age of the more eastern portion of the limestone and of the quartzyte and schists remains undetermined. My opinion is that the quartzyte will be found to be newer than the Red Sandrock, and of the same age essentially as the Taconic slates.

[To be continued.]

ART. XXIX.—*On the preparation of Cylinders of Zirconia for the Oxy-hydrogen Light;* by JOHN CHRISTOPHER DRAPER, M.D., LL.D., Professor of Natural History in the College of the City of New York.

SUCCESS in the use of the microscope for the purpose of projecting magnified representations of microscopic objects on a screen depends primarily upon the light employed, especially when high powers are used, as for example, a quarter inch objective. To answer the purpose in question the light must possess: 1st, intrinsic brilliancy; 2d, the brilliancy must be as nearly as possible invariable; 3d, it must retain its fixity of position in the optical axis of the apparatus.

If the experimenter has a good heliostat, the light from the sun fulfills these conditions better than any artificial light; but, experience teaches the unwelcome lesson that though sunlight is preferable to any other, it scarcely ever happens that it is available at the time it is wanted. The weather is almost certain to be either cloudy or hazy just at the hour when it is desired to make an important demonstration, and the lecturer is obliged to postpone it, thereby lessening its value, and often entirely losing its effect. The selection of the best artificial light therefore becomes a matter of importance to those who desire to secure the advantages to be derived from the successful demonstration of such microscopic objects as preparations of animal and vegetable tissues, animalcules, the circulation of the blood, etc.

The artificial lights possessed of sufficient intrinsic brilliancy are: 1st, the electric arc or light; 2d. the magnesium ribbon light; 3d, the oxy-calcium light; 4th, the oxy-magnesium light; and 5th, the oxy-zirconium light. The first has greater brilliancy than any other in the list, but in addition to fifty or one hundred cups of a nitric acid or bichromate battery a good regulator is also necessary; this involves a very considerable expenditure of money, and even when this is made, the labor and trouble required to manage the battery, and the continued change in the part of the carbon electrodes between which the arc of light passes renders its use unsatisfactory.

The magnesium ribbon light has the great disadvantage of the emission of fumes of oxide, which coat the surface of the condensing lenses in spite of all attempts to dispose of it otherwise. The light also is not concentrated on a small fixed surface; but, is emitted from a varying length of ribbon.

The oxy-calcium light produced by projecting the flame of mixed oxygen and hydrogen gases upon a cylinder or pencil of calcium oxide is the one generally employed. It is fixed in its position in the optical axis of the apparatus, it is thrown into operation with comparative facility when cylinders containing the compressed gases are available, and it has sufficient intrinsic brilliancy for the majority of experiments. The difficulties in the way of its use are however serious, and it is very desirable that they should be lessened. They arise chiefly from the volatility of the calcium oxide at the intensely high temperature employed. The volatilized material depositing on the condensing lenses prevents the passage of the luminous rays, and the cavity formed in the cylinder of lime at the spot where the flame impinges soon interferes with the brilliancy of the light; this necessitates a change in the position of the lime cylinder to present a new surface to the action of the flame, and this in its turn implies a distraction of the attention of the experimenter, which interferes seriously with the satisfactory management of his subject. Though the attempt is made to avoid this difficulty by clock work, or other mechanical contrivances, they are still unsatisfactory in their action. Another serious objection is the necessity of placing the cylinders in a closed vessel when not in use to protect them from the action of the air.

The oxy-magnesium light is similar to the preceding, differing only in the substitution of a cylinder or pencil of magnesium oxide for calcium oxide, and the light emitted is of equal brilliancy. Following the instructions given for the preparation of these cylinders, I have taken the greatest pains to procure samples of magnesium oxide of the utmost purity. I have also tried various methods for its preparation, among which the combustion of the metal in oxygen may be mentioned, but failure has thus far attended all efforts to make pencils or cylinders which could withstand the intense heat of the flame of the mixed oxygen and hydrogen gases without undergoing volatilization. The pencils obtained were fully equal in this respect to those of calcium oxide; but, I did not find any superiority that repaid the trouble of their preparation.

The oxy-zirconium light produced by the action of the flame of mixed oxygen and hydrogen gases on a cylinder of zirconium oxide meets all the requirements of the case in question. It has the intrinsic brilliancy, the invariable brilliancy, the fixity of position in the optical axis of the apparatus, and it does not volatilize under the heat employed. The condensing lenses remain free from deposit, and after the light is once adjusted the experimenter can carry on his demonstrations without the distraction of his attention that attends the use of the other lights. All that is necessary is according to the size of the reservoirs of compressed gas to open the cocks a little as the pressure diminishes. There is also no necessity to remove the zirconium oxide pencil from its position, as is the case with the calcium oxide, it may on the contrary remain *in situ* for any length of time, and the apparatus is always ready for use whenever it is wanted.

Though the standard works on chemistry generally mention the light-emitting power of zirconium oxide under a high temperature, the only successful attempt that has been made to apply it practically that I am aware of was that of Tessié du Motay. Unsatisfactory references to his process for preparing zirconia cylinders are to be found in various chemical works and journals, the best that I have seen being that given on page 47 of "Crooke's Select Methods in Chemical Analysis." The careful reader of this and other articles on zirconia will be prepared to expect difficulties in the way of its preparation, and it is to the removal or lessening of these difficulties that I now propose to address myself by the minute relation of the process I have finally adopted after many weeks of experiment.

The subject naturally divides itself: 1st, into the preparation of zirconium oxide; and, 2d, the preparation of the cylinders or pencils.

Preparation of zirconium oxide.

The compound of zirconium used is that known as the zircon of North Carolina. It is essentially zirconium silicate, and the composition of this and other specimens of zircon will be found in Dana's Mineralogy. The difficulty in the operation consists in the complete removal of the silica and of the sodium compounds used in the disintegration of the mineral.

1st. Select the zircon crystals or fragments thereof of as light a color as possible, and carefully remove all attached foreign matter; provide about ten grams in weight.

2d. Reduce five or six grams to powder in a steel mortar; or, by first heating to bright redness and chilling in water while very hot the same may be done in a porcelain mortar. Remove any mica or other foreign matter that may appear.

3d. Complete the pulverization in an agate mortar, introducing small quantities at a time, and reduce to an impalpable powder. The final yield of zirconia depends on the thoroughness with which this is done.

4th. Weigh out two grams of the fine zircon powder and mix it intimately in a mortar with ten grams of dry sodium carbonate, place the mixture in a covered platinum crucible of twenty cubic centimeters capacity.

5th. Place the crucible over a strong Bunsen flame; the burner should be at least fifteen millimeters in diameter; in about twenty minutes the mass in the crucible will have shrunken to one-third of its original volume if the heat is sufficient. To secure uniformity in temperature of the crucible

I have employed the following device. The platinum crucible being placed in a triangle of platinum wire supported on the ring of a retort stand, a graphite crucible having a diameter of five centimeters was taken and an opening fifteen to twenty millimeters in diameter made in its bottom. It was then placed mouth downward over the platinum crucible, with its mouth at the level of the bottom of the latter, and resting on the same support. A brass or iron tube two and a half centimeters in diameter and six to eight decimeters in length was placed vertically over the bottom of the graphite crucible, resting on it and enclosing the opening previously made therein. A furnace was thus constructed, the long tube being the chimney, giving a good draught, and the graphite crucible the body which confined the flame to the surface of the enclosed platinum crucible and heated it equally.

6th. The shrinkage of the mass having been satisfactorily accomplished it is to be fused; for this purpose a powerful gas blowpipe flame urged by a foot bellows answers very well. In place of the ordinary blowpipe flame I have used a modification contrived by my assistant, Mr. Ivin Sickels. It consists of a large Bunsen burner two centimeters in diameter, the upper opening is closed by a cap through which seven small tubes pass, each having a diameter of two and a half millimeters. The lower openings of the burners are also closed except one through which a tube passes and communicates with a foot bellows. Coal gas being turned into the burner, ignited, and the bellows thrown into action, seven clean sharp pointed blowpipe flames are produced which give a very intense heat.

The mass in the platinum crucible having been fused and the fusion continued until it begins to assume a pasty state, it is again liquified according to the plan of Berzelius by the addition of caustic soda about equal in weight to that of zircon. The heat being again applied the disintegration of the silicate continues, and if necessary a second addition of caustic soda may be made.

7th. The contents of the platinum crucible having cooled, separate them therefrom, and place in a beaker, add two hundred cubic centimeters of distilled water; any portions of the fused material that adhere to the walls or cover of the crucible are also to be removed by a jet of distilled water and added to the contents of the beaker. An occasional stirring will promote the disintegration of the mass, which is completed in the course of a couple of hours, silicate of sodium, the excess of sodium carbonate and soda dissolving, and leaving a white powder, which according to Dr. Melliss is composed of zirconium oxide, silicium anhydride, and sodium oxide, together with any zircon that may have escaped disintegration.

The contents of the beaker are thoroughly stirred and set aside for twenty-four hours to settle. The clear supernatant fluid is decanted, another two hundred cubic centimeters of distilled water added, the mixture stirred and set aside for twenty-four hours or longer, and when the precipitate has settled the liquid is decanted and the beaker with its contents set on the water bath to dry.

8th. Pulverize the dried material in the beaker with a glass rod, add twenty cubic centimeters of pure hydrochloric acid (Merck's), cover the beaker with a large watch glass and set on the water bath; when the acid has dissolved as much as it will take up, it is to be decanted while hot into a shallow evaporating dish of about five hundred cubic centimeters capacity. A second dose of twenty cubic centimeters of hydrochloric acid is added to the contents of the beaker, and when all lumps are broken down the mixture is transferred to the evaporating dish, a little hydrochloric acid being used to complete the transference.

9th. For the final separation of the silica the contents of the dish are evaporated to dryness on the water bath, and the heat continued until they cease to emit acid fumes, a little distilled water is then added and thoroughly incorporated with the residue by stirring. The mixture is again evaporated to dryness at 212° F. The second drying being completed, about two hundred cubic centimeters of distilled water are added, and when all the soluble material is taken up the mixture is transferred to a filter. On the filter there remains silica and undecomposed zircon. In the filtrate there are zirconium chloride, sodium chloride and iron chloride.

10th. The next step is the separation of the zirconium chloride from the iron chloride, and as completely as possible from the sodium chloride. This I have accomplished as follows. The filtrate being made up to five hundred cubic centimeters with distilled water, washed sulphurous acid gas is passed through the fluid as long as a precipitate forms, or until the contents of the flask smell strongly of sulphurous acid. The mixture is then boiled as long as it emits any odor of sulphurous acid, the loss of liquid being made up from time to time by the addition of distilled water. The precipitate of zirconium sulphite is allowed to settle for a day or two and is then collected on a filter, where it must drain for a day, the funnel being covered with a sheet of paper. As it is impossible to wash the precipitate properly on the filter, it must be carefully transferred therefrom to a beaker while it is still moist by means of a glass rod and jet of distilled water from a washing bottle. The lumps being completely broken up the contents of the beaker are again made up to five hundred cubic centimeters with distilled water well stirred, and when the precipitate has settled it is collected on a filter as before and allowed to drain as long as it will yield any fluid.

11th. The precipitate obtained above is dissolved in as little pure hydrochloric acid as possible, the solution diluted with distilled water to five hundred cubic centimeters and heated to boiling for some time. Ammonia is added to the hot solution, when the zirconium oxide is thrown down and is to be collected on a filter, washed with hot water and allowed to dry at the temperature of the air, the yellowish or whitish lumps resulting are pulverized in an agate mortar, when a white powder is obtained. The quantities I have given in the various operations detailed above apply to two grams of the powdered zircon. For the preparation of a zirconia cylinder of sufficient size the product obtained from four grams of zircon is required, the quantities may be doubled throughout; but, it is better to make two fusions of two grams each and double the quantities given in the latter part of the description.

I have also tried the separation of zirconium chloride from iron chloride by hydrochloric acid; but, though I worked at a temperature of 32° F., the yield was very small and therefore unsatisfactory. In the process by hyposulphite of soda I found it very difficult to get rid of the soda. The process of disintegrating the zircon by chlorine at a high temperature also failed to give satisfactory results in my hands, and I find that Dr. Melliss records the same experience.

Preparation of the Cylinders.

The zirconium oxide powder obtained in the manner described above is to be heated in a platinum crucible and kept at a bright red for five or six hours; it will under these circumstances shrink considerably in volume. I have sometimes in addition submitted the powder to the heat of the oxy-hydrogen flame with advantage, spreading it out for this purpose on a piece of platinum foil supported on a slab of iron, and directing the flame on the powder. The operator should wear smoked spectacles. The powdered oxide thus condensed by heat is then moistened with just enough water to give it a tendency to form small lumps. In this condition it is placed in a cylindrical mould and submitted to severe pressure by a piston fitting closely to the cavity of the cylinder, both of which should be properly oiled. The size of the pencils I have prepared is about six millimeters in diameter and one centimeter in length. When in use they are mounted so as to present one end to the action of the oxy-hydrogen flame, when a brilliant circular spot of light is formed admirably adapted for all kinds of optical experiments.

The cylinder in which the pencils have been compressed is about two centimeters in diameter and four centimeters in length; the cavity running centrally through it is six millimeters in diameter, the piston rod fits closely, and both it and the cylinder are of hardened steel; the source of compression is a small hydraulic press, and the pressure employed is about two tons. The pencil is forced from the cylinder after compression by the press itself, and is very hard. It is allowed to dry slowly and is then ready for use. When first heated the temperature is gradually increased until at last the full force of the oxy-hydrogen jet is employed. In case the pencil chips or loses any part of its substance the portions are to be preserved and ground up with old pencils in an agate mortar mingled with a little fresh zirconia powder and compressed in the cylinder. The pencils thus obtained from portions of older ones are generally superior to those made entirely from fresh oxide.

In the process of Tessié du Motay certain agglutinant materials are employed in preparing the pencils; but these reduce the brilliancy of the light considerably. With care in the management of the pencils the use of agglutinants may be avoided, and though they may be necessary in the case of pencils to be handled by an ordinary peripatetic calcium light manipulator they are not only unnecessary in the hands of a lecturer; but, are also detrimental exactly in the proportion in which they reduce the brilliancy of the light.

If the zirconium oxide is free from silica there is no evidence of fusion on the extremity of the pencil, though it may have been submitted to the action of the flame for a full hour. If on the contrary silica is present the spot on which the flame impinges becomes glazed, giving evidence of fusion, and the brilliancy of the light decreases greatly. The pencils made from the zirconia prepared in the manner related above have been tested alongside of those made from zirconia prepared by Merck, which is stated to be pure, and is sold at the rate of one dollar per gram. Whatever the process may be that is used in its preparation it does not give a product as free from iron and silica as the one which I have described, nor does it possess the same illuminating power.

June 22d, 1877.

ART. XXX.—*Mineralogical Notes.* No. V. *On the occurrence of Garnets with the Trap of New Haven, Connecticut;* by by EDWARD S. DANA.

GARNETS have been recently discovered in connection with the New Haven trap rocks, at two distinct localities; and their method of occurrence presents some points of considerable interest.

These "trap rocks," as they are commonly called, belong to the system of dikes of igneous rocks which characterize the Mesozoic sandstone areas of the Atlantic border. Mr. G. W. Hawes has given these rocks a thorough chemical examination,* and has shown that they have all essentially the same composition, being for the most part true dolerites, but including also the hydrous, chloritic variety called diabase. I take the liberty of quoting here Mr. Hawes's analysis of the trap from West Rock, which, as he states, is "the typical rock of this region." Specific gravity 3·03.

Silica	51·78
Alumina	14·20
Iron sesquioxide	3·59
Iron protoxide	8·25
Manganese protoxide	0·44
Lime	10·70
Magnesia	7·63
Soda	2·14
Potash	0·39
Phosphorus pentoxide	0·14
Ignition	0·63
	99·89

The writer has made a microscopic examination,† by means of thin sections, of this series of rocks, including, among many others, specimens from West Rock (see the analysis above) and also from the two localities where the garnets have been found, viz: East Rock and Mill Rock. These three points, it should be stated, are within four miles of each other, all lying just outside of the limits of the city of New Haven. It was found that the specimens from the localities named were identical in mineralogical character, and that they were all quite free from any alteration. The mineralogical constituents are as follows: A triclinic feldspar which Mr. Hawes has shown chemically to be labradorite, pyroxene, and magnetite, also more or less chrysolite, and a little apatite in minute acicular crystals.

* This Journal, III, ix, 185, March, 1875.
† This Journal, III, viii, 390.

Garnets from East Rock.

At the East Rock locality the trap is very distinctly columnar, and the garnets occur on the vertical surfaces of the columns where they have been exposed in the process of quarrying. The spot at which they are found is in the body of the dike, far away from the line of contact with the sandstone; they are scattered here quite freely over a considerable surface; a careful search for them, however, along the extended front of the Rock, failed to reveal any other locality.

The associated minerals are: Magnetite, apatite, pyroxene now altered to chlorite, calcite, and also in traces chalcopyrite and sphalerite.

The garnets themselves are uniformly crystallized in rhombic dodecahedrons, with the edges truncated by the planes 2–2. Isolated crystals, however, are rare; more commonly they are grouped together in nearly parallel positions in very pretty little rosettes. These groups are scattered over the exposed surface of the rock, and are quite characteristic of the locality. Still, again, the crystals are crowded together, without any regularity of position, into crusts of some little thickness.

The color of the garnets is generally dark-brown to jet-black, though occasionally they are yellowish-brown. Their luster is very brilliant, and in general they are entirely free from alteration. An analysis of the garnets proved, what indeed was suggested by their appearance, that they belonged to the variety *melanite*, or a calcium-iron garnet having the formula $Ca_3FeSi_3O_{12}$. The material analyzed was taken from the crystalline crusts which have been mentioned. It was selected with care to ensure freedom from the rock, and still more from the apatite crystals, which, as remarked below, were intimately associated with the garnet. The specific gravity was 3·740.

The mean of two analyses gave:

Silica	35·09
Iron sesquioxide (with AlO_3 *trace*)	29·15
Iron protoxide	2·49
Manganese protoxide	0·36
Lime	32·80
Magnesia	0·24
Ignition	0·35
	100·48

It has been recently shown by Knop* that the melanite crystals from several localities in the Kaiserstuhlgebirge and also from Frascati contain from three to seven per cent of titanic acid. In view of this fact special tests were made for titanic acid in the progress of the analysis; they served, however, only

* A. Knop, Zeitschrift für Krystallographie, i, 58, 1877.

to prove its absence. The magnetite was also tested qualitatively for titanic acid, but none was discovered.

The associated minerals deserve also a few words of description. The *magnetite* stands first in order of abundance. It appears in the form of brilliant octahedrons, scattered sometimes thickly, sometimes sparsely, over the surface of the rock; it uniformly underlies the garnet where they occur together. The octahedrons of magnetite are sometimes unmodified, but generally the solid angles are replaced with the planes of the form 3-3, and the edges beveled with those of the form 2-2; an *m-n* form is also common, but with planes so rounded as not to admit of determination. The development of the last form occasionally produces irregular bullet-shaped crystals. The octahedral faces are brilliant, the others dull.

The *pyroxene* occurs in minute dark-green crystals, destitute of luster; they are crowded together on the surface of the rock. These crystals are strictly pseudomorphs after pyroxene, for though having unquestionably its form, they are so soft as to be easily cut with a knife, and in the powder have all the appearance of chlorite.

The *apatite* occurs in very minute prismatic crystals of a yellowish-green color. They are most common on and among the crystals of pyroxene. They are more numerous, however, than would appear at first glance, since a careful examination shows that they interpenetrate the garnet crystals in great numbers. The crusts of garnet particularly, which are apparently perfectly homogeneous, are found when broken up to be penetrated in every direction with these minute apatite needles. In this respect the garnets resemble those of the Kaiserstuhl described by Knop.

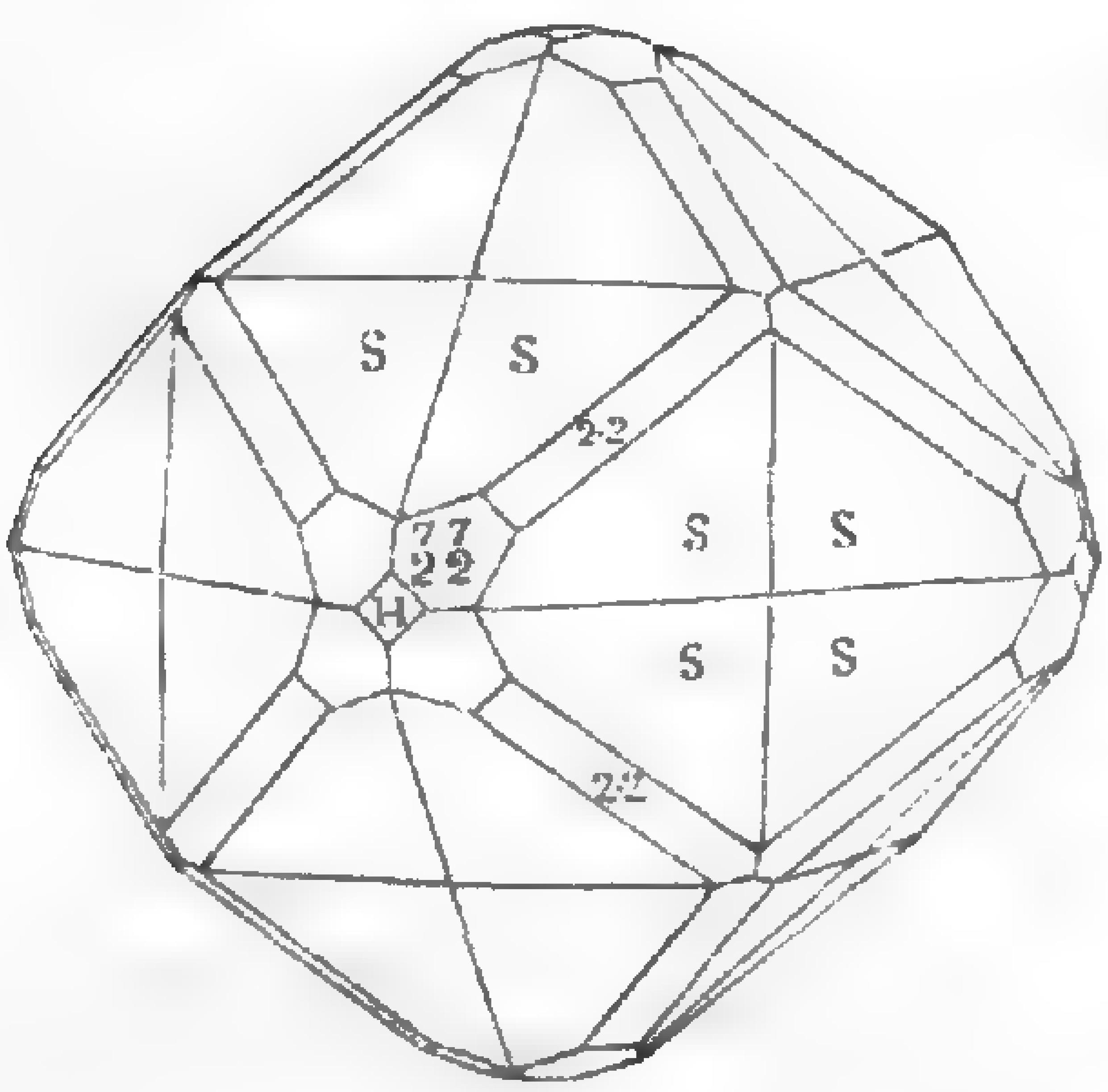
Finally, the *calcite* is found in crusts, and in rhombohedral crystals, covering the other minerals and also the surface of the rock itself. This calcite is very common not only at the point to which the garnets and their associates are confined, but also at many other places, so that it may not have any essential paragenetic relation to them.

All the above minerals are here true secondary products deposited on the columnar surface of the trap, and probably in the following order: magnetite, pyroxene, apatite, garnet, calcite. It will be noticed too, that, of the species which have been mentioned, the magnetite, pyroxene and apatite, are all original constituents of the rock itself, so that it can hardly be questioned that it has furnished immediately the material out of which these later minerals have been formed. The other essential ingredient of the rock, the triclinic feldspar, must have furnished the lime to the garnet and probably to the calcite; the excess of silica above that needed by the garnet, and also the alkalies have disappeared entirely.

Garnets from Mill Rock.

The other garnet locality is at the west end of Mill Rock. In appearance and in method of occurrence the garnets here found are a decided contrast to those that have been just described. They occur on the line of contact between the trap and the adjoining sandstone, and probably owe their origin to the metamorphic action of the heat of the erupted rock. They are found best in seams and little cavities in the trap, where they are implanted as isolated crystals upon an earlier deposit of quartz crystals. Occasional garnets of indistinct crystalline form but presumably of similar origin occur on the surfaces of the sandstone adjoining; scales of hematite produced by metamorphic action are common on the same surfaces.

The garnets in the trap only are distinctly crystallized: the crystals are highly complex and interesting. They appear at first sight to be dodecahedrons, but further examination shows that each dodecahedral plane is replaced by the four planes of a very obtuse hexoctahedron, having the symbol 64-$\frac{64}{63}$; the other forms occurring with this are: 2-2, $\frac{7}{2}$-$\frac{7}{2}$, and *H*. The adjoining figure shows the habit of the crystals. The following angles were measured to determine these forms.



For $\frac{7}{2}$-$\frac{7}{2}$ ∧ $\frac{7}{2}$-$\frac{7}{2}$ (over *H*) = 136° 15′, required 135° 59′ 48″.
" " " adjacent (edge B) = 149° 16′, required 149° 16′ 38″.
For 64-$\frac{64}{63}$ edge B = 178° 15′, required 178° 5′.
" " " C = 178° 56′, " 179° 6′.

Of the above enumerated forms, the basal plane (*H*) is quite rare with this species, the tetragonal tris-octahedron $\frac{7}{2}$-$\frac{7}{2}$ is new, though it has been observed on fluorite, and also by Klein (as a hemihedral form) on sphalerite; and the hexoctahedron 64-$\frac{64}{63}$ has been observed only on the *topazolite* from Piedmont (Quenstedt), though the related form *i*-$\frac{64}{63}$ was found by Websky on the transparent garnets of Jordansmühl, Silesia.

The Mill Rock garnets have a wine-yellow color, and a brilliant luster. The material available was much too scanty to admit of any chemical examination, but in view of their similarity of form and color, they may safely be referred to the variety *topazolite.*

In addition to the crystallized quartz upon which the garnets are implanted, the only other associated mineral is one occurring very sparingly in silky hair-like fibres. It was impossible to obtain enough for even a blowpipe examination, so that its character remains undetermined.

Art. XXXI.—*A description of the Rochester, Warrenton, and Cynthiana Meteoric Stones, which fell respectively December* 21st, 1876, *January* 3d, 1877, *and January* 23d, 1877, *with some remarks on the previous falls of Meteorites in the same regions;* by J. Lawrence Smith, Louisville, Kentucky.

A short notice of the three meteorites which form the subject of this communication, was published by me shortly after their fall, the detailed account of their flight and fall having been deferred until I could make a more thorough examination. This I am now able to do, as there have been sent to me the entire stone that fell near Cynthiana, and a large portion of the fragments which have been saved of the other two.

The points of interest in connection with these three meteorites are as follows: *First*, they fell within a period of thirty-two days, and within a circumscribed territory of about two degrees of latitude and six degrees of longitude. *Secondly*, they differ from each other in their structural characteristics, and each has some peculiarity distinguishing it from the ordinary type of meteoric stones. *Thirdly*, they fell within a belt of territory, which I shall show has been the lodging ground of all the meteoric masses that have been observed to fall and have been collected in the United States during the past eighteen years, with the exception of about one kilogram.

1. *Rochester* (*Indiana*) *Meteorite.*

The passage of this meteorite through the earth's atmosphere has left but a small souvenir of its visit. It was well observed at Bloomington, Indiana, lat. 39° 12′, long. 36° 32′, by the distinguished astronomer Professor Kirkwood, who communicated to me at the time his observations; and he has subsequently given them more in detail to the American Philosophical Society, with the observations he had collected from others. I will therefore simply give a summary of the phenomena attendant upon its flight before describing the chemical and mineralogical characteristics of the stone which fell.

The bolide made its appearance about nine o'clock P. M., December 21, 1876, and was of extraordinary magnificence. It passed eastward over the States of Kansas, Missouri, Illinois, Indiana, Ohio, and parts of Pennsylvania and New York. Although no observations were made in the two last mentioned States, still Professor Kirkwood is doubtless correct in defining this as its course. At Bloomington its elevation was fifteen degrees. According to the calculation, the length of its observed track was from 1,000 to 1,100 miles, one of the longest on record. Its height is supposed to have been thirty-eight miles above the place where the small fragment fell from it.

In various parts of its track, it threw off fragments, accompanied with the usual rumbling noise and commotion in the atmosphere common to the flight of these bodies. When crossing Indiana, the main body was followed by a train of smaller bolides, many of them of the apparent size of Venus or Jupiter. Its velocity in reference to the earth's surface appeared to be from eight to twelve miles per second. The pyrotechnic display is said to have been transcendently beautiful, hardly equalled or surpassed by any previous occurrence of the kind. The cause of this brilliancy lay in the physical structure of the body, which will be detailed farther on.

The fragment which fell.—The only fragment of this bolide known to have fallen was one found on the farm of Mr. Morris, three miles northwest of Rochester, Indiana, lat. 41°, long. 86°. This farmer heard the explosion, and shortly afterward noticed a body strike the ground not far from him. There were six inches of snow upon the ground, and, on the following morning he found the stone, which had rebounded to a short distance from the place where it first fell, it not having penetrated the ground. The entire stone did not weigh four hundred grams, and as we have not heard of the fall of any other mass, it is reasonable to suppose that it was dissipated into very minute fragments and dust, as in the case of the Hessle stones and other similar falls.

The manner in which the molten matter of the exterior of many of these meteorites is swept over their surfaces, in shining streaks, covering freshly broken surfaces, show clearly that this disintegration is constantly and rapidly going on in these bodies during their passage through the air. I have in my collection many fine examples illustrating this fact.

Professor Kirkwood is of the opinion that this bolide never passed out of our atmosphere, which is in accord with my general view on this subject, viz: that a bolide rarely, if ever, gets entangled in our atmosphere without being entirely reduced to fragments or powder.

The stone has been broken up into many small fragments, of which I have fortunately secured a good portion. Others have been lost and a few have found their way into collections. With the exception of the largest specimen in my collection, weighing ninety-five grams, hardly any other fragment weighs over thirty grams. It is important to treasure these specimens, small as they are, for it is a remarkable stone of its type. It is of the pisolitic variety, very friable, of a gray color, easily crushed under the fingers into light powder (some of it to fine dust), and to small globules, some of them *perfectly spherical*, of which I have specimens two millimeters in diameter. It resembles more closely the Aussun stone than any other I know of, although much more friable. This peculiar structure, so often seen in many parts of meteoric stones, has recently attracted much attention, Professor Tschermak, of Vienna, having recently published an interesting paper on the subject.*

The specific gravity of the stone, taken with several average specimens, is 3·55. There is nothing peculiar about the coating on the specimens I have examined; it is of a dull black and quite rough.

Chemical examination.—The stony part of the meteorite separated almost perfectly from the metallic part still contained a notable portion of troilite that could not be separated mechanically. The amount of sulphur found in that part of the meteorite indicated the amount of troilite present, viz: 3·31.

The stony material, when treated with chlorhydric acid over a water bath, affords soluble part 47·80 per cent, insoluble 52·20 per cent, and is constituted as follows:

	Soluble part, per cent.	Insoluble part, per cent.
Silica	34·55	57·81
Iron protoxide	27·75	11·04
Alumina	trace	·23
Lime	trace	5·31
Magnesia	36·38	24·97
Chromium oxide		·10
Soda	·46	·84
	99·14	100·30

I separated some of the globules perfectly free from the intervening matrix, which is easily done by rubbing a piece of the stone between the fingers. Very minute specks of iron could be distinguished on them, and when pulverized and treated with chlorhydric acid, they gave about the same result as the matrix, viz: soluble, 46·80 per cent; insoluble, 53·20 per cent; and the magnesia in the soluble part was 34·48 per cent, showing clearly that they were merely concretions of the matrix of the stone.

The nickeliferous iron, which was separated mechanically, is composed of:

Iron	94·49
Nickel	4·12
Cobalt	·51
	99·12

The quantity of iron was too small for an examination of the other constituents, as phosphorus and copper, but they were no doubt both present.

* Sitzungsb. Akademie der Wissenschaften, vol. lxxi, p. 661.—Wien.

Mineral constituents of the Stone.—Careful examination under the microscope of the broken surface, as well as of a section rubbed down very thin, show the stone to be composed of the unisilicates and bisilicates usually found in these bodies, mixed with nickeliferous iron and troilite; nothing like anorthite is distinguishable. The first two minerals constitute the bulk of the stone, and there is possibly more than one variety of each of these minerals present. The nickeliferous iron is quite abundant, although Professor Shepard states that from a casual observation he estimates it at one per cent; by the careful method adopted for separating it, I find in two average specimens over ten per cent. The particles of iron are very bright and lustrous, looking as if they were covered with plumbago, although there is no evidence of the presence of the latter mineral. The troilite is not detected so readily by the eye as it is by chlorhydric acid. One of the spherules was rubbed down to a thin section and examined by polarized light; and in this way it was found to contain both classes of silicates referred to, a fact, as already stated, sustained by chemical examination. I consider the mineral constituents of the Rochester stone to be about as follows:

Bronzite and pyroxene minerals	46·00
Olivine minerals	41·00
Nickeliferous iron	10·00
Troilite	3·00
Chrome iron	·15

2. *Warrenton (Missouri) Meteorite.*

About sunrise, on the 3d of January, 1877, five miles from Warrenton in the State of Missouri, lat. 38° 50′, long. 91° 10′, a sound was heard by certain observers similar to the whistle of a distant locomotive; or, as stated by others, like the passage of a cannon ball through the air. The sound came from the northwest, and became louder and louder to four observers near Warrenton. On looking up they saw an object falling, which struck a tree, breaking off the limbs, and then coming to the ground with a crash. The observers were fifty or sixty meters distant from the spot where it fell. On approaching the place they saw a mass of stone broken into a number of pieces. From the fragments they suppose it to have been originally of a conical form, and about eighteen inches in length. The snow was melted, and the frozen ground thawed near where it fell, but the pieces, although warm, were easily handled. The weight was estimated to have been about one hundred pounds; but, whether this estimate be correct or not, only about ten or fifteen pounds of fragments have been preserved, a good portion of which is in my possession, mostly in small fragments;

some specimens are in the cabinet of Yale College, and others scattered about among the inhabitants of the country where it fell.

As regards its temperature at the time of falling I would say that I have a specimen, which gives as it were a satisfactory record that it was not very hot when it struck the tree, for a portion of the fibers of one of the branches is adhering to the surface entangled in the rough crust of the stone, and these delicate fibers show not the slightest signs of having been heated. A fact to be noted in connection with the fall of this meteorite is that no explosion was heard, or any luminous phenomena produced, by its passage through the air after it was first noticed; this may be in part due to the fact that the fall happened at sunrise; but it was no doubt a meteorite well spent in its rapid motion through the atmosphere, and dropped quietly like an exhausted bird in its flight. Its direction, so far as made out, was from northwest to southeast.

Aspect of the Stone.—Studied by the various fragments that are under my observation, it differs in a marked degree, although pisolitic, from the one just described, and which fell only a few days previously. It has its own points of peculiar interest, and is not like any meteorite that I am familiar with, except the Ornans meteorite, which fell July 11th, 1868; and this it resembles closely in every particular, as may be seen by comparing my results with those of Pisani (Comptes Rendus Acad. Sci., 1868, vol. ii, p. 663), although his method of recording the analytical results is different from mine, and the specific gravity, as made out by him, is higher than mine, which is not singular in different specimens of these porous bodies. Its crust is dull black, and quite thick; in many places, of several centimeters square, from two and one half to three and one half millimeters thick (the thickest I have ever seen), where the crust is a rough scoria that sometimes terminates abruptly on a smooth portion of the crust, and is doubtless produced by the melted matter on the surface being forced backward and opposite to the direction of the flight of the stone, being swept off one portion of the surface, and leaving this part smooth, and piled up behind it, in the form of a surface of scoria.

The interior of the stone has a very dark uniform ash color, and is soft and easily crushed; the latter fact accounts for its having broken into fragments as it struck the ground. Its specific gravity is 3·47, and the amount of metallic matter contained in it is small.

Chemical composition.—The stone pulverized and freed from metallic particles gave on analysis an amount of sulphur equal to 3·51 per cent of troilite; the amount of nickeliferous iron was small, being equal to 2·01 per cent. The stony minerals treated with chlorhydric acid gave—

Soluble in acid	80·40 per cent.
Insoluble in acid	19·60 per cent.

composed as follows:

	Soluble.	Insoluble.
Silica	33·02	56·90
Iron protoxide	37·57	10·20
Alumina	0·12	·20
Lime	trace	7·62
Magnesia	28·41	22·41
Soda	·07	1·00
Nickel oxide	1·54	
Cobalt oxide	·31	
Chromium oxide		·33
	101·04	97·66

I obtained chrome oxide thirty-three per cent, indicating 0·50 of chrome iron, if the chrome be present in that form. There is no way, however, by which I can decide this question, although it is probable, since the chrome is in the insoluble part; the oxide of nickel, with the exception of perhaps a minute portion, belongs to the composition of the soluble silicates.

The nickeliferous iron contained in this stone is very small in quantity. This on analysis gave

Iron	88·51
Nickel	10·21
Cobalt	·60
	99·32

Mineral constituents of the Warrenton Meteorite.—A microscopic examination did not give me any clear indications, for it is not possible to prepare a good section for observation. Its chemical examination, however, shows the usual uni- and bi-silicates, of the olivine and bronzite and pyroxenic types. The most marked feature is the preponderance of the olivine minerals, constituting four-fifths of the mass. The proportion of the mineral constituents is about as follows:

Olivine minerals	76·00
Bronzite and pyroxenic minerals	18·00
Nickeliferous iron	2·00
Troilite	3·50
Chrome iron	·50

3. *Cynthiana (Kentucky) Meteorite.*

I have called this the Cynthiana stone, although it fell nine miles from that place, in Harrison county, Cynthiana being the nearest important point to the place where it fell.*

* I will take occasion just here to correct an error that I have seen in several catalogues, among them those of Vienna, the British Museum, and the Garden of Plants. These catalogues designate the meteoric fall described by me in 1858, as that of Harrison county, Kentucky: it should read Harrison county, *Indiana.*

At four o'clock P. M., on the 23d of January, 1877, a brilliant bolide was seen traversing Monroe county, Indiana, in a southeasterly direction, about thirty-five degrees above the horizon. The same bolide was observed by a number of persons in Decatur county, of the same State, lat. 39° 27′, long. 85° 28′, and it disappeared just as it seemed to touch the earth, apparently not more than a quarter of a mile distant. As will be seen, it fell about sixty miles distant from these places. It seemed to fall almost perpendicularly toward the earth's surface. I cannot learn that it was seen by any one in the State of Ohio, but suppose that it was. In the State of Kentucky it was seen over a considerable territory. The phenomena culminated in the usual noises heard in the heavens accompanying the approach of these bodies, and much consternation was produced among the inhabitants of the surrounding country. Fortunately one of the observers, an intelligent farmer (Mr. Cragmyle), heard a solid body strike the ground; he walked immediately to the spot, and dug the stone from a depth of thirteen inches, to which extent it had penetrated the ground. A few days after its fall and before it had become generally known, Professor Kirkwood wrote me a letter, stating what observations had been made in Indiana, and telling me to look out for a meteoric fall somewhere about the region where the stone did fall. I had, however, made the observations and secured the meteorite, before his letter arrived, but the stone had not yet been forwarded to me.

Character of the Stone.—It is wedge-shaped, with one portion of it very extensively and regularly pitted, while the rest is comparatively smooth. The crust is dull black, and, as it reached me, it was as perfect as when it fell. There was a fresh broken spot of two or three square centimeters, which, to a casual observer, would appear to have been made after the fall; but upon close examination, I saw that it had been made prior to the fall, and before the melted matter of the surface had entirely cooled, for a few small specks of this matter have been sprinkled on this broken surface, to which it firmly adheres, and the molten matter is running over one border of it. This could not have arisen from any fusion of that surface, which is too fresh and unaltered to have been heated to any high degree. The fracture was produced by the same cause that produced the pitting.*

The weight of the stone is six kilograms. It is of the harder brecciated variety, and when broken presents a mottled surface, identical with that of the Parnallee stone, which it resembles also in every other particular, the very pale yellow round spots,

* This is clearly and fully set forth by Professor Maskelyne, in the Phil. Mag., for August, 1876.

sometimes five or six millimeters in diameter, are disseminated through the two alike; and so with the triolite, the globular structure in some parts, and a few specks of a black siliceous mineral; and, by a singular coincidence, the specific gravity of the part I tested is identical with that as made out by Maskelyne, viz: 3·41. Under the microscope it presents the appearance described by the same author.

Chemical examination.—The stony material freed from metallic iron, consisted of—

Matter soluble in chlorhydric acid	56·50
Matter insoluble in chlorhydric acid	43·50

Some of the soluble part was composed of troilite, which I could not separate mechanically, but is deducted in the following analysis:

	Soluble part.	Insoluble part.
Silica	33·65	57·60
Iron protoxide	30·83	11·42
Alumina	·11	·43
Lime	trace	5·70
Magnesia	34·61	23·97
Chromium oxide		·38
Soda		1·24
	99·20	100·74

The portions examined contained nickeliferous iron 5·93 per cent, consisting of:

Iron	90·64
Nickel	8·35
Cobalt	·73
	99·72

Mineral constituents of the Cynthiana Stone.—The minerals in this stone are quite easily distinguished by the eye, but are very much more conspicuous under a moderate magnifying power, especially the round and distinct concretions of a light yellow bronzite. The troilite and metallic specks and filaments are also easily seen.

No attempt was made to separate the stony minerals in sufficient quantity for analysis; quantitative tests were made to distinguish their character. From the chemical examination previously made I deduce the following as about the proportion of the mineral constituents:

Olivine minerals	50·00
Bronzite and pyroxenic minerals	30·00
Nickeliferous iron	6·00
Troilite	5·50
Chrome iron	·52

There were no distinct crystals of minerals visible either to the unaided eye or with a lens.

4. *Remarks on the region where these meteorites fell.*

In the study of the three aerolites just described it is interesting to note the relation of the region where they fell to that of previous falls of recent date.

During a period of less than eighteen years there have been twelve falls of meteoric stones in the United States, of which specimens have been collected. All of these, with one or two exceptions, I have described in detail, and furnished specimens to various cabinets in this country and in Europe.

In grouping together these twelve falls and estimating the amount of meteoric matter accompanying them, I have been struck with the singular fact that eight of them, with over one thousand kilograms of matter, have occurred over the prairie regions of the West, not far from my home; and the extreme limits of these falls is within a region not exceeding one-eighth of the surface of the United States, east of the Rocky Mountains. It may be supposed that one reason for this may be that this region is more thickly populated than others, and consequently that there are more observers. This however is not the case, for the population is not much above the average of the country.

I have made a map of the region (see next page) where these eight falls occurred, which shows at a glance their relative positions. The accompanying table gives a few comparative details in relation to each of them.

No.	Time of Fall.	Place of Fall.	Lat.	Long.	Estimated Weight of Fall.
1	28th March, 1859	Harrison Co., Ind.	38° 20′	86° 10′	1· kilo.
2	1st May, 1860	Guernsey Co. (Concord), O.	40	81 30	500· "
3	25th March, 1865	Claywater (Vernon Co.) Wis.	43 30	91	3· "
4	Not known, 1874	Waconda, Kansas,	39 20	98 10	40· "
5	12th Feb., 1875	Iowa Co., Iowa,	41 40	92	500· "
6	21st Dec., 1876	Rochester, Indiana,	41	86	·40 "
7	3d Jan., 1877	Warrenton, Missouri,	38 50	91 10	10· "
8	23d Jan., 1877	Cynthiana, Ky.	38 20	84 20	6· "
				Total,	1060·40 kilos.

There have been four other falls in the United States during the same period; but the aggregate weight of them is less than two kilograms. They occurred respectively, Nov. 28th, 1868, lat. 34° 30′, long. 87°; Dec. 9th, 1868, lat. 34° 30′, long. 87° 50′; Oct. 6th, 1869, lat. 32° 10′, long. 85°; May 21st, 1871, lat. 44° 30′, long. 69° 10′.

Again: in this region more bolides have recently been observed than in any other. Professor Kirkwood has described,

1. Lat. 38° 20′, Long. 86° 10′; 2. Lat. 40°, Long. 81° 30′; 3. Lat. 53° 30′; 4. Lat. 39° 20′, Long. 98° 10′; 5. Lat. 41° 40′, Long. 92°; 6. Lat. 41°, Long. 86°; 7. Lat. 38° 50′, Long. 91° 10′; 8. Lat. 38° 20′, Long. 84° 20′.

as seen by him and others, eight from July, 1876, to February, 1877, the stones from three of them are those described in this paper, the others left no evidence of their passage. By personal observation I have noted, in the last two or three years, three splendid bolides, that were seen to burst in the sky, but of which no fragments were found; these I have described, and still others have been described to me by several observers. It is a still more striking circumstance, that, in the past sixty years, there have been twenty well noted falls of meteoric stones; and of these just one half have fallen within the region mapped by me as including the eight falls of the past eighteen years; and the weight representing them is nearly twelve hundred kilograms—an amount twenty times greater than that of the other ten falls scattered over various regions.

I have mentioned this singular fact not that it has any cosmical significance, but simply as a part of the record I keep of my observations and study of these curious links between heaven and earth. Before very long I hope to put together my more recent speculative studies in regard to these bodies.

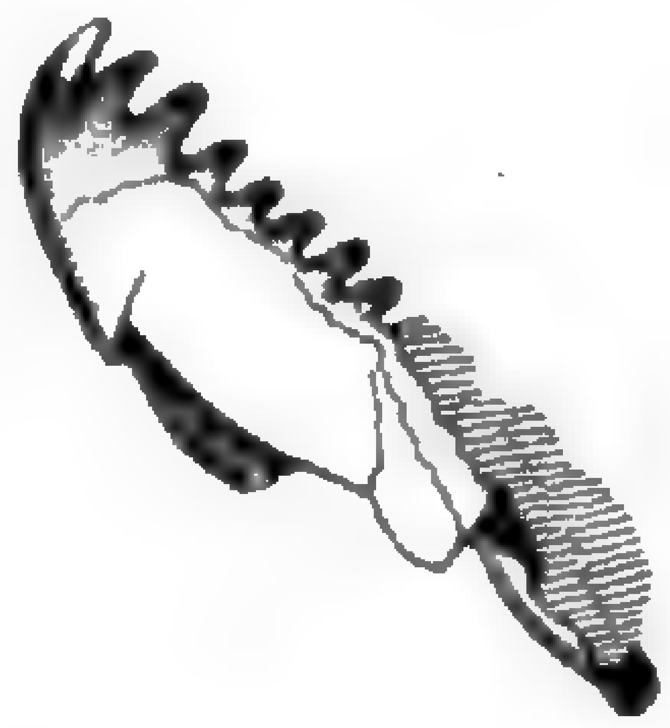
Art. XXXII.—*Notice of a new genus of Annelids from the Lower Silurian;* by Geo. Bird Grinnell.

The Museum of Yale College has recently received, from the rocks of the Cincinnati group, a series of fossils which are of unusual interest. The remains are shining black in color, and present a striking contrast to the associated fossils, Trilobites, Brachiopods, Crinoids, etc., which have assumed the color and constitution of the matrix. An examination of these black remains shows that they are the hard chitinous parts of Annelids.

While the presence of animals of this group in the Lower Silurian has been inferred from their "trails" and impressions in the rocks, no portions of their bodies have as yet been found preserved in the deposits of this age. The remains which first suggest themselves for comparison with these specimens are the Conodonts of Pander. Through the kindness of Professor Marsh, the writer has been enabled to examine a number of the original specimens of these fossils, collected by Pander himself near St. Petersburg; and a comparison makes it clear that they are quite unlike the remains referred to. They are widely different in color and form from the material under observation, while chemical tests show that their composition is by no means similar.

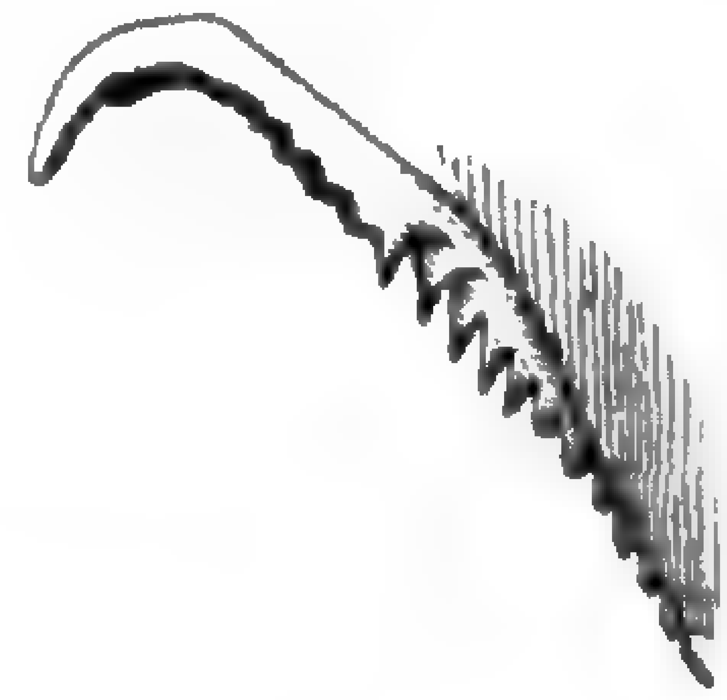
These Cincinnati fossils include a large number of specimens, and, as might be expected, there is a wide variation in their form. So little is at present known in regard to the jaws of Annelids, that any general conclusions drawn from the material at the command of the writer would be premature; and for the same reason it would be unwise to distinguish by a name each of the many forms which appear. Further study will doubtless furnish data for a more extended description, with numerous illustrations, which it is hoped will soon be completed.

1.



× 5.

2.



× 10.

Nereidavus varians, gen. et sp. nov.

The jaw selected as a type for the genus (fig. 1), is one of the largest and most perfectly preserved of those at hand. It is dark brown, with a coppery luster in some places, this coloring being due to the weathered condition of the specimen. It is hollow at the base and throughout the greater part of its length, and so strikingly resembles the jaw of the common *Nereis pelagica* Linn. of the Atlantic coast, as to render their near affinity almost certain. The denticulations, or teeth, are eight in number, but were probably more numerous originally, since the posterior portion of the specimen is wanting. The anterior tooth, which is the largest, is somewhat twisted outward, not lying in the same plane with its fellows. The length of the specimen is 5·6 mm., the depth beneath the fourth tooth 1·4 mm.

A second very perfect specimen, which may possibly belong with the jaw above referred to, is represented in fig. 2. It contains eighteen teeth, the anterior one quite long and stout, the next five mere slight protuberances, and only to be seen under the microscope, while the remaining teeth are sharp and strong. The length of the exposed portion of this individual is 2·8 mm.; depth under the first of the strong teeth, the seventh in the series, ·22 mm. Since the base of this specimen is buried in the rock and cannot be seen, it is not altogether certain what it is. It bears some resemblance to one of the setæ of *Nereis Dumerilii*, Aud. and M. Ed., figured by Ehlers in his work entitled Die Borstenwürmer, pl. XX, fig. 31.

The specimens under consideration were collected by Professor A. G. Wetherby, near Cincinnati, Ohio. Through the energy and courtesy of this naturalist, a large suite of specimens has been secured and forwarded to New Haven, and to him the writer would express his grateful acknowledgments.

Yale College Museum, New Haven, Conn., July 28th, 1877.

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *The Radiometer.*—A large number of papers on this subject have appeared during the past few months. Several of these have been published in Poggendorff's Annalen, and of the rest, excellent abstracts are given in the "Beiblätter" to that journal. They give evidence of a very great amount of ingenuity expended in devising experiments to test the theory of this very remarkable instrument, and they show how easily experimental evidence may be misinterpreted in support of an assumed theory when the phenomena in question are liable to be modified by many adventitious circumstances. Five theories of the radiometer have found prominent and weighty advocates. The first regards the motion of the instrument as a *direct* effect of radiation. The second refers it to electrical action. The third to convection currents. The fourth to the emission of material particles from the vanes or the walls of the instrument. The last finds in the apparatus simply a new heat engine, and sees in the motion a simple result of the difference of temperature of the parts, wholly in accordance with the modern mechanical theory of heat.

When this motion was first discovered it seemed to be a direct mechanical effect of radiation, and there were not wanting ingenious speculations to show how the force exerted by the waves of the luminiferous ether might be resolved so as to produce such an effect. It is to be remarked, however, that Mr. Crookes, to whom we owe the discovery, did not indulge in such speculations, and, as he says, aimed to keep himself unbiased by any theory while he accumulated the facts upon which a satisfactory explanation might be based. But the very name *radiometer* implied, and the whole tenor of his published papers have certainly justified, the common opinion that, until very recently, he regarded the phenomena—he had so admirably developed—as a *direct effect* of radiation, and not, as he now thinks, a secondary result depending on differences of temperature, which may be produced by radiation or by other means. Hence, several experimenters have labored to show that in the motion of the little wheel of the radiometer the reaction was exerted not against anything independent of the instrument, but against the enclosing walls of glass. The early experiments of Mr. Schuster* on this point were very convincing. He hung the whole instrument by a delicate bifilar suspension, and found that while the vanes were revolving under the action of a beam from an oxyhydrogen lamp, the glass bulb also turned slightly in the opposite direction. Soon after M. Salet† constructed a very ingenious apparatus in which this reaction was made to turn a mica disk; and very recently, M.M. Bertin et

* Philosophical Magazine, Nov., 1876.
† Comptes Rendus, Nov. 20, 1876.

Garbe* have published an interesting paper, in which they show by careful measurements that the reaction of the glass bulb fully accounts for the motion of the wheel; and their investigation may be regarded as finally disposing of the radiation theory, by proving that the motion of the wheel of the radiometer is wholly caused by forces which act within the glass bulb.

The electrical theory has never had many supporters. It is, however, defended in two recent articles by J. Delsaulx† and W. de Fonvielle.† In opposition it is urged that no distribution of statical electricity could maintain a constant motion,‡ and further, Mr. Crookes§ cites an experiment of Mr. Cromwell F. Varley, with an apparatus so arranged that the electrical condition could be tested with a delicate electroscope; when not the slightest trace of electrical excitement could be detected, although the motion of the wheel was regularly maintained.

The convection theory has been recently advocated by F. Neesen,‖ who describes a number of experiments which he thinks indicate that the wheel of the radiometer is moved by the gas currents occasioned by the rising or falling of the residual air particles as they are warmed or cooled, at the surfaces of the vanes or of the enclosing glass walls. But the effects he obtains by placing similar wheels unsymmetrically under the receiver of a mercury pump, do not, as it seems to us, necessitate his explanation, and moreover the distinction between the effect of convection currents and the peculiar motion of the radiometer is strikingly marked in many experiments which have been elsewhere described, the one passing into the other at a certain degree of exhaustion.¶

The emission or evaporation theory appears to have originated with Mr. Osborne Reynolds. It was later maintained by Govi,** and recently it has formed the subject of an extended article—in three parts—by F. Zöllner.†† This theory refers the motion to an alternate emission and absorption of material particles—determined by variations of temperature—at the several surfaces, between which the moving forces in the radiometer are exerted. The particles thus emitted may be either those of aeriform substances adhering to or occluded by the solid materials of which the instrument is made—as Reynolds supposed—or it may be, as Zöllner suggests, that these solids themselves *evaporate* slowly into the vaccuous space. Leaving, however, such questions in abeyance—as these physicists prefer,—there is no doubt that the general order of the phenomena might be explained if the assumptions which the emission theory requires could be accepted; but on the other hand, the phenomena which Zöllner adduces in support of his view, may be,—for the most part at least—fully as well explained by the more general mechanical theory of heat. Zöll-

* Annales de Chim. et de Phys., [V] xi, 45, Mai, 1877.
† Beiblätter, i, 170. ‡ Beiblätter, i, 329. § Pogg. Ann., clx, 143.
‖ Compare Zöllner, Pogg. Ann., clx, 459. ¶ Proc. Royal Soc., 1874, June 18.
** Pogg. Ann., clx, 154, 296 and 459. †† Comptes Rendus, lxxxiii, 1.

ner endeavors to show* that the mean path of the molecules of the residual gas in the bulb of the radiometer, when it is in the condition of maximum sensitiveness, is not large enough to fulfill the conditions which the mechanical theory requires. On the other side, Crookes† has obtained motion or the reverse, under conditions which certainly appear incompatible with the emission theory. Moreover, the very fact which appears to have been well established by several observers, that, with a certain degree of exhaustion, different for different gases, a point of maximum sensitiveness is reached, and that on further exhaustion the sensitiveness rapidly diminishes, seems to us,—especially when viewed in connection with the experiments just referred to—fatal to the emission theory.

The last theory we have to consider is, as we have said, but a phase of the mechanical theory of heat. The application of the now well known principles of molecular dynamics to the explanation of the new phenomena is said to have been first suggested by Mr. Johnstone Stoney.† Similar views were also very early expressed by Professors Tait and Dewar.‡ More recently they have been adopted by Mr. Crookes,§ and are now very generally accepted by physicists.

According to the mechanical theory of heat, the molecules of any gas which rebound from a surface with a temperature—that is, with a velocity—different from that with which they struck, must cause a recoil, and this must be the general case whenever the temperature of the surface is different from that of the mass of the gas. Unless, however, the density of the gas is exceedingly small, the rebounding molecules almost at once collide with their neighbors, and are immediately driven back against the same surface. Thus the change of temperature merely affects a very thin layer of molecules near the surface, and these are only slowly displaced by convection. In such an atmosphere, the vanes of a radiometer, for example, with the adjacent molecules, are parts of one system, and, by a well known mechanical law, no motion of the system as a whole can be produced by any action between its parts; but when the medium becomes so rare that the mean path of the molecules is comparable with the dimensions of the enclosing vessel, so that some of the molecules, rebounding from the vanes of the radiometer, may even reach the opposite walls, then of course a force is exerted between the opposing surfaces, and the now familiar motion of the wheel is the result. The radiometer is then simply a heat engine in which the action takes place between two surfaces of different temperature, the heater and the cooler of the engine. As such a difference of temperature may be maintained in a great variety of ways, so the apparatus admits of a great number of modifications. Moreover, it is obvious that

* Pogg. Ann., clx, 305. † Beiblätter, i, 167 and 330. ‡ Nature, July 15th, 1875.
§ Philosophical Transactions, vol. clxvi, p. 375, in postscript dated June 17, 1877. See also Mr. Stoney's papers. Phil. Mag., V, i, pp. 177–182, 305–314, (1876).

when, as in most cases, the difference of temperature is the result of radiation, very irregular effects may be produced by the different absorbing or radiating power of the surfaces for the various rays of the spectrum, and also by similar differences in the diathermancy of the glass envelope. It is not surprising then that some of the phenomena which have been met in the course of the numerous investigations already made on this subject, should have been so difficult to trace. There can be no question, however, that the general order of the phenomena is fully explained by this theory. In the postscript just referred to, Mr. Crookes writes, "Twelve months' research, however, has thrown much light upon these actions, and the explanation afforded by the dynamical theory of gases makes, what was a year ago obscure and contradictory, now reasonable and intelligible."

It does, however, still remain to show that the dynamical theory of heat is quantitatively as well as qualitatively confirmed by the new phenomena. The necessary measurements unfortunately present very great experimental difficulties, and the data thus far obtained can only be regarded as rough estimates, and for this reason we do not attach much importance to the criticisms of Zöllner already referred to. Among the results bearing on this question recently obtained, the most interesting are the following.

Of course, according to the theory in question, there would be no motion whatever in an absolute vacuum, and hence, as we have intimated, the molecular pressure on the vanes of a radiometer ought to reach a maximum effect with a certain limited degree of exhaustion. Moreover, as the length of the mean path of a molecule, other things being equal, depends on the molecular weight,—the lightest molecules having the greatest extent of motion under the same conditions,—it also follows that the limit just mentioned should be sooner reached in the residue of a light than in that of a heavier gas. In accordance with these anticipations, Mr. Crookes has found that while with hydrogen the maximum effect is reached at a tension of about 0·0532 millimeters, it is not obtained with oxygen until the tension is reduced to 0·0228 millimeters, or less than one half of the previous value. In an ordinary radiometer, according to the same experimenter, the tension of the residual air is about 0·19 millimeters, but he has succeeded in reducing it to 0·0076 millimeters, and then the velocity of the motion was only one-tenth of the maximum. Still later he states that by heating the bulb to 300° during the exhaustion, he has been able to reduce the tension to one or two millionths of an atmosphere, and that he can most readily secure the condition of greatest sensitiveness by first pushing the exhaustion to the utmost limit of the power of his apparatus,* and then with the aid of a peculiarly constructed cock allowing gas to enter until the proper tension is reached. By

* Crookes has obtained these later results with a new form of the Sprengel pump, contrived by C. H. Gimingham, and an ingenious application of the mercury gauge to measuring low tensions, made by McLeod. Full descriptions of these new forms of apparatus, with figures, will be found in the Beiblätter, i. 175.

using vanes of mica previously rendered anhydrous by ignition and working with hydrogen, he has thus succeeded in constructing a radiometer of such sensibility that it moved under the sole influence of the moon's rays. The results of Finkener on the point of maximum sensibility in different gases confirm those of Crookes, the two series of measurements agreeing as nearly as could be expected, and all these results—with yet others—have been collected in a very interesting paper recently published by M. Bertin.* No one has yet succeeded in pushing the exhaustion so far beyond the point of maximum effect that the radiometer became again insensible to radiation, nor was that to be expected.

It is another consequence of the dynamical theory of gases that a radiometer with a small bulb ought to be more sensitive—under otherwise like conditions—than one with a large bulb, and this also has been fully realized by Mr. Crookes.† Quite recently, Stoney and Moss‡ have published some preliminary results of an investigation, in which they propose to compare the molecular pressure between the "cooler" and "heater" in this new form of heat engine at different distances and with various gas residues, and under varying conditions of tension, temperature, etc. The investigation was begun soon after the publication of Stoney's original communication to the Phil. Mag., March, 1876, and is not yet completed. They give a description of their apparatus, and they call the reaction exerted between the cooler and heater in the radiometer and all similar instruments, "Crookes' Force." We must refer to their paper for details which appear to authorize the conclusion that in a residue of hydrogen having a tension of five millimeters, the molecular pressure, or "Crookes' Force," is sensible at a distance of at least ten millimeters.

Again, although the molecular pressure we are considering must in general conform to the well known laws of hydrostatics, like the tension of the atmosphere, yet the mechanical theory of gases would lead us to anticipate certain striking differences of effect resulting from the great amplitude of the molecular motion in an extremely rarified medium. Thus the tension of the atmosphere does not move the vanes of an anemometer; but a wind does. And in a somewhat similar way—when the wheel of a radiometer is made like that of the anemometer—the resultant of the recoils due to the acceleration of the rebounding molecules will be greater on the convex than on the concave surface of the cups, although being made of thin metal plate, the temperature of the two surfaces must be essentially the same. Such effects have been studied both by Crookes§ and by Zöllner.‖

It is greatly in favor of the view of the subject last presented that it does not invoke a new agency or exaggerate an old one to explain the new phenomena; but it is merely a new phase of an already well established theory, which, by thus readily marshalling the new phenomena, becomes more firmly established. Indeed, to

* Annales de Chimie et Physique, V, x, 396, Mars, 1877. † Beiblätter, i, 165.
‡ Beiblätter, i, 318, No. 6; also Proc. Roy. Soc., xxv, 553.
§ Beiblätter, i, 169. ‖ Pogg. Ann., clx, 159.

those who accept this theory the radiometer becomes an instrument of the very highest interest, affording as it does, another and very striking manifestation of molecular motion. Moreover, when we shall be able to overcome the experimental difficulties so as to estimate with certainty the force exerted under determinate conditions, we may hope to obtain by its aid a direct measure of absolute molecular magnitudes.

We may be permitted to add to this notice a brief account of a few experiments made with the radiometer at Cambridge in the spring of 1876, soon after the instrument had been received from Europe. We became at once greatly interested in the new phenomena, and with the aid of a skillful glass blower made more than a hundred instruments of different patterns. Our experience led us at once and independently to the theory of its action now generally received; but although we sustained this view in our college lectures, in a communication to the American Academy, and in a popular article in the Boston Daily Advertiser, we did not otherwise publish our results, because we felt that the field had been in a measure preëmpted by the discoverer of the phenomena, who was then investigating the subject, and who, we felt sure, must come at last to the same conclusions which we had reached. Our results can now add nothing to the strength of the theory, which has been since so well worked out by Mr. Crookes, but two of the experiments have never been—so far as we know—described before, and being so simple that they can be easily repeated in any physical cabinet, a description of them, even at this late day, may have an interest for teachers of physics.

We first experimented with a common radiometer having mica vanes blackened on one side, which we placed in a beam of parallel rays from an oxyhydrogen lantern; and having satisfied ourselves—by using an alum cell—that the rays acted chiefly at least through their heating and not their luminous power, we made at once this experiment. We placed an opaque screen near the radiometer so that only the blackened faces should be exposed as the wheel turned the vanes into the beam of light. We then counted with a stop watch the number of seconds which passed during ten revolutions. We then in a similar way exposed only the uncoated faces; when the wheel continued to turn in the *same direction*, although much more slowly than before. Again we counted the revolutions. Lastly we counted the revolutions while the beam shone on both sides of the vanes as usual. We repeated the experiment several times, and were surprised at the remarkable constancy of the results. They were as follows:

	Time of ten revolutions.	Revolutions in same time.
With both faces exposed	8″	319
With lampblack faces alone exposed	11″	232
With mica faces alone exposed	29″	88

and it will be noticed that 88+232 equals very nearly 319. Now any uniform force whatever, acting from without and at once on the two arms of a lever like these vanes, must act differentially and not concurrently, as here. Hence the reaction which causes the motion must take place between the parts of the instrument itself; or else we are driven to the most improbable alternative that lampblack and mica should have such a remarkable selective power that the impulses, then supposed in some mysterious way to be imparted by the beam of light, could exert a repulsive force at one surface and an attractive force at the other. Were there, however, such an improbable effect, it must be independent of the thickness of the mica vane; while on the other hand, if, as seemed to us most probable, the whole effect depended on the difference of temperature between the lampblack and the mica, and if the light produced an effect on the mica surface only because the mica plate being diathermous to a very considerable extent, the lampblack became heated through the plate more than the plate itself, then it would follow that if we used a thicker mica plate, which would of course absorb more of the heat, we ought to obtain a marked difference of effect. Accordingly we repeated the experiment with an equally sensitive radiometer—which we made for the purpose with comparatively thick vanes; and with this the effect of a similar beam of light on the mica surface was absolutely null, the wheel revolving in the same time whether these faces were protected or not. It was now an obvious step to heat the glass of the bulb independently of the vanes in order to see if under these circumstances we should not obtain a reverse action. This was easily effected both by warming the glass over a lamp and also by placing the bulb tangentially toward the beam from the lantern, so that it heated the glass without striking the vanes of the wheel. We thus easily obtained the now familiar reverse motion, but which was to us a new discovery. We therefore felt ourselves justified in speaking of the radiometer, as we did in the communications referred to, as a heat engine, of which, when moving in the ordinary way, the lampblack surface of the vanes is the "heater" and the inner surface of the glass bulb the "cooler," but in which these conditions could be reversed as just described. And then the parallel with the steam engine, which we drew, suggested the extension of the dynamical theory of gases to include the new phenomena almost in the very words used above. Moreover, while exhausting the large number of radiometers of which we have spoken, we noticed variations in the effects produced, caused by differences in diathermancy between crown and flint glass, and were thus led to realize what an important part this property of matter played in these phenomena. We also observed that the larger the bulb to the greater degree must the exhaustion be pushed in order to obtain equal sensitiveness. We further found that the same sensitiveness could be more readily obtained with a residue of hydrogen than with one of air, and we recognized plainly that there was with each instrument a point of maximum sensitiveness which could not be exceeded. We had also devised an apparatus for measuring the force exerted under determinate conditions, but our experiments were brought to an end by the sudden death of the only skillful glass blower in our neighborhood.

Soon after these experiments, Mr. B. O. Peirce, now assistant in the Physical Laboratory of Harvard College, made the following striking comparison of the relative effects produced by a large variation in the same radiant source on a radiometer and a thermopile. He used a large Bunsen burner provided with an air valve, so that the non-luminous could be at once changed to a luminous flame. He placed the burner midway between the radiometer and the pile which were about one meter apart. The radiometer was protected from the radiation of surrounding objects by a tin case, blackened on the inside, except where a circular aperture admitted the rays of the lamp and where the reflecting surface of the cover set obliquely enabled the observer to count the revolutions of the radiometer wheel. In front of the thermopile was placed an opaque screen, having an aperture of the same size as that of the radiometer case, and also a thin plate of glass to correspond to the glass of the radiometer bulb. Beginning with the non-luminous flame, Mr. Peirce counted the number of turns of the wheel of the radiometer in a minute, and also took the readings of the galvanometer; then, after rendering the flame luminous (by shutting the air valve), the same observations were repeated. A comparison of the similar values gave, of course, the relative radiation of the non-luminous and the luminous flame as measured by the radiometer on the one side and the thermopile on the other.

	Radiometer.	Thermopile.
1.	0·343	0·287
2.	0·309	0·380
3.	0·248	0·283
4.	0·267	0·325
5.	0·277	0·350
6.	0·367	0·250
7.	0·394	0·304
Mean,	0·315	0·311

While, therefore, there was quite a large variation between the several observations, as might be expected with such a variable source as a Bunsen flame, yet the close agreement of the averages showed conclusively that with the radiometer, as with the thermopile, the effect caused by the rays of light must arise solely from the change of temperature thus produced. It will be noticed that—as measured by either instrument—the radiation of the luminous flame produced only about three times the effect obtained from the non-luminous flame; while a photometric comparison made at the same time showed that the illuminating power of the first was at least a thousand times greater than that of the second. Two separate experiments gave 1080 and 1079 times greater respectively.

In this notice we have been able to refer to only a few of the salient points presented in recent articles on the radiometer, and it will of course be understood that our limits prevent us from even alluding to a large number of other very interesting observations bearing on the subject. J. P. C., JR.

Newport, August 3d, 1877.

II. Geology and Mineralogy.

1. *Gravel deposits referred to the Drift, in Boone County, Kentucky.*—Mr. George Sutton states (Proc. Amer. Assoc., 1876, p. 225), that on the highest part of the table-land in Boone County, Kentucky, 450 to 500 feet above high-water mark in the Ohio, there are extensive deposits of gravel, some of which is cemented into a firm conglomerate. Similar accumulations occur at a height of about 100 feet above the same level near the mouth of Wolper Creek, and a bluff of it at this place has a height of 72 feet. It here blends with a stratified terrace formation which extends for six or seven miles along the river and is in some places over a mile in width. The material is unstratified, small pebbles and large angular bowlders being mingled in confusion. Near this part of Kentucky, the Great Miami and the White Water rivers, coming from the north, empty into the Ohio, where the river makes a sudden bend to the southeast, forming an acute western angle of the great North Bend. A line drawn from the valleys of these rivers across this acute angle intersects the drift conglomerate at Wolper Creek. Along this line, behind hills east of Petersburgh, Kentucky, there is an ancient valley of the Ohio, three to four miles long and half a mile broad, cut out of the rocks, which is now above the highest floods of the river. The drift accumulations are attributed to glacier ice coming down the Miami and White Water valleys, and crossing the Ohio valley, carrying drift material for deposition beyond. The author supposes that there may have been ice obstructions in the Ohio below, to have favored the transfer across; but if the glacier was the wide-spread northern glacier, extending across into Kentucky, the obstructions would hardly have been necessary. North of the Ohio the drift occurs nearly opposite Loughery Island, and at the mouth of Hogan Creek, at about the same height as the river-terrace formation in Kentucky. That of Hogan Creek consists of laminated clay and loam with very little gravel, and, as the author remarks, it was evidently formed away from the current of the Ohio River.

2. *Gravel Ridges in the Merrimack valley.*—Mr. G. F. Wright describes the gravel ridges connected with the Quaternary of the Merrimack valley, in the vicinity of Andover and both south and north of that place, in the Proceedings of the Boston Society of Natural History for December, 1876. At Andover there are three such ridges, at a height of 82, 90, and 132 feet above the bed of the river, the highest being most remote from the stream. They are often only wide enough at top for a foot path. The courses of the ridges are more or less tortuous, and they are frequently broken into hills among which are often depressions occupied by water. They consist of sand, gravel and water-worn stones, and stones from a few inches to two feet through, and they are not in all parts stratified. The coarse material is as

likely to abound near the top as at the bottom. The material overlies the "bowlder clay" or "till" of the region. These ridges are part of what are referred to as "Kames" by Mr. W. Upham in a paper noticed on page 156 of this volume. They are regarded by Mr. Wright as depositions directly from the glacier during its dissolution, modified afterward by the water which, especially in the summer months, would have flowed freely, over, beneath and from the foot of the glacier.

3. *On the supposed Fossil Tracks called Protichnites and Climatichnites;* by Professor E. J. CHAPMAN.—The Potsdam sandstone of Beuharnois and Vaudreuil, Canada, near the junction of the St. Lawrence and Ottawa rivers, and the same formation in the vicinity of Perth, Canada, afforded the *Protichnites*, four species of which were made out by Professor Owen. Professor Chapman, of Toronto, concludes, from his examination of them that they are impressions of large fucoids. This view he regards as strengthened by the occurrence of the *Protichnites* at Perth along with the impressions known as *Climatichnites*. The latter have the form of a band five to six inches wide and several feet in length, with transverse series of narrow parallel ridges, an inch and three-quarters apart, which he believes cannot be explained satisfactorily, except on the supposition of their having been the impressions of large fucoids. Professor Chapman therefore suggests a change in the names to *Protichnides* and *Climatichnides.*—*Canadian Journal*, July, 1877.

4. *Glaciers of the Swiss Alps in the Glacial era.*—Mr. A. FAVRE has prepared a chart containing the results of his study of the older glacial phenomena of the Alps. It is on a scale of $\frac{1}{250000}$. He states that the contours of five principal glaciers proceeding severally from the Swiss valleys of the Rhine, the Aar, the Reuss, the Linth and the Rhine, have been distinguished and their limits, as nearly as obtainable, have been laid down. The thickness of the glaciers, as deduced from the erratic blocks along the upper limit was from 1,200 to 1,600 meters. From the distribution of bowlders, the pitch of the upper surface of the ancient glaciers has been ascertained to be about thirty feet in 1,000, in the narrow valleys, while elsewhere it was more gentle; and in some places the surface was, for 50 kilometers in length, horizontal or nearly so. This state of things gives to the ancient Swiss glaciers, as he remarks, a close resemblance to those which now cover Greenland and Spitzbergen.—*Verhandl. Nat. Ges. Basel*, 1875–76, p. 136.

5. *The Geology of New Hampshire.* C. H. HITCHCOCK, State Geologist, J. H. HUNTINGTON, WARREN UPHAM, and G. W. HAWES, Assistants. Part II, Stratigraphical Geology. 684 pp. Royal 8vo, with many maps, plates, and sections. Concord, 1877. —A notice of this Report is deferred to another number.

6. *Lithology of the Adirondacks.*—Professor A. R. LEEDS has described, in the American Chemist for March, rocks from the Adirondacks collected by him in Essex County and mostly in the

valley and township of Keene. He adopts for the rocks, which Hunt showed to consist of feldspar identical with or near Labradorite along with hypersthene or a related augitic or hornblendic mineral (and more or less of magnetite or menaccanite), the name norite, and uses the terms hypersthenic norite, hornblendic norite, pyroxenic norite, for varieties. He gives the specific gravities of forty-four varieties of norites, which vary from 2·67 to 3·459, the proportion of the feldspar to the amphibolic species and menacanite determining it. The labradorite, from the norite forming the mass of Mount Marcy afforded him on analysis—

SiO_2	AlO_3	FeO_3	FeO	CaO	MgO	Na_2O	K_2O	H_2O	TiO_2
54·47	26·45	1·30	0·66	10·80	0·69	4·37	0·92	0·53	undet.=100·19

giving the quantivalent ratio for the protoxides, sesquioxides and silica, 1·13 : 3 : 6·83. Another analysis was made of a waxy felsitic variety, from the same place, which afforded very nearly the same result.

Professor Leeds gives also an analysis of a doleryte from the region, and others of the pyroxenic portion of the Mount Marcy norite. He also gives the characters afforded by thin slices of some of the rocks.

7. *On a new method of determining the species of Feldspars contained in rocks*, by Dr. J. Szabó, Professor of Mineralogy and Geology in the University of Budapest, Hungary. 88 pp. 8vo; with eleven wood-cuts and five colored plates. Budapest, 1876.—Professor Szabó states, in the opening of his memoir, that his new method of determining the feldspar species is based upon the well-known papers of Bunsen entitled "Löthrohrversuche" and "Flammenreactionen." This method, to the elaboration of which he has devoted four years of study and experiment, is based, first, upon the accurate determination of the degree of fusibility, and, secondly, upon the degree of coloration of the flame, observed under certain conditions, from which the amounts of sodium and potassium present are estimated. For the detailed description of the methods employed in the different experiments reference must be made to the paper itself. The main points are as follows: The only articles of apparatus needed are: an ordinary Bunsen lamp; a fine platinum wire fastened in a short piece of glass tube and having a small loop on the free end; and a support with an arm, adjustable at any height, to hold this glass tube. The small fragment of mineral of the size of a mustard seed, supported on the loop in the wire, is brought slowly into the flame of the Bunsen lamp at a height of five millimeters, and allowed to remain there one minute, and the amount of coloration due to sodium, or potassium (observed with cobalt glass), is noted. After removal from the flame the extent of fusion and character of the fused mass are observed. The same assay is then introduced a second time into the point of fusion of the Bunsen flame, the lamp now having its chimney on, and the same points noted as before. Finally the same piece of feldspar is moistened with distilled water and put into powdered gypsum, and thus covered it is introduced into the

hottest part of the flame and allowed to remain two minutes; the alkalies, now converted into sulphates, color the flame more distinctly than before, and this effect is duly noted.

Professor Szabó gives a general scale of fusibility containing eight degrees from quartz (0) to antimonite (7), and a special scale of six grades for the different feldspar species; he distinguishes the character of the fused products in the case of the feldspars according as a clear, milky or blebby glass, or a gray, white or blebby enamel, is obtained; he also gives large colored plates exhibiting the intensity of color, yellow and violet, corresponding, as found by experiment, to certain percentage amounts of sodium and potassium respectively. By means of these he is able to determine, within certain limits, the amount of the alkalies present in a given feldspar, and thus to determine the species.

This method doubtless requires considerable skill in manipulation, and also extended experience in the application of the delicate tests described. The end aimed at, however, is so important a one—especially in view of the tendency now prevalent to confound all the triclinic feldspars under the general term "*plagioclase*"—that it is worthy of much time and labor, and Professor Szabó deserves the thanks of lithologists for the care and minuteness with which he has worked out his results. E. S. D.

8. *Brief notices of some newly described minerals.*—*Venerite* occurs as a greenish earthy-looking "clay-ore" in irregular layers in the schists connected with the magnetite of Jones Mine near Springfield, Berks County, Pennsylvania. The purer portions have a pea-green or apple-green color when moist, becoming greenish-white on drying, when the mass falls to powder. This powder is seen under the microscope to consist of minute, transparent shining scales mixed with a little quartz and magnetite. An analysis made by Mr. G. W. Hawes, upon material purified by careful washing, gave:—SiO_2 28·93, $\bar{Al}O_3$ 13·81, $\bar{Fe}O_3$ 5·04, FeO 0·27, CuO 16·55, MgO 17·47, H_2O 12·08, insoluble sand 6·22 = 100·37. After deducting the insoluble matter the composition becomes:—SiO_2 30·73, $\bar{Al}O_3$ 14·67, $\bar{Fe}O_3$ 5·35, FeO 0·29, CuO 17·58, MgO 18·55, H_2O 12·83 = 100. The quantivalent ratio for $R : \bar{R} : Si : H = 3 : 4 : 6 : 4$, "which puts the mineral, if it be a homogeneous substance (as its microscopic character would indicate) among the chlorites." (Dr. T. Sterry Hunt, in a pamphlet entitled "Description of a Double Muffle Furnace by Professor B. Silliman, and A new ore of Copper and its metallurgy, by Dr. T. Sterry Hunt; Philadelphia, Dec. 30th, 1876.)

Uranocircite occurs in quartzy veins in the granite of Falkenstein, Saxon Voigtland; it has long gone by the name of autunite which it closely resembles. Specific gravity 3·49–3·56 (autunite 3·05–3·19). Optically biaxial; apparent angle of axes about 15°–20°. An analysis by Winkler gave: BaO 14·57, UO_3 56·86, P_2O_5 15·06, H_2O 13·99 = 99·88, which corresponds to the formula $BaU_2P_2O_{12}+8H_2O$ or $2(UO_2)_3P_2O_8+Ba_3P_2O_8+24aq$. (Dr. A. Weisbach, *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen*, 1877.

Sphærocobaltite occurs in spheroidal forms with roselite, at Schneeberg, Saxony. Structure coarsely radiated; the spherical surface under the microscope is found to be made up of minute rombohedral crystals; color peach-red; hardness = 4; specific gravity = 4·02–4·13. B.B. becomes black on ignition in closed tube. Dissolves with effervescence in warm hydrochloric acid. On analysis gave Winkler CoO 58·86, CaO 1·80, $\text{F̶e}O_3$ 3·41, CO_2 34·65, H_2O 1·22 = 99·94, or, deducting the hydrated iron oxide CoO, 64·25, CO_2 35·75 = 100. This corresponds to the formula $CoCO_3$, which requires: CoO 63·06, CO_2 36·94 = 100. (Weisbach, l. c.)

Dysanalyte. Found in cubical crystals in granular limestone of Vogtsburg in the Kaiserstuhl; these crystals have long gone by the name of "perofskite." Specific gravity = 4·13. An analysis gave Knop: Cb_2O_5 22·73, TiO_2 40·57, FeO 5·70, MnO 0·42, CeO 5·58, CaO 19·36, MgO tr., Na_2O 3·50, K_2O tr., F tr., $\text{A̶l}O_3$ tr., SiO_2 2·31 = 100·17. This agrees closely with the formula $6RTiO_3 + RPb_2O_6$, when R = Fe, Ce, Ca, Na_2, etc. The mineral is named *dysanalyte*, in consequence of the difficulties met with in its analysis. (Knop, *Zeitschrift für Krystallographie*, i, 284, 1877.) E. S. D.

III. BOTANY AND ZOOLOGY.

1. *Rapid Growth.*—A. W. BENNETT says, of a plant of *Vallisneria spiralis:* The first flower-bud made its appearance in my aquarium this year on July 1st, the pedicel being at 3 P. M. apparently about 1·5 inch long. On the 3rd, at 4 P. M., the base of the bud just touched the surface of the water, and the pedicel was about 7 inches long. At 1 P. M. on the 7th (an interval of ninety-three hours), it had reached the astonishing length of 43 inches. The bud was then still closed, and the flower-stalk quite straight, i. e., not showing yet any tendency to coil. At 10 A. M. on the 9th the length was 45·5 inches, the flower being then open, and the lower half of the flower-stalk so strongly undulating that it was almost impossible to straighten it. At 11 A. M. on the 10th it had reached its ultimate length of 48 inches, the undulation of the lower portion being more strongly marked.

2. *Evolutionary Law as illustrated by Abnormal Growth in an Apple Tree.*—Mr. THOMAS MEEHAN exhibited some branches of a "Smoke-house" apple tree, which had the cluster of flowers at the end of a young shoot, flowering after the leaves and growth had matured, instead of blooming in spurs early in spring, and simultaneously with the expansion of the leaves, as in ordinary cases. There were numerous instances of the normal and abnormal growths on the same tree, the abnormal ones flowering about six weeks after the normal ones, but both classes maturing the fruit at about the same time in the fall.

The point he wished particularly to draw attention to was that when there was a change in one important character, there was often change in others making a complete set of characters which need nothing but permanence to be regarded as specific. For instance, the fruit from these terminal clusters was as unlike the normal "Smoke-house" as it was possible to be. The fruit stems were very long and slender, and the fruit flattened—what pomologists term oblate. It might further be noted that this change was not a change by gradual modification through seminal agency; but a leap, and from a tree that had always produced flowers in the normal way. There was apparently no more reason why the law, whatever it may be, that operated on this one tree might not under some circumstances operate on all the trees in the orchard, or on other wild trees in native places of growth, or on the individuals of a whole district, as well as on a single tree. It was such illustrations as these which made the doctrine of evolution in some form an absolute certainty.—*Proc. Acad. Nat. Sci. Philad.*, 1877, p. 132.

3. *Remarks on the Yellow Ant.*—Professor LEIDY remarked that recently while seeking certain animals beneath stones in the woods near Philadelphia, he had had the opportunity of observing the Yellow Ant, *Formica flava*, in possession of large numbers of other insects. This fact, in itself common enough, in one respect, was new and of special interest to him, and may be so to others. In one instance a comparatively small colony of the Yellow Ants had three different insects in their possession, consisting of a species of *Aphis*, a *Coccus*, and the larva of an insect, probably Coleopterous. The Aphides were kept in two separate herds, and these were separated from a herd of Cocci. The larva was in the midst of one of the former herds. In a larger colony of the Yellow Ants, there was a herd of Aphides which occupied the under part of one margin of the stone and was almost ten inches long by three-fourths of an inch in breadth. The same colony also possessed a separate herd of Cocci, closely crowded and occupying almost a square inch of space. In both colonies the *Aphis* and the *Coccus* were the same. The *Aphis* is pale yellow with white tubercles on the dorsal surface of the abdominal segments. The *Coccus* is of a dark-red hue. Both Aphides and Cocci, with few exceptions, adhered to the under surface of the stones, and were not attached to roots. They appeared to be carefully attended by the ants, which surrounded them. The larva alluded to was almost six millimeters long, was covered on the back with a thick white cotton-like secretion. It was also carefully attended by the ants, which were frequently observed to stroke it with their antennæ. The Aphides and Cocci were all in good condition, but without visible means of subsistence excepting the neighboring grass roots partially extending into the earth beneath the stones, to which it is probable they were at times transferred by their masters.—*Proc. Acad. Nat. Sci.*, 1877, p. 145.

4. *Sexual Dimorphism in Butterflies.*—Mr. S. H. Scudder, in an article on sexual dimorphism in Butterflies—to which special kind of dimorphism he applies the term *Antigeny*—states that it is not the male but the female that departs from the normal type of coloring of the group to which the species belongs; while it is

the male that shows divergences from the type in structural characters. These structural divergences in Butterflies appear in the wings and the legs, and sometimes in the antennæ. Mr. Scudder knows of no example in which the male alone diverges from the general plan of coloration belonging to the group.—*Proc. Amer. Acad.*, 1877.

IV. Miscellaneous Scientific Intelligence.

1. *Narrative of the North Polar Expedition, U. S. Ship Polaris, Captain Charles Francis Hall commanding.* Edited under the direction of the Hon. G. M. Robeson, Secretary of the Navy, by Rear Admiral C. H. Davis, U. S. N., United States Naval Observatory. 696 pp. large 8vo. Government Printing Office, Washington. 1876–77.—The melancholy interest which attaches to the death of the enthusiastic explorer, Hall, just as he was seemingly about to realize his life-long hopes, is increased by the reflection that the distinguished officer, to whom was entrusted the preparation of this narrative, was himself called away by death while his task was almost complete. The final chapters were consigned by him to the editorial care of Professor Nourse of the National Observatory. This volume is what its title declares—a narrative of the Polar Expedition from its inception in 1870 until the "Frolic" brings the survivors of the party to Washington, on the 5th of June, 1873, after experiences which must ever be considered memorable, even among the almost incredible trials and heroisms of Arctic exploration. The closing chapters of the narrative recite the cruises of the Juniata and Tigress for the rescue of the Polaris and her crew, the examination of the icefloe, and the Buddington Parties, with the Report of the Board of Enquiry. The volume also contains a translation of the report made to the Royal Geographical Society of Paris, April 21, 1875, by M. V. A. Malte Brun, awarding the Roquette gold medal to the memory of Hall in consideration of eminent services in Arctic exploration, which medal was sent to the family of the unfortunate explorer; the instructions of the National Academy of Sciences; the correspondence between the British Admiralty and the U. S. Navy Department in relation to the stores left by the Polaris Expedition on the west coast of Greenland; the Journals of Mr. H. C. Chester and Captain Geo. E. Tyson while on boat journeys, June and July, 1872; and lastly a list of the Journals used in the preparation of the Narrative of the Polaris Expedition.

The scientific results of the expedition have been worked up by Dr. Bessels, under the supervision of the Smithsonian Institution, in three volumes, the publication of which may be shortly expected.

This narrative is illustrated by thirty-eight full page wood engravings from original sketches by Mr. Emil Schumann and Dr. Emil Bessels, painted in oil by Mr. J. H. Morgan and photographed on wood by Mr. Smilie. There are also eighteen tail pieces from original sketches, two photolithographs, a steel portrait of Captain Hall, and a steel engraved frontispiece of the Polaris.

It is a pleasure to know also that Professor Nourse is now engaged in preparing for publication Captain Hall's Journals during his second expedition, 1864-69, in obedience to a resolution introduced into the U. S. Senate, February 6, 1877, by Mr. Sargent. B. S.

2. *The American Meteorologist*, JOHN H. TICE, Editor. In monthly numbers of 32 pages, 8vo. Saint Louis, Missouri.—The second volume of this Journal, consisting of six monthly numbers, commenced with January of the current year. The author holds peculiar views with regard to meteorological and other phenomena, and their causes, and presents them in his Monthly. Facts are, in his opinion, in "irrepressible conflict," as he expresses it, with ordinary physical theories.

3. *The American Journal of Pure and Applied Mathematics.*—Under this title, a much needed addition to the scientific journals of the country, will soon be made, under the auspices of the Johns Hopkins University. The editors announced are: J. J. SYLVESTER, BENJAMIN PEIRCE, SIMON NEWCOMB, H. A. ROWLAND, and WM. E. STORY, the first, "Professor of Mathematics in the University, bearing the title of Editor-in-Chief," and the last being "Associate-Editor-in-Charge." Four numbers in quarto, will for the present be issued annually, making a volume each year of 384 pages. The price is five dollars a volume. The first number will appear in January, 1878. Subscriptions and contributions should be addressed to WILLIAM E. STORY, Johns Hopkins University, Baltimore, Maryland.

4. *Publications of the Cincinnati Observatory.*—Two numbers —2 and 3—have recently been issued in octavo. No. 2, eighteen pages, contains Micrometrical Measurements of 176 double and triple stars, observed with the 11-inch reflector of the Observatory by O. M. Mitchell; Cincinnati, 1876; and No. 3, thirty-four pages, bears the title, Micrometrical Measurements of 166 double and triple stars, during the years 1875–76, under the superintendence of Ormond Stone, A.M., Director, Cincinnati, 1877.

5. *Two New Meteoric Irons.* (Letter to the Editors.)—I have had lately sent to me two new meteoric irons, one from Casey County, Kentucky, and the other from Dalton, Whitfield County, Georgia. Descriptions and analyses of these will be published shortly. J. LAWRENCE SMITH.

6. *Table of Logarithms.* — M. GAUTHIER VILLARS has published in Paris a volume of logarithms, containing tables for all numbers from 0 to 434,000,000,000 with twelve decimals, by M. Namur, Secretary of the Ecole Moyenne of Thuin (on the Sambre, Belgium). This wonderful volume, selling at three francs, has been printed by order of the Royal Academy of Sciences of Belgium.—*Nature*, July 5.

7. *Tenth Annual Report of the Trustees of the Peabody Museum of American Archæology and Ethnology.* Presented

to the President and Fellows of Harvard College, June, 1877. Vol. II, No. 1, 168 pp. 8vo. Cambridge, 1877.—A paper, by Dr. C. C. ABBOTT, describes the occurrence of what appear to be flint chippings in undisturbed gravel deposits, only partially stratified, of the Delaware River valley, near Trenton, New Jersey. The stone is a hard or indurated argillite, somewhat fusible before the blowpipe; but in one case, flint. Bowlders eight or ten feet in diameter occur over the surface. Mr. Abbott regards the material as of Glacial origin, and the relics, as those of man of the Glacial era. This paper is followed by another, by Professor N. S. SHALER, on the same relics and deposits, which states that he accompanied Dr. Abbott over the region, and obtained from the beds two of the supposed relics, and concludes with the remark that "if these remains are really those of men, they prove the existence of interglacial man on this part of our shore."

This Report contains also papers on the exploration of Ash Cave in Benton, Hocking County, Ohio, and on explorations of mounds in Southeastern Ohio, by Professor E. B. ANDREWS; on the exploration of a mound in Lee County, Va., by LUCIEN CARR, Assistant Curator in the Museum; and on the Art of War and Mode of Warfare of the Ancient Mexicans, by AD. F. BANDELIER.

Professor Andrews describes instruments, beads, and other ornaments of copper, from the mounds examined by him. One of the mounds (W. Connett's in Dover, Athens County, Ohio) is spoken of as "of great scientific value, because by it we prove that the mound-builders sometimes practised cremation."

In the paper by Mr. Carr, on the Virginia Mound, it is stated that among the relics obtained from it, Mr. J. A. Allen identified the bones of the *Caribou*, and remarked that "this is farther south than bones of the Caribou have hitherto been found."

8. *Kinetic Theories of Gravitation;* by WILLIAM B. TAYLOR. From the Smithsonian Report for 1876. Washington. Government Printing Office. 1877. pp. 78, 8vo.—This is a valuable historical *résumé* of the various attempts that have been made, by the most eminent philosophers, to account for the phenomena of gravitative attraction, from the time of Newton to the present day. The sketch is concluded by a vigorous criticism of the leading theories, in which the author, passing over "the consideration of the *statical* method of explaining gravitation by pressure," finds that "*kinetic* systems are essentially of two classes, the hypotheses of emissions or corpuscles, and the hypotheses of fluid undulations," and proceeds to show "that neither form of either hypothesis can satisfy the two Newtonian conditions of a scientific theory—*verity* and *sufficiency.*" A. W. W.

Vacher's Primer of Chemistry. Lindsay & Blakiston, Philadelphia.

OBITUARY.

TIMOTHY ABBOTT CONRAD.—Dr. CONRAD died on the ninth of August, at the residence of his brother-in-law, Mr. T. Abbott, Trenton, New Jersey. He was son of the late Solomon Conrad, of the University of Pennsylvania, and was born in 1803.

His scientific labors began early in life and were continued up to the present year. They were devoted especially to the study and description of recent shells and the fossil shells of the Tertiary and Cretaceous formations of the United States; and in the Tertiary species they exceed in importance those of any other American Paleontologist excepting Mr. Meek. As early as 1832 he published the first number of an illustrated work on the "Fossil shells of the Tertiary formation," which, however, was never completed; and in 1831 began his "American Marine Conchology," which he carried to 72 pages and 17 plates. Later his papers were published from time to time in this Journal, and in the Publications of the Academy of Sciences of Philadelphia; the first communication to this Journal appearing in 1833, and the last in February, 1877. Memoirs by him are also to be found in the reports of various surveying expeditions. Between 1835 and 1841 he issued thirteen numbers of a "Monography of the Family Unionidæ," with many colored plates. In part of his publications he was his own lithographer. During the years 1838 to 1841, Professor Conrad had charge of the Paleontological department of the Geological Survey of New York, and his Annual Reports for those years and the Journal of the Philadelphia Academy for 1842, contain descriptions of many of the species discovered—the larger part of all that were known previous to the labors of Professor James Hall, into whose hands this department fell in 1843. Some of his general geological conclusions are presented in his "Notes on American Geology," published in this Journal for 1839 (vol. xxxv, 237), in which he advocates the doctrine (which Agassiz first suggested) that the grander divisions of geological time, or abrupt transitions in life, were determined by cold intervals in the course of the earth's progress, and he points out the great fact that the Mississippi depression, as it is often called, was a consequence of the elevation of the Appalachians on the east, and of the Rocky Mountain area, late in geological time, on the west. On the first of these points he remarks that "the theory of periodical refrigeration alone can explain the sudden extinction of whole races of animals and vegetables."

Professor Conrad took a most important part in laying the paleontological foundations of American Geology—a work shared largely also by Lea and Lyell as regards the Tertiary, by Morton for the Cretaceous, and, still more largely, by Hall for the Paleozoic species, and carried forward later by other able paleontologists.

ROBERT WERE FOX, F.R.S., died on the 25th of July, in the eighty-eighth year of his age, "having spent his long life in acts of usefulness and deeds of the purest Christian benevolence." His experiments on the temperatures of deep mines proving an increase of depth downward, on the electro-magnetic properties of mineral veins, and his construction of the first dipping needle, are among the important scientific works that have given his name a world-wide reputation. "To his latest days, in the retirement of his beautiful home, he delighted to surround himself with intellectual friends," and watched with unfailing interest the progress of scientific discovery.

APPENDIX.

ART. XXXIII.—*Notice of some new Vertebrate Fossils;* by O. C. MARSH.

THE specimens described in the present article are all from the Rocky Mountain region, and include Mammals, Birds, Reptiles, and Fishes. Among the Mammals are two Miocene Edentates, the first detected in this country, and a third species of this group from the lower Pliocene. Another Mammal of much interest is a Rhinoceros from the Eocene, the oldest known member of the family. A number of new genera are introduced, some of which have an important bearing on the genealogy of Tertiary Mammals. Among the other vertebrates is a new genus of Crocodilians from the horizon of the Wealden, and a species of *Crocodilus* from the Pliocene.

Moropus distans, gen. et sp. nov.

This genus of Edentates is based mainly upon the bones of the feet, which have been found in several individuals. These remains are quite different from the feet bones of any of the American Edentates, recent or fossil; but indicate affinities with the extinct *Ancylotherium*, from the Tertiary of Europe, which is supposed to be related to the African Ant-bear (*Orycteropus*). The specimens here described belong to a distinct family, the *Moropodidæ*.

In the type specimen of the present species, only the hind feet appear to be represented. One of the most characteristic bones is a coössified first and second phalanx. The articulation for the metatarsal is nearly in a horizontal plane, and situated on the proximal end of the upper surface of the base. It is somewhat heart-shaped in outline with the apex rounded and about equally concave in both directions, or slightly less so transversely. This articulation occupies nearly half the length of the first phalanx which is thoroughly coössified with the second. The line of junction between the bones can, however, be traced easily, and is strongly marked on the under surface by a pit or foramen entering obliquely upwards and forwards. Except near this line of junction, the surface of the bone is rather smooth. The under surface, below the articulation, is flattened. The second phalanx is less than half the length of the first, and its surface is roughened, as if by abnormal growth of bone over the surface. The length of the first phalanx is 43^{mm}; the longitudinal diameter of the metacarpal articulation 18^{mm}; its transverse diameter 23^{mm}. The least transverse diameter of the bone is 21^{mm}: its vertical diameter at the middle is 20^{mm}. The second phalanx is broken in this specimen, its distal articular face being absent.

Associated with the above specimen, is a short bone evidently a median phalanx, with both articular surfaces well preserved and in form corresponding to each other. Proximally there are two grooves separated by an intermediate ridge, and distally two pulley-shaped ridges with a deep groove between. The length of the shaft of this bone is 23^{mm}; its transverse diameter is 21^{mm} proximally, and 17^{mm} distally. Near the center of the terminal pulleys is a deep pit on each side. The greatest vertical diameter of the bone is 32^{mm}. This bone resembles the penultimate phalanx of the middle finger of *Priodontes*, but is somewhat shorter and thinner.

These and other less characteristic remains indicate an animal somewhat larger than a tapir. They were found in the Miocene of Oregon by the Yale Expedition of 1873.

Moropus senex, sp. nov.

A second larger species of the same genus is indicated by a few remains, among which is the characteristic bone formed of the united phalanges. The proximal phalanx is considerably larger than the one above described. Its length is 52^{mm}. The proximal articulation is oblique, and does not occupy more than one-third the upper surface of the bone. The median phalanx is well preserved, and measures 25^{mm} in length. It is not united with the first phalanx in a line with the axis of that bone, but is inclined about 15° toward the sole of the foot. Its distal articulation is composed of two not very prominent pulley-shaped surfaces with a groove between.

Moropus elatus, sp. nov.

The largest species of this genus, now known, is represented at present by a number of bones of the posterior extremities, mainly from the feet. The peculiar duplex bone already mentioned is among them, and affords means for comparing the different species.

The proximal phalanx here measures about 90^{mm} in length, and the medial one 40^{mm}. The articulation for the metatarsal is more nearly vertical than in either of the Miocene species. Its median vertical diameter is 30^{mm}; and transverse diameter

42^{mm}. The least vertical diameter of the phalanx is 28^{mm}; transverse diameter 31^{mm}. The second phalanx has a transverse diameter of 32^{mm}, and a vertical diameter of 49^{mm}, measured across the curve of the terminal pulley. The least vertical diameter is 38^{mm}.

Associated with this bone is a well preserved first metatarsal, measuring 135^{mm} in length. Its minimum transverse diameter is 25^{mm}. The proximal surface is subtriangular, with the external side of the triangle curved outward, and the other shorter sides somewhat curved inward. The external three-fourths of the surface is transverse, and occupied by a nearly flat articular surface, which rises along a vertical ridge near the inner margin of the face. Beyond this ridge, the upper part of the surface shows marks of articulation with another bone. The inner face of the bone is somewhat concave proximally; it then presents a low broad elevation, and is flattened distally. The shaft of the bone is rounded throughout. The distal articulation is hemispherical above, but presents two shallow grooves below, which are carried around so far as to become nearly horizontal. The greatest proximal diameter is 50^{mm}, and the greatest distal diameter 44^{mm}.

The proximal face of the fifth metatarsal is oblique, triangular in outline, convex vertically, and through the greater part of its tranverse extent. Its greatest vertical extent is 65^{mm}, and greatest horizontal diameter the same. The vertical diameter of the shaft of this bone is 40^{mm}, and its transverse diameter 38^{mm}. The calcaneum measures 108^{mm} from its posterior end to the vertical face for articulation with the astragalus. The vertical diameter of the shaft is 53^{mm}, and the transverse diameter 41^{mm}.

These remains are from the Lower Pliocene of Nebraska, and indicate an animal about as large as a Rhinoceros.

Amynodon, gen. nov.

The present genus is based upon a nearly perfect skull, and various other remains which belonged to the oldest representative of the Rhinoceros family yet discovered. These specimens are from the Uinta or *Diplacodon* beds, of the Upper Eocene, and about the horizon of the Paris basin. The skull is intermediate in form between that of a Tapir and a Rhinoceros, but the molar teeth are entirely of the latter type. The premolars are all unlike the molars, and the canines above and below are very large. The incisors are small, and the inner one in each jaw is lost in the present adult animal. The lower canines are placed nearly horizontal, and taken in connection with the rest of the anterior dentition, they prove conclusively that the large lower teeth, usually regarded as incisors in *Acerotherium* and many other members of the Rhinoceros family, are really canines.

The nasals in this genus are smooth, and evidently were without horns. There were four toes in front and three behind. The type species is *Amynodon advenus* Marsh, which was provisionally referred to the genus *Diceratherium* when first described.

Tapiravus rarus, **gen. et sp. nov.**

The paucity of Tapiroid remains in the Miocene and Pliocene lake basins of Western America is a singular fact, probably due in part to temperature, and in part to the nature of the surrounding country. The few specimens found have been referred to *Lophiodon*, a Lower Eocene genus. Various remains from these formations on the Atlantic coast and in the West show, however, that they are quite distinct from *Lophiodon* and the existing Tapir, and represent an intermediate genus, which may be called *Tapiravus.* The type species is *T. validus* Marsh, (*Lophiodon validus*) from the Miocene of New Jersey. This genus may readily be distinguished from *Lophiodon* or *Hyrachyus*, by the last upper premolar, which is similar to the adjoining molars.

A second species of this genus occurs in the Lower Pliocene east of the Rocky Mountains, and remains were collected there by the writer in 1873. The most characteristic specimen obtained was an upper molar tooth which indicated an animal considerably smaller than the living Tapir. The crown of this molar was 15^{mm} in antero-posterior diameter, and 17^{mm} in transverse diameter. It is peculiar in having the antero-exterior angle very obtuse, and less prominent than the outer cusps.

Bison ferox, **sp. nov.**

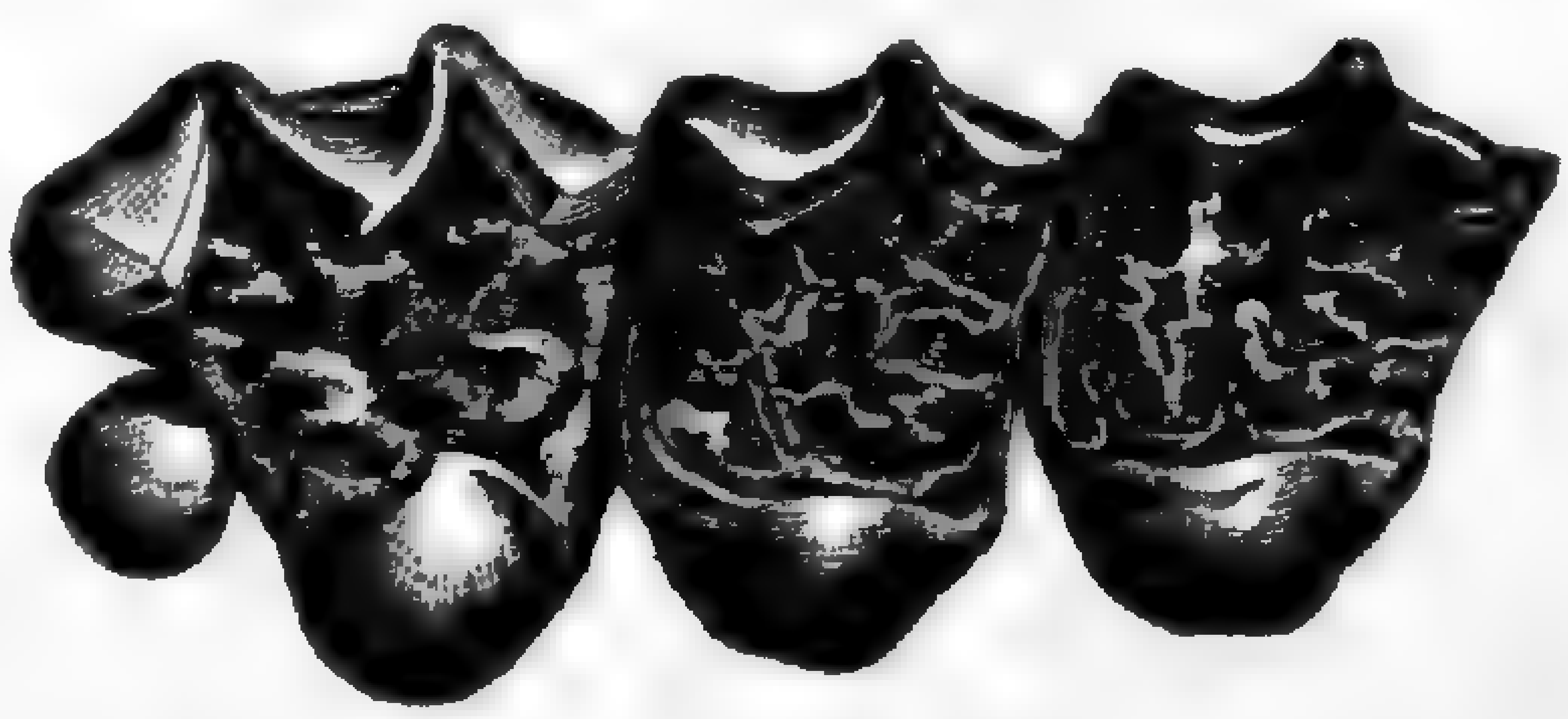
This genus has not hitherto been found in the Tertiary of this country, although not uncommon in later deposits. The Museum of Yale College contains two well preserved horn-cores from the later Tertiary, one of which was found by the writer in the lower Pliocene of Nebraska. This is quite as low as the genus has been found in the Old World. This specimen indicates an animal much larger than the existing Bison, and having very powerful horns. The specimen preserved was over 500^{mm} in length, when complete. The radius of the inner curve measures about 400^{mm}. The largest end has a diameter of 125^{mm}, and the smaller, at a distance of 300^{mm}, measures 77^{mm}.

A second larger species, with more curved horns, is indicated by a nearly perfect horn-core from the lower Pliocene of Kansas. This species, which may be called *Bison Alleni*, in honor of Dr. J. A. Allen, of Cambridge, also had very large horns. The type specimen has its greatest and least diameters near the base, 140^{mm} and 110^{mm}. At a distance of 300^{mm} further toward the end, the diameters are 100^{mm} and 90^{mm}. The radius of the inner curvature, except for the last 150^{mm} of the length, was 350^{mm}.

The discovery of these two lower Pliocene species of Bison, suggests the probability that this form is a New World type, although it has generally been credited to the other hemisphere.

Allomys nitens, gen. et sp. nov.

Among the Upper Miocene mammals, a peculiar genus is found, which is probably related to the flying squirrels, but the teeth are somewhat like those of Ungulates. Its affinities are evidently with the Rodents, however, and it represents a distinct family, the *Allomyidæ*. The general characters of the upper molar teeth are shown in the accompanying figure,



which is six times natural size. The animals of this species are all very small, hardly larger than a rat. The extent of three molar teeth is 8^{mm}. The transverse distance between the two series is, in front, 3·8^{mm}, and posteriorly, 4·4^{mm}.

The known remains of this species are all from the Upper Miocene of Oregon.

Graculavus lentus, sp. nov.

The Cretaceous deposits of the Atlantic coast and of Kansas have hitherto alone yielded remains of Birds, but these have recently been found in beds of the same age in Texas. The most characteristic specimen obtained is the distal end of a metatarsal, which differs from the corresponding bone of the toothed birds from Kansas, and may be referred provisionally to the genus *Graculavus*, the type of which is from the Upper Cretaceous of New Jersey. This specimen shows that there were three toes of nearly equal size, and also a hallux raised above the main digits.

Transverse diameter of shaft of tarsometatarsal bone	4·2^{mm}
Vertical diameter of same	3·6
Transverse diameter across distal articular faces	10·
Vertical diameter of median distal articular face	4·8

The known remains of this species indicate a bird about as large as a small duck.

Diplosaurus felix, gen. et sp. nov.

An interesting discovery recently made in the lower Cretaceous, or Wealden beds, of Colorado, is a new genus of Crocodilians, intermediate between the old Teleosaurian type and the modern *Crocodilus.* The new genus has a head and teeth very similar to the latter, but with this the ancient biconcave vertebræ. The present type species is based upon a nearly perfect skull, and a number of vertebræ belonging with it. These pertained to an animal smaller than most existing Crocodilians.

Some of the principal measurements of this species are as follows:

Length of skull on median line	255·mm
Length of skull from quadrate to end of snout	275.
Transverse diameter of premaxillaries	46·
Transverse diameter of skull, at front of orbits	90·
Transverse diameter at ends of quadrates	122·
Transverse diameter of quadrate at end	20·

A second species of this genus is apparently the *Hyposaurus Vebbii* Cope, which may be called *Diplosaurus Vebbii.*

Crocodilus solaris, sp. nov.

No Miocene Crocodilians are known from the Western lake-basins, and none have been described from the Pliocene of the same regions. One species, however, lived in the Pliocene lake east of the Mountains, and, as an indication of climate, at least, is well worthy of record. The remains preserved indicate an animal of moderate size, well protected with deeply pitted bony plates, and probably belonging to the genus *Crocodilus.*

Measurements of some of the more important remains are the following:

Length of centrum of lumbar vertebræ	42· mm
Vertical diameter of anterior articulation	25·
Transverse diameter	30·
Vertical diameter of neural canal	11·
Vertical diameter of posterior articulation	25·
Transverse diameter	30·
Transverse diameter of dermal scute	34·

These specimens were found by the writer, in 1873, on the Niobrara River in Nebraska.

Nanosaurus agilis, gen. et sp. nov.

The most diminutive Dinosaur yet discovered is represented by various portions of a skeleton recently received from the Mesozoic deposits of the Rocky Mountains. These remains indicate an animal not larger than a cat, and yet apparently fully adult. Most of the bones are hollow, and the walls thin.

The crowns of the teeth are apparently compressed, and inserted in distinct sockets. The femur has the characteristic third trochanter, and is shorter than the tibia.

The principal dimensions of this pigmy Dinosaur are as follows:

Space occupied by five teeth in lower jaw	13· mm
Depth of jaw below last tooth	10·
Length of femur	63·
Distance from head to middle of third trochanter	25·
Length of tibia	75·
Least diameter of shaft	6·

The geological horizon of this unique fossil is probably Jurassic, but possibly in the lower part of the Dakota group, which I regard as the equivalent of the Wealden of Europe.

Nanosaurus victor, sp. nov.

Another small Dinosaur, which may be provisionally referred to the same genus, is indicated by portions of a skeleton found in the same region, and probably at or near the same horizon. These remains belonged to a reptile about twice as large as the one just described. The bones are equally hollow, and the walls very thin. The tibia is much more elongated, and slender. No teeth were found with this specimen. The length of the tibia was about 100^{mm}, and the diameter of its shaft at the middle 6^{mm}. A metatarsal bone measures 41^{mm} in length. The remains at present known indicate an animal about as large as a fox.

Apatodon mirus, gen. et sp. nov.

One of the most interesting specimens hitherto found in the Rocky Mountain region, is a portion of a lower jaw with the last molar in place. This fossil is widely different from anything yet described, and its exact affinities are doubtful. The fragment pertained to an animal about as large as a Tapir, and the general appearance of the specimen at once suggests the mammalian type. The tooth most resembles, in form and superior surface of crown, that of a typical Suilline. The structure of the tooth, however, is different, and the fangs are, in part at least, coössified with the jaw.

This specimen was found near a locality where Dinosaur bones were abundant, and it is possible it may belong with that group. The jaw, however, is very unlike any corresponding jaw of a Dinosaur, so far as now known. This tooth measures about 41^{mm} in length of crown; 20^{mm} in transverse diameter, and 8^{mm} in height. The geological horizon is Lower Cretaceous or Jurassic.

Heliobatis radians, gen. et sp. nov.

The most interesting fossil Fish hitherto found in the Tertiary of the west is a land-locked Ray, recently discovered in the Green River beds of Wyoming. The specimen is in excellent preservation, and shows the characters of the group most perfectly. It differs much from recent Rays, and resembles most nearly the genus *Cyclobatis* of Egerton, from the Mt. Lebanon deposits of Syria, which are probably in nearly the same horizon as the locality of the present specimen. The latter differs from *Cyclobatis* in having a much greater number of radiating digits, which entirely encircle the body, and suggested the generic name. There are also numerous dermal defensive tubercles, which are wanting in *Cyclobatis*.

The principal dimensions of this rare specimen are as follows:

Antero-posterior extent of rays	235·mm
Transverse diameter across scapular arch to bases of rays	75·
Total transverse diameter	220·
Transverse diameter of head	82·
Distance between scapular and pelvic arches	55·
Length of vertebræ at pelvic arch	2·6
Length of vertebræ in caudal region	2·

Yale College, August, 1877.

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[THIRD SERIES.]

ART. XXXIV.—*On the relations of the Geology of Vermont to that of Berkshire*; by JAMES D. DANA.

[Continued from page 207.]

2. LITHOLOGICAL CONCLUSIONS: WITH SPECIAL REFERENCE TO THE USE OF LITHOLOGICAL CHARACTERS AS A TEST OF GEOLOGICAL AGE.

IT is sometimes laid down as a canon in geology that the age of a crystalline terrane or formation can be told from the kind of rock constituting it. Thorough knowledge as to the kinds that may exist in formations of the same age is the proper basis for such a canon—if it has a basis—and a test of its value. The limestone series affords important facts on this subject.

The Taconic slate-belt in the western half of the limestone area and the quartzyte group of the eastern half may be separately considered, and, afterward, the relations of the two.

1. *Taconic slate-belt or range.*

The diversity of rocks in the Taconic slate-belt is small compared with that in the Eastern or Quartzyte group.

A. *In Vermont.*—The rocks, as has been explained, are (1) *argillyte* to the north; then argillyte along the center with borders of (2) *hydromica slate* varying from a pure slaty hydrous mica to a mixture of hydrous mica with more or less quartz; (3) *chloritic hydromica slate*, in which quartz seams and veins (often chloritic) are common. Besides these, there is (4) a *hydromicaceous conglomerate*, consisting of quartz pebbles in a hydromica paste, "abundant in Ira, Middletown, Wells, Poultney and Pawlet," and the main constituent of Bird Mountain, in Ira—as stated in the Vermont Geological Report (p. 426).

B. *In Berkshire and farther south.*—There are here the same slates, but in part coarser. Also (5), a rock of gneissoid aspect. in which the mica is a pearly hydrous mica (found in the Graylock range, near Williamstown); (6) a *garnetiferous chloritic hydromica slate*, common; (7) *mica schist;* (8) *graphitic mica schist;* (9) *garnetiferous mica schist;* and (10) *staurolitic mica schist* (in Salisbury and Sharon.)*

2. *Schists of the Quartzyte group.*

A. *In Vermont.*—(1) *Hydromica slate*, which is often very fine in grain and is then called *novaculite slate;* (2) *chloritic hydromica slate;* (3) *chlorite slate or schist*, sometimes containing octahedrons of magnetite; (4) *hydromica conglomerate*, like No. 4 above; (5) *hydromica quartzyte*, all shades occurring between hydromica slate and true quartzyte; (9) greenish-gray hydromica gneiss, containing disseminated chlorite—a kind of *protogine*—the mica pearl-white, the feldspar white, seen by the writer on the western slope of the quartzyte and hydromica ridge northeast of Rutland—the rock much like the kind from near Williamstown (No. 5 above).

B. *In Berkshire and farther south.*—(1) *Hydromica slate*, more or less chloritic, and often garnetiferous; (2) *mica slate*, that is, fine-grained mica schist; (3) *mica schist*, varying in color from a dark-gray to black, the latter a fissile rock consisting largely of black mica; (4) *garnetiferous mica schist;* (5) *quartzytic mica schist.*

Varieties of gneiss.—(6) *Fine-grained gneiss*, thin bedded, the mica in very small scales and in general mostly black, the feldspar in small white grains; (7) *the same*, but thick-bedded and very hard, color mostly light gray, the rock sometimes a *contorted gneiss;* (8) *the same*, but with little mica, the color whitish, graduating into (9) *granulyte*, a granular compound of quartz and feldspar, with only traces of mica; (10) a whitish or grayish *striped gneiss* having the mica in lines of spots or in interrupted lines, looking interruptedly striped, the mica mostly biotite; (11) *granitoid gneiss*, and (12) fine-grained *granite*, the gneiss graduating into these rocks, by a loss of its schistose structure; (13) *quartzytic gneiss*, fine-grained, whitish (often yellowish from alteration of pyrite or black mica), a rock that graduates by insensible shades into laminated quartzyte; (14) *epidotic gneiss*, containing much mica, half of which is musco-

* The occurrence of staurolite as well as garnet in the mica slate of Salisbury is mentioned by Prof. Dewey, in this Journal, vol. viii, p. 7, 1824. Earlier, in vol. v, 1822, he had announced the existence of staurolite in Sheffield.

vite, and also small green grains of epidote: (15) *syenyte gneiss*, consisting mainly of hornblende and whitish feldspar, not common; (16) *hornblende slate*, occasional beds; (17) *pyroxenyte*, consisting of white pyroxene (at Canaan, Conn.).

(18) *Garnet rock*, a firm tough rock of a blackish-gray color, consisting of quartz, pale-red garnet, some feldspar, magnetite and pyrite, and also minute disseminated prisms showing one lustrous cleavage which may be zoisite (from Beartown Mountain)—rare.

(19) *Feldspathic quartzyte*, the feldspar (orthoclase) sometimes in largish cleavable pieces, the decomposition and removal of which leaves the quartzyte cellular, looking like a buhrstone; (20) *micaceous quartzyte*, gneiss-like in aspect, but containing little or no feldspar. Besides these quartzytic rocks, and the common hard quartzyte, there is a laminated *calcareous quartzyte*, which is very porous when weathered, owing to the removal of the calcareous portion, and which has often on its surfaces minute crystals of brown tourmaline. Abrupt transitions occur between the laminated and hard massive quartzyte; the latter sometimes corresponding for a short distance to several successive beds of the former, or taking wholly its place in the formation.

3. *Schists along an East-and-West section of the limestone region.*

In Vermont.—The schists of a section across the limestone region from west to east in the line of Rutland, are the same nearly as occur in the Quartzyte group from north to south, argillyte being the only rock to the west not found to the east.

In Berkshire.—The remark just made for Vermont applies equally to Berkshire. Along an east-and-west section in southern Berkshire, there are, commencing to the west: argillyte, various kinds of hydromica slate, from a black glossy slate differing little from argillyte, to pale pearly slates, chloritic and garnetiferous hydro-mica slates; farther east, fine-grained mica schist and gneiss, coarser garnetiferous mica schist and staurolitic mica schist; and all the gneisses and other rocks mentioned above.

Thus the same kinds of rocks are met with on going from east to west across Berkshire as in going from north to south along the Quartzyte ranges of Vermont and Berkshire.

The above lists afford an idea of the great diversity in the crystalline rocks of the limestone series. We are now prepared for a conclusion.

Since then these rocks of the limestone series are conformable, and of Lower Silurian age; and since they were all crystallized into their present state after the Lower Silurian era had nearly or quite passed, we learn—that all the various mica and chloritic schists mentioned, and the varieties of gneiss, and also, the other rocks designated, as protogine, granulyte, hornblendic, pyroxenic, epidotic and garnet rocks, were in this case a product of a single metamorphic process, acting on deposits of Lower Silurian age; and, since this wide diversity of rocks occurs in the eastern or Quartzyte portion alone of the limestone area, they have also come from that portion of the Lower Silurian to which the Quartzyte group belongs.

Consequently, if the lithological canon is a good one, neither of the rocks in the above list can be good for distinguishing formations of any other geological era than the one here considered.

But they are useless for this unless the kinds belong exclusively to it. Now no one will claim that hydromica, mica and chlorite schists, protogine, gneisses, granite, garnet and staurolitic schists, granulyte, and the rest have been derived exclusively from Lower Silurian sediments crystallized at the close of the Lower Silurian. Hence it is clear that they are not satisfactory for identifying rocks of this or any other single age. And if so, the lithological canon, as far as the varieties of these rocks described above are concerned, is not available.

The prominent point in which the gneisses and mica schists of the limestone series in Berkshire are at all peculiar is in their fineness of grain or texture. In Connecticut and farther south, the mica schists and gneisses are coarser in crystallization than those in Berkshire; so that this feature is apparently one dependent on degree of metamorphism. Temperature and rate of cooling determine the degree of coarseness (or fineness) of granular-crystalline structure in other cases, and so should it be in the metamorphic process.

One variety of the gneiss is characteristic of the eastern portion of the region—namely, the whitish kind interruptedly banded with mica spots or lines (passing into granulyte as the mica disappears). I have not observed it in New England except near the limestone region of Western Massachusetts, Connecticut and New York. The chloritic schist and chloritic hydromica schists of the series are not distinguishable from those of many other geological regions.

The lithology of the region has still some peculiarities. These are: the absence of hornblendic granite, and syenyte; the sparing occurrence of hornblende schist and hornblendic gneiss, these rocks occurring only in beds subordinate to the mica schist or true gneiss; the absence, so far as observed, of labradorite rocks; and the certain absence of granitoid labradorite rocks (those having cleavable labradorite as a prominent constituent); the absence of chrysolite rocks, corundum-bearing rocks, and zircon-bearing rocks. Moreover, coarse flesh-colored granites and coarsely porphyritic gneiss or granite are not among the rocks mentioned.

The frequent abrupt transitions between quartzyte and gneiss is of so much interest that I may refer to it here again, and repeat that it means abrupt transitions from sand deposits to mud deposits in the old seas, just as are now common along the borders of the modern.

I may also observe, again, that the great diversity found in the crystalline rocks had nothing notable to correspond to it in the external characters of the original sediments. The hydromica and mica schists are essentially one in composition, quartz being equally a variable constituent in both; so the hydromica gneiss or protogine is nearly identical with true gneiss. A gneiss or mica schist in which the mica is black (as is commonly the case here), and a hornblendic gneiss or schist, have almost the same ultimate constitution.

In the condition of sedimentary rocks, the differences which, under metamorphism, have led to so long a list of rocks would hardly be apparent to the eye, and generally be overlooked in a description—a little difference in color, or in texture, or in proportion of sand, or in compactness, or thickness of bedding, being the chief points visible in an *unaltered* rock made of clay, mud or sand.

3. OROGRAPHIC CONCLUSIONS.

Among the orographic relations between the limestone region in Vermont and Berkshire I mention here only two.

(1.) The first relates to the positions of the rocks, and the connection between position and height.

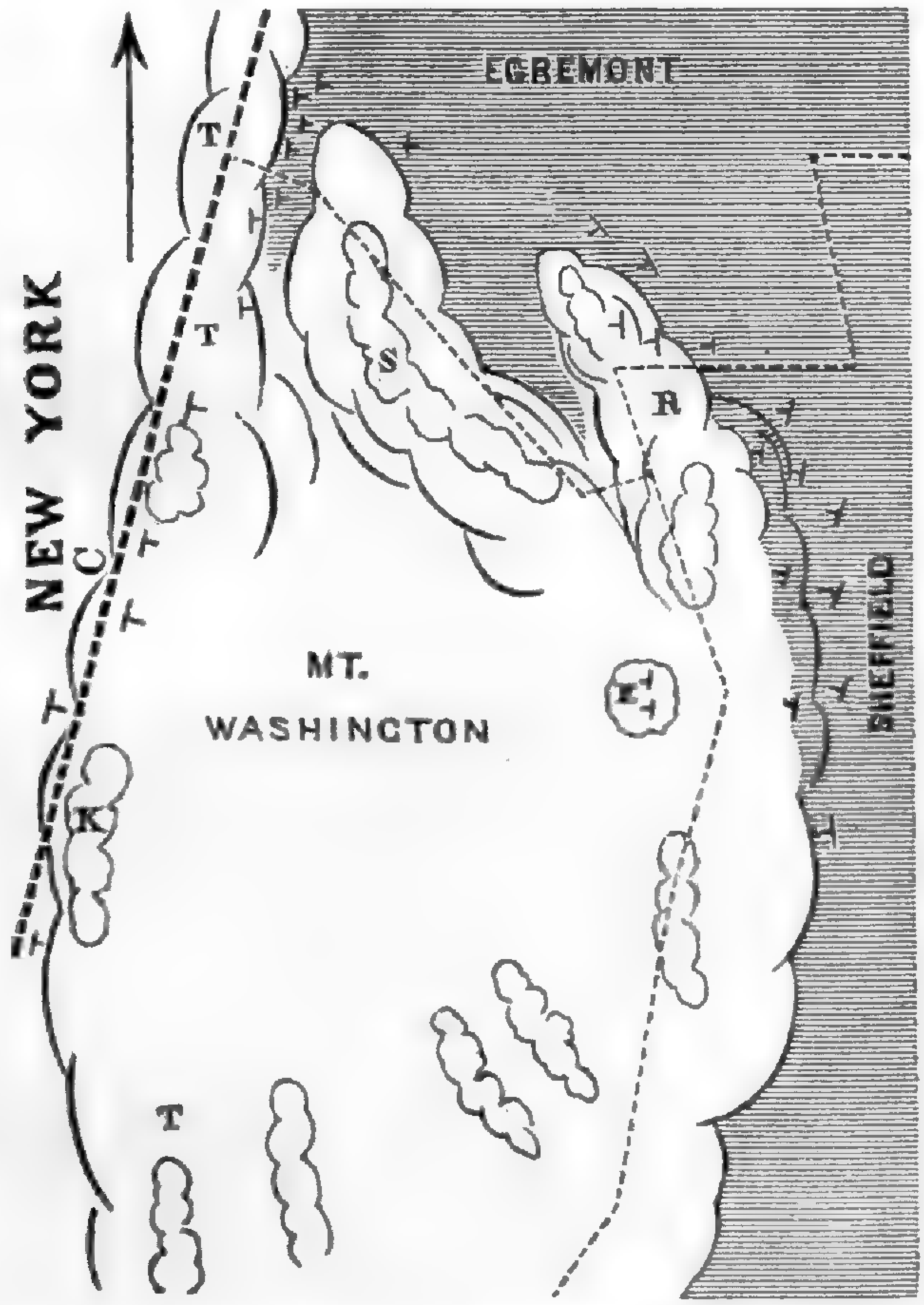
a. Along the Central slate-belt of Vermont and its continuation in Berkshire, called the Taconic range, the slates, for the most part, have a high eastward dip; and the facts show that where this is the case they are pushed over in synclinal folds (sometimes with subordinate or local anticlinals and synclinals), the axial plane of which dips eastward.

b. At intervals the slate-belt rises into peaks over 2,500 feet in height. *Such peaks occur wherever the synclinal is a broad and comparatively shallow one.*

In Vermont, this is the case in Danby Mountain, Mount Dorset or Eolus, Spruce Peak, Equinox Mountain and Mount Anthony, as illustrated on pages 346, 347, of the last volume of this Journal. The explanation is simply—that a very broad synclinal or trough holds a very large mass of mountain material; and that, on account of its magnitude, and often also its greater compactness or hardness due to the heat and pressure, it has had its height less reduced by denudation.

Berkshire, as I have already shown,* owes its highest summits, similarly, to the occurrence of broad synclinals. Graylock, the highest, is one of them; and the Berkshire Mount Washington is another.

This feature is so remarkable and so instructive in Mount Washington, that I here reproduce the outline map of the mountain, used in a former article,* on which the position,



dip and strike of the limestone is given, the shaded area representing this rock, and the T-shaped symbols indicating the strike and dip of the rocks.* The northern portion, lettered T T, represents part of the ordinary Taconic range as it extends from Mount Washington about N. 16° E. (true), along the boundary between Massachusetts and New York, the width of which seldom exceeds a mile; while the rest of the unlined part of the map represents the area of Mount Washington, over five miles in breadth. The Taconic range, as above stated, corresponds in its narrower part to a close synclinal, with the axial plane dipping eastward. But in Mount Washington the lime-

* This Journal, II, vi, 266. The outline of the mountain is taken from the large wall-map of Berkshire, bearing the date 1858.

stone and schists at its eastern foot dip *westward* at a small angle—usually 20° to 25° (5° to 10° in the spur R); and also *westward*, but at a higher angle, in its highest summit, Mount Everett (E, on the map, 2,634 feet above the sea-level); while on the western slope the dip is throughout eastward at an average angle of 50°, the strike N. 10°–15° E. (true). Thus the broad synclinal and its contrast with the ordinary synclinal of the Taconic range is well exhibited in the position of the rocks.

c. The great breadth of this synclinal and the size of the mountain is connected also with a *compound character in the synclinal*, another common feature in orography. As remarked in a former article, the limestone of the Egremont plain extends south in two belts between the northern spurs R and S, and S and T, and each indicates a separate anticlinal fold bringing up the limestone between synclinals of the schist. It has not been possible to follow these subordinate anticlinals southward, because the limestone is not continued far in that direction, and the summit of the mountain is under soil and cultivated farms. But yet the fact of flexure at the north end is strong reason for believing that similar flexures, if not the same continued, characterize the whole length from north to south of the mountain-mass, such a slate easily flexing under uplifting lateral pressure. This is further sustained by observations proving that other subordinate anticlinals exist on the western slope of the mountain, in the vicinity of Copake Furnace. Close to the western foot there are two nearly parallel limestone areas, parallel to the axis of the range. The inner (or more eastern) one is about a mile long, and the other about half a mile. They are separated from one another by a thin belt of hydromica slate, and the same slate exists on the other sides. The dip of the beds of limestone and slate is to the eastward 50°, the strike averaging N. 15° E. (true). They are evidently registers of local folds—anticlinal and synclinal, the former bringing up the limestone. Such flexures are not distinguishable in the schists unless sufficiently profound to bring up the limestone; for the dip is throughout to the eastward; and hence there may be many of these subordinate anticlinals and synclinals in the broad mass where there is nothing to prove it. In the memoir referred to I have mentioned some evidence that the Graylock mountain-mass, while a broad synclinal, comprises one or more subordinate anticlinals and synclinals. It is a point to be considered in the study of all mountain-masses consisting of steeply flexed rocks.

In another place in this volume, I speak of the Mt. Washington range in New Hampshire, east of the principal valley, as probably corresponding to a synclinal. I would here add that it may be a

compound synclinal, and to this owe the apparently great thickness of its andalusitic mica schists. Flexures of less span than five miles, and much less, are far more common among steeply dipping rocks than those of greater extent, and simply because, under the pressure producing such bold upturnings shaly strata cannot help flexing at narrow intervals, so as to have frequent local flexures subordinate to the larger folds.

2. The uniformity in character of the long Taconic slate-belt from Weybridge in Vermont to Salisbury and Sharon in Connecticut, and of the adjoining limestone through a still longer range, and the parallelism of the whole in position and strike with the more eastern ranges of quartzyte and schist, and parallelism, also, with the axis of the Green Mountain elevation, show that the uplifting force corresponded entirely in direction of action with that in which the Green Mountains were made, and, further, that it was sufficient in power to produce vast flexures of strata over an area of great extent. One of the summits in the Taconic range is but 600 feet lower than the highest in the more easterly Green Mountain series; and others, both in Vermont and Berkshire, are little inferior in elevation. Moreover, those of Berkshire and of the adjoining part of Connecticut far overtop all ridges to the eastward, and really constitute in those latitudes the most elevated portion of the Green Mountain system. Yet the width of the area which has been under consideration hardly anywhere exceeds twenty miles.

The magnitude of the results are strong evidence that the so-called limestone-area is really but a small part of a larger region of cotemporaneous disturbance and uplift. The true breadth of the area, as well as length—whether it reached to the Connecticut Valley on the east and to the Hudson River Valley on the west, and so had the breadth of the Appalachian disturbance of a later epoch, or whether it had narrower limits—may be ascertained by studying the stratification. Some of the results of such a study as regards Connecticut and a portion of New York I propose to give in another paper.

Note.—Of the two fossils from the quartzyte of Vermont, referred to on page 207 of this volume, the theca-like species—or so-called Orthoceras—has a rather close resemblance to the species of Hyolithes from the Primordial near Troy, New York, described and figured in this Journal, volume iii, for 1872, by Mr. S. W. Ford; and, were that the only species, there would seem to be ground for a strong suspicion that the quartzyte is Primordial. But the Lamellibranch shells (the other species) are even stronger evidence, in the present state of paleontological discovery, that the rock is later than Primordial. As before stated, more fossils are needed for a conclusion.

Art. XXXV.—*Address before the Department of Anthropology of the British Association, at Plymouth;* by Francis Galton, F.R.S.

Permit me to say a few words of personal explanation to account for the form of the address I am about to offer. It has been the custom of my predecessors to give an account of recent proceedings in anthropology, and to touch on many branches of that wide subject. But I am at this moment unprepared to follow their example with the completeness I should desire and you have a right to expect, owing to the suddenness with which I have been called upon to occupy this chair. I had indeed the honor of being nominated to the post last spring, but circumstances arising which made it highly probable that I should be prevented from attending this meeting, I was compelled to ask to be superseded. New arrangements were then made by the Council, and I thought no more about the matter. However, at the last moment, the accomplished ethnologist who otherwise would have presided over you, was himself debarred by illness from attending, and the original plan had to be reverted to.

Under these circumstances I thought it best to depart somewhat from the usual form of addresses, and to confine myself to certain topics with which I happen to have been recently engaged, even at the risk of incurring the charge of submitting to you a memoir rather than an address.

I propose to speak of the study of those groups of men who are sufficiently similar in their mental characters or in their physiognomy, or in both, to admit of classification; and I especially desire to show that many methods exist of pursuing the inquiry in a strictly scientific manner, although it has hitherto been too often conducted with extreme laxity.

The types of character of which I speak are such as those described by Theophrastus, La Bruyére, and others, or such as may be read of in ordinary literature and are universally recognized as being exceedingly true to nature. There are no worthier professors of this branch of anthropology than the writers of the higher works of fiction, who are ever on the watch to discriminate varieties of character, and who have the art of describing them. It would, I think, be a valuable service to anthropology if some person well versed in literature were to compile a volume of extracts from novels and plays that should illustrate the prevalent types of human character and temperament. What, however, I especially wish to point out is, that it has of late years become possible to pursue an inquiry into certain fundamental qualities of the mind by the aid of exact measurements. Most of you are aware of the recent progress of what has been termed psycho-physics, or the science of subjecting mental processes to physical measurements and to physical laws. I do not now propose to speak of the laws that have been deduced, such as that which is known by the name of Fechner, and its numerous offshoots, including the law of fatigue, but I will briefly allude to a few instances of measurement of mental processes, merely to recall them to your memory. They will show what I desire to lay stress upon, that the very foundations of the differences between the mental qualities of man and man admit of being gauged by a scale of inches and a clock.

Take, for example, the rate at which a sensation or a volition travels along the nerves, which has been the subject of numerous beautiful experiments. We now know that it is far from instantaneous, having indeed no higher velocity than that of a railway express train. This slowness of pace, speaking relatively to the requirements that the nerves have to fulfill, is quite sufficient to account for the fact that very small animals are quicker than very large ones in evading rapid blows, and for the other fact that the eye and the ear are situated in almost all animals in the head, in order that as little time as possible should be lost on the road, in transmitting their impressions to the brain. Now the velocity of the complete process of to and fro nerve transmission in persons of different temperaments has not been yet ascertained with the desired precision. Such difference as there may be is obviously a fundamental characteristic and one that well deserves careful examination. I may take this opportunity of suggesting a simple inquiry that would throw much light on the degree in which its velocity varies in different persons, and how far it is correlated with temperament and external physical characteristics. Before I describe the inquiry I suggest, and toward which I have already collected a few data, it is necessary that I should explain the meaning of a term in common use among astronomers, namely, "personal equation." It is a well-known fact that different observers make different estimates of the exact moment of the occurrence of any event. There is a common astronomical observation, in which the moment has to be recorded at which a star that is traveling athwart the field of view of a fixed telescope, crosses the fine vertical wire by which that field of view is intersected. In making this observation it is found that some observers are over sanguine and anticipate the event, while others are sluggish and allow the event to pass by before they succeed in noting it. This is by no means the effect of inexperience or maladroitness, but it is a persistent characteristic of each individual, however practiced in the art of making observations or however attentive he may be. The difference between the time of a man's noting the event and that of its actual occurrence is called his personal equation. It remains curiously constant in every case for successive years, it is carefully ascertained for every assistant in every observatory, it is published along with his observations, and is applied to them just as a correction would be applied to measurements made by a foot-rule, that was known to be too long or too short by some definite amount. Therefore the magnitude of a man's personal equation indicates a very fundamental peculiarity of constitution; and the inquiry I would suggest, is to make a comparison of the age, height, weight, color of hair and eyes, and temperament (so far as it may admit of definition) in each observer in the various observatories at home and abroad, with the amount of his personal equation. We should thus learn how far the more obvious physical characteristics may be correlated with certain mental ones, and we should perhaps obtain a more precise scale of temperaments than we have at present.

Another subject of exact measurement is the time occupied in forming an elementary judgment. If a simple signal be suddenly shown, and if the observer presses a stop as quickly as he can when he sees it, some little time will certainly be lost, owing to delay in nerve transmission and to the sluggishness of the mechanical apparatus. In making experiments on the rate of judgment, the amount of this interval is first ascertained. Then the observer prepares himself for the exhibition of a signal that may be either black or white, but he is left ignorant which of the two it will be. He is to press a stop with his right hand in the first event, and another stop with his left hand in the second one. The trial is then made, and a much longer interval is found to have elapsed between the exhibition of the alternative signal, and the record of it, than had elapsed when a simple signal was used. There has been hesitation and delay: in short, the simplest act of judgment is found to consume a definite time. It is obvious that here, again, we have means of ascertaining differences in the rapidity of forming elementary judgments, and of classifying individuals accordingly.

It would be easy to pursue the subject of the measurement of mental qualities to considerable length, by describing other kinds of experiment, for they are numerous and varied. Among these is the plan of Professor Jevons, of suddenly exhibiting an unknown number of beans in a box, and requiring an estimate of their number to be immediately called out. A comparison of the estimate with the fact, in a large number of trials, brought out a very interesting scale of the accuracy of such estimates, which would of course vary in different individuals, and might be used as a means of classification. I can imagine few greater services to anthropology than the collection of the various experiments that have been imagined to reduce the faculties of the mind to exact measurement. They have engaged the attention of the highest philosophers, but have never, so far as I am aware, been brought compendiously together, and have certainly not been introduced, as they deserve, to general notice.

Wherever we are able to perceive differences by inter-comparison, we may reasonably hope that we may at some future time succeed in submitting those differences to measurement. The history of science is the history of such triumphs. I will ask your attention to a very notable instance of this, namely, that of the establishment of the scale of the thermometer. You are aware that the possibility of making a standard thermometric scale wholly depends upon that of determining two fixed points of temperature, the interval between them being graduated into a scale of equal parts. These points are, I need hardly say, the temperatures of freezing and of boiling water respectively. On this basis we are able to record temperature with minute accuracy, and the power of doing so has been one of the most important aids to physics and chemistry as well as to other branches of investigation. We have been so accustomed, from our childhood, to hear of degrees of temperature, and our scientific knowledge is so largely based upon exact thermometric measurement, that we cannot easily realize the state of science when the thermometer, as we now use it, was unknown. Yet such was the condition of affairs so recently as two hundred years ago, or thereabouts. The invention of the thermometer, in its present complete form, was largely due to Boyle, and I find in his "Memoirs" (London, 1772, vol. vi, p. 403), a letter that cannot fail to interest us, since it well expresses the need of exact measurement that was then felt in a particular case, where it was soon eminently well supplied, and therefore encourages hope that our present needs as anthropologists may hereafter, in some way or other, be equally well satisfied. The letter is from Dr. John Beale, a great friend and correspondent of Boyle, and is dated February, 1663. He says in it:—

"I see by several of my own thermometers that the glass-men are by you so well instructed to make the stems in equal proportions, that if we could name some degrees, ... we might by the proportions of the glass make our discourses intelligible in mentioning what degrees of cold our greatest frosts do produce. . . . . If we can discourse of heat and cold in their several degrees, so as we may signify the same intelligibly, ... it is more than our forefathers have taught us to do hitherto."

The principal experiments by which the mental faculties may be measured require, unfortunately for us, rather costly and delicate apparatus, and until physiological laboratories are more numerous than at present, we can hardly expect that they will be pursued by many persons.

Let us now suppose that, by one or more of the methods I have described or alluded to, we have succeeded in obtaining a group of persons resembling one another in some mental quality, and that we desire to determine the external physical characteristics and features most commonly associated with it. I have nothing new to say as regards the usual anthropometric measurements, but I wish to speak of the great convenience of photographs in conveying those subtle but clearly visible peculiarities of outline which almost elude measurement. It is strange that no use is made of photography to obtain careful studies of the head and features. No single view can possibly exhibit the whole of a solid, but we require for that purpose views to be taken from three points at right angles to one another. Just as the architect requires to know the elevation, side view, and plan of a house, so the anthropologist ought to have the full face, profile, and view of the head from above of the individual whose features he is studying.

It might be a great convenience, when numerous portraits have to be rapidly and inexpensively taken for the purpose of anthropological studies, to arrange a solid framework supporting three mirrors, that shall afford the views of which I have been speaking, by reflection, at the same moment that the direct picture of the sitter is taken. He would present a three-quarter face to the camera for the direct picture, one adjacent mirror would reflect his profile towards it, another on the opposite side would reflect his full face, and a third sloping over him would reflect the head as seen from above. All the reflected images would lie at the same optical distance from the camera, and would, therefore, be on the same scale, but they would be on a somewhat smaller scale than the picture taken directly. The result would be an ordinary photographic picture of the sitter surrounded by three different views of his head. Scales of inches attached to the framework would appear in the picture and give the means of exact measurement.

Having obtained drawings or photographs of several persons alike in most respects, but differing in minor details, what sure method is there of extracting the typical characteristics from them? I may mention a plan which had occurred both to Mr. Herbert Spencer and myself, the principle of which is to superimpose optically the various drawings and to accept the aggregate result. Mr. Spencer suggested to me in conversation that the drawings reduced to the same scale might be traced on separate pieces of transparent paper and secured one upon another, and then held between the eye and the light. I have attempted this with some success. My own idea was to throw faint images of the several portraits, in succession, upon the same sensitized photographic plate. I may add that it is perfectly easy to superimpose optically two portraits by means of a stereoscope, and that a person who is used to handle instruments will find a common double eye-glass fitted with stereoscopic lenses to be almost as effectual and far handier than the boxes sold in shops.

In illustration of what I have said about photographic portraits, I will allude to some recent experiences of my own in a subject that I have still under consideration. In previous publications I have treated of men who have been the glory of mankind, I would now call your attention to those who are its disgrace. The particular group of men I have in view are the criminals of England, who have been condemned to long terms of penal servitude for various heinous offences.

It is needless to enlarge on the obvious fact that many persons have become convicts who, if they had been afforded the average chances of doing well, would have lived up to a fair standard of virtue. Neither need I enlarge on the other equally obvious fact, that a very large number of men escape criminal punishment, who in reality deserve it quite as much as an average convict. Making every allowance for these two elements of uncertainty, no reasonable man can entertain a doubt that the convict class includes a large proportion of consummate scoundrels, and that we are entitled to expect to find in any large body of convicts a prevalence of the truly criminal characteristics, whatever these may be.

Criminality, though not very various in its development, is extremely complex in its origin: nevertheless, certain general conclusions are arrived at by the best writers on the subject, among whom I would certainly rank Prosper Despine. The ideal criminal has three peculiarities of character; his conscience is almost deficient, his instincts are vicious, and his power of self-control is very weak. As a consequence of all this, he usually detests continuous labor. This statement applies to the criminal classes generally, the special conditions that determine the description of crime being the character of the instincts; and the fact of the absence of self-control being due to ungovernable temper, or to passion, or to mere imbecility.

The deficiency of conscience in criminals, as shown by the absence of genuine remorse for their guilt, appears to astonish all who first become familiar with the details of prison life. Scenes of heartrending despair are hardly ever witnessed among prisoners; their sleep is broken by no uneasy dreams—on the contrary, it is easy and sound; they have also excellent appetites. But hypocrisy is a very common vice; and all my information agrees in one particular, as to the utter untruthfulness of criminals, however plausible their statements may appear to be.

The subject of vicious instincts is a very large one; we must guard ourselves against looking upon them as perversions, inasmuch as they may be strictly in accordance with the healthy nature of the man, and, being transmissible by inheritance, may become the normal characteristics of a healthy race, just as the sheep-dog, the retriever, the pointer, and the bull-dog have their several instincts. There can be no greater popular error than the supposition that natural instinct is a perfectly trustworthy guide, for there are striking contradictions to such an opinion in individuals of every description of animal. All that we are entitled to say is, that the prevalent instincts of each race are trustworthy, not those of every individual. A man who is counted as an atrocious criminal by society, and is punished as such by the law, may nevertheless have acted in strict accordance with his instincts. The ideal criminal is deficient in qualities that oppose his vicious instincts; he has neither the natural regard for others which lies at the base of conscience, nor has he sufficient self-control to enable him to consider his own selfish interests in the long run. He cannot be preserved from criminal misadventure, either by altruistic or by intelligently egoistic sentiments.

It becomes an interesting question to know how far these peculiarities may be correlated with physical characteristics and features. Through the cordial and ready assistance of Sir Edmund Du Cane, the Surveyor-General of Prisons, who has himself contributed a valuable memoir to the Social Science Congress on the subject, I was enabled to examine the many thousand photographs of criminals that are preserved for purposes of identification at the Home Office, to visit prisons and confer with the authorities, and lastly to procure for my own private statistical inquiries a large number of copies of photographs of heinous criminals. I may as well say, that I begged that the photographs should be furnished me without any names attached to them, but simply classified in three groups according to the nature of the crime. The first group included murder, manslaughter, and burglary; the second group included felony and forgery; and the third group referred to sexual crimes. The photographs were of criminals who had been sentenced to long terms of penal servitude.

By familiarizing myself with the collection, and continually sorting the photographs in tentative ways, certain natural classes began to appear, some of which are exceedingly well marked. It was also very evident that the three groups of criminals contributed in very different proportions to the different physiognomic classes.

This is not the place to go further into details: indeed my inquiry is far from complete. I merely quote my experiences in order to show the way in which questions of character, physiognomy, and temperament admit of being scientifically approached, and to give an instance of the helpfulness of photography. If I had had the profiles and the shape of the head as seen from above, my results would have been much more instructive. Thus, to take a single instance, I have seen many pencil studies in outline of selected criminal faces drawn by Dr. Clarke, the accomplished and zealous medical officer of Pentonville Prison; and in these sketches a certain very characteristic profile seemed to me conspicuously prevalent. I should have been very glad of photographs to corroborate this. So, again, if I had had photographic views of the head taken from above, I could have tested, among other matters, the truth of Professor Benedict's assertion about the abnormally small size of the back of the head in criminals.

I have thus far spoken of the characters and physiognomy of well-marked varieties of men: the anthropologist has next to consider the life history of those varieties, and especially their tendency to perpetuate themselves, whether to displace other varieties and to spread, or else to die out. In illustration of this, I will proceed with what appears to be the history of the criminal class. Its perpetuation by heredity is a question that deserves more careful investigation than it has received, but it is on many accounts more difficult to grapple with than it may at first sight appear to be. The vagrant habits of the criminal classes, their illegitimate unions and extreme untruthfulness, are among the difficulties. It is, however, easy to show that the criminal nature tends to be inherited while, on the other hand, it is impossible that women who spend a large portion of the best years of their lives in prison can contribute many children to the population. The true state of the case appears to be that the criminal population receives steady accessions from classes who, without having strongly marked criminal natures, do nevertheless belong to a type of humanity that is exceedingly ill-suited to play a respectable part in our modern civilization, though they are well-suited to flourish under half-savage conditions, being naturally both healthy and prolific. These persons are apt to go to the bad; their daughters consort with criminals and become the parents of criminals. An extraordinary example of this is given by the history of the infamous Jukes family in America, whose pedigree has been made out with extraordinary care, during no less than seven generations, and is the subject of an elaborate memoir printed in the thirty-first annual report of the Prison Association of New York, 1876. It includes no less than 540 individuals of Jukes blood, among whom the number of persons who degraded into criminality, pauperism, or disease, is frightful to contemplate.

It is difficult to summarize the results in a few plain figures, but I will state those respecting the fifth generation, through the eldest of the five prolific daughters of the man who is the common ancestor of the race. The total number of these was 103, of whom thirty-eight came through an illegitimate granddaughter, and eighty-five through legitimate grand-children. Out of the thirty-eight, sixteen have been in jail, six of them for heinous offences, one of these having been committed no less than nine times; eleven others were paupers or led openly disreputable lives; four were notoriously intemperate; the history of three had not been traced, and only four were known to have done well. The great majority of the women consorted with criminals. As to the eighty-five legitimate descendants, they were less flagrantly bad, for only five of them had been in jail and only thirteen others had been paupers. Now the ancestor of all this mischief, who was born about the year 1730, is described as having been a hunter and a fisher, a jolly, companionable man, averse to steady labor, working hard and idling by turns, and who had numerous illegitimate children, whose issue has not been traced. He was, in fact, a somewhat good specimen of a half-savage, without any seriously criminal instincts. The girls were apparently attractive, marrying early and sometimes not badly; but the gipsy-like character of the race was unsuited to success in a civilized country. So the descendants went to the bad, and the hereditary moral weaknesses they may have had rose to the surface and worked their mischief without a check. Cohabiting with criminals and being extremely prolific, the result was the production of a stock exceeding 500 in number, of a prevalent criminal type. Through disease and intemperance the breed is now rapidly diminishing; the infant mortality has of late been horrible among them, but fortunately the women of the present generation bear usually but few children, and many of them are altogether childless.

This is not the place to go further into details. I have alluded to the Jukes family in order to show what extremely important topics lie open to inquiry in a single branch of anthropological research, and to stimulate others to follow it out. There can be no more interesting subject to us than the quality of the stock of our countrymen and of the human race generally, and there can be no more worthy inquiry than that which leads to an explanation of the conditions under which it deteriorates or improves.

ART. XXXVI.—*Analyses of Cast Nickel, and Experiments on the combining of Carbon and Silicon with Nickel;* by WILLIAM E. GARD. Contributions from the Sheffield Laboratory of Yale College. No. L.

NUMEROUS analyses of commercial nickel have been published, according to which the usual impurities of this product are cobalt, iron, copper, sulphur, arsenic, alumina, alkaline earths and silica, in very varying quantities. In a few cases carbon is reported.

In text-books of metallurgy it is usually stated that the final step in the process of preparing commercial nickel is to reduce the oxide in the form of lumps or cubes without fusion by means of charcoal. According to Kerl,* the already reduced outside portion of the cube takes up carbon by contact and transfers it to the interior. If the reduced metal be allowed to remain in contact with the coal at a high temperature, it takes up more and more carbon. It is also stated in Gmelin's Handbook of Chemistry,† on the authority of Döbereiner, that nickel takes up carbon.

The nickel plates now largely used as anodes for nickel plating are prepared by fusing commercial nickel, generally with addition of charcoal, and casting in suitable form. The process of fusion could hardly be expected to effect much change in composition beyond the removal of intermixed oxides, as alumina, alkaline earths and silica. The subjoined analyses show, however, that silica may be reduced and retained as silicon, and that a considerable amount of carbon may be present.

	No. I.		No. II.		No. III.	
	a	b	a	b	a	b
Carbon,	·530	·549	1·104	1·080	1·900	1·830
Silicon,	·303	·294	·130	·125	·255	·268
Iron,	·464	·463	·108	·110	·301	·318
Cobalt,	·446	·438	trace		trace	
Sulphur,	·049	·057	·266	·340	·104	·096
[Nickel],	98·208	98·199	98·392	98·345	97·440	97·488
	100·000	100·000	100·000	100·000	100·000	100·000

Carbon was estimated by the method that is generally employed in this laboratory for its determination in iron, viz: treatment with solution of perfectly neutral normal cupric chloride, or of cupric ammonium chloride, and combustion of the residue after washing on an asbestos filter. The action of

* Handbuch der metallurg. Hüttenkunde, vol. iv, p. 482, 1865.

† Vol. v, p. 366, 1851.

cupric chloride on nickel is extremely slow, two or three weeks being required for the solution of five grams, although crushed fine in a steel mortar. The cupric ammonium chloride is a better solvent, two or three days sufficing for the solution. Of the subjects of analysis, No. I was American nickel, manufactured and cast by Jos. Wharton at Camden, N. J. A careful examination by means of Marsh's apparatus showed not the least trace of arsenic or antimony. No. II was a sample taken from a cast nickel anode used by a nickel plating establishment in New Haven. No. III, a sample taken from the same anode after it had been used in the plating bath until upward of half its weight had been removed. Solvent action had extended quite through the plate, leaving as usual a porous flexible mass retaining its original form. A comparison of Nos. II and III shows that under galvanic action the carbon, silicon and iron of the anode dissolve relatively slower than nickel, while the reverse happens with sulphur.

Experiments.

It is well known that when oxide of iron is reduced by carbon at a high temperature in presence of silica, a portion of the latter is simultaneously reduced and combined with the iron. To ascertain the deportment of silicon to nickel under similar conditions, the following experiment was made. A quantity of pure nickel oxide was intimately mixed with about half its weight of finely pulverized quartz, and enough charcoal powder to effect reduction of both. The mass was made into pellets with starch paste, dried, ignited and finally, with addition of more charcoal, exposed to an intense heat for three hours. A perfectly fused metallic button was obtained, white, homogeneous in structure, soft enough to be easily drilled, having a specific gravity of 7·73. The smallest particles were not attracted by an ordinary magnet. It was found to contain

Carbon	8·90	9·50
Silicon	6·039	6·190

In order to obtain further knowledge in regard to the amount of carbon which nickel may take up under conditions to which it is more or less exposed in the processes of manufacture and casting, half a pound of granular commercial nickel was packed in layers with charcoal in a Hessian crucible and exposed to a full red heat twelve hours. Examination of the contents of the crucible showed that no fusion had taken place. The temperature was then raised until complete fusion ensued. The resulting metal was strongly magnetic, quite soft and to a considerable extent malleable. It possessed a specific gravity of 8·04, and a fracture resembling that of fine-grained grey pig-iron, scales of graphite being plainly visible. It was found to contain:

	a	b
Total carbon	2·105	2·130
Graphitic carbon	2·030	1·990
Silicon	·360	----

To ascertain the deportment of nickel and cobalt toward hydrocarbon at high temperature, the following substances were placed in a platinum trough within a porcelain tube and treated with a slow current of pure dry marsh gas at a full red heat.

No. 1, thin plates of electroplate nickel—which a careful examination proved to be free from impurities. No. 2, nickel prepared by reducing pure oxide by hydrogen. No. 3, fine soft iron wire. No. 4, cobalt prepared from pure oxalate by ignition and reduction with hydrogen. These metals were first ignited in the porcelain tube with hydrogen and weighed. Three exposures to a red heat with a current of marsh gas were then made, the metals being weighed each time after cooling in the current of gas. A portion of the electro-plate nickel was used for examination after the second exposure, so that an amount equal to ·5638 grams was present at the last heat.

A condensed statement of the result is exhibited in the following tables, in which the first column contains the original weights of the metals; the second, third and fourth, the total increase in weight after successive treatments; and the fifth shows the percentage of carbon in the final resulting compounds, assuming that the gain was due exclusively to this element.

Weights of metals.		Gain in 3½ hours.	Gain in 4¾ hours.	Gain in 6½ hours.	% C. at close.
1. Ni,	·8597	·0067	·0823	[·0672]	10·649
2. Ni,	1·9008	·0046	·0071	·0114	5·96
3. Fe,	1·2837	·0078	·0096	·0103	·795
4. Co,	1·2697	·0758	·1680	·1857	12·758

No deposit of carbon could be detected on any part of the apparatus or on the metals at the close of the operation. The iron and nickel No. 2 were unchanged in appearance. The cobalt was somewhat blackened. It was as first prepared very porous and spongy: a part of its increase in weight may have been due to deposited carbon. Nickel No. 2 was in the form of coarse compact grains presenting comparatively little surface. The electro-plate nickel at the end of the operations had become brittle, and resembled gas carbon in color and luster; treatment with nitric acid readily dissolved the nickel, leaving a spongy mass of easily combustible carbon. A broken surface appeared under the microscope homogeneous, granular, with dull metallic luster. When ground to fine powder with water all settled rapidly and every particle was strongly attracted by the magnet. These properties seem to render it probable that the carbon was all in a combined state.

ART. XXXVII.—*On the practical use of Autography, especially for Natural History publications.* Condensed from a letter to the Christiania paper "Morgenbladet," 1875, by G. O. SARS, Professor of Zoology at the University of Christiania, Norway, and translated by J. LINDAHL.

AUTOGRAPHY is a long-known process by which manuscript, or drawings, made on common paper by means of a peculiar kind of ink, may be transferred to a lithographic stone and then printed. This simple and cheap method has, however, had hitherto a very limited practical use, and almost exclusively for the reproduction of original manuscripts, hieroglyphs, or other simple figures, for which types could not be used. In Norway it was introduced in 1873, by Dr. Lieblein, who illustrated his Egyptological work with some pages of hieroglyphic inscriptions reproduced in autography. This suggested to me the idea that the same process might answer also for representing simple zoological objects, and thus afford the means of removing one of the great impediments that too often have interfered with a free development of zoology, viz: the heavy expense connected with a production in the usual way—by lithography or copper plate engraving—of illustrations so necessary for all works on descriptive zoology. * * * There are a number of objections to the autographic process hitherto used, and these led me to experiment on the subject. I have been fortunate enough by my experiments to devise an easy method and to prove its extensive practical use, and it gives me pleasure to communicate it to the scientific world, believing that I am doing science an important service. I must add that the success of my experiments is greatly due to Mr. Fehr's warm interest and assistance.

The following is a detailed explanation of this improved autographic process. The drawing is done on common paper, not too thick (for instance common letter paper), which, on one side (where the drawing is to be made), has been coated, by means of a sponge, with a thin film of starch. As it is not well for the shading to use quite glossy paper, it is a good way to give it a granulated surface by pressing it against a lithographic stone. By using for this purpose stones with more or less smooth surface, the paper will assume any degree of smoothness required, according to the character of the drawing. The next process is to fasten the paper to a sketching board or a piece of pasteboard; the drawing is then made by means of the lithographic crayon. I use a kind of crayon containing copal ("*crayons copal*") and therefore less brittle than the common kind; and as this kind is also in other respects preferable, it had better always be used for this purpose. It can be obtained in small boxes from Monsieur Lemercier, Rue de Seine, St. Gn., 57, Paris.

The paper must be cut to the size intended for a full plate, and the drawings arranged in the same order as they will have to appear in the printed plate. The execution is exceedingly simple, and any draughtsman will easily acquire the necessary skill in the work. The method is the same as in common drawing with lead pencil, or rather crayon. The figures should, however, first be sketched in outline on common paper and then transferred to the prepared paper in the usual manner, by means of transparent paper and plumbago paper, blue paper, or, still better, red paper, the transferring being done with a lead pencil that is not too soft. The details of the figures, the shading and finer structural conditions may be drawn off-hand with the crayon on the prepared paper, after the outline has been transferred. Any correction or change in the drawing can easily be done by erasing with a fine scalpel, taking care only that the starch film be not injured. I have in this way made numerous corrections in my drawings without the slightest injury to the prints. When the plate is finished to satisfaction, it is transferred to a common smooth lithographic stone, in the following simple way. The back of the paper is moistened with water containing a small portion of nitric acid; and, after having been put for some time between moistened soft printing paper, the plate is laid, face downward, on the stone, which then for a moment is put in the press. To make more sure of it the outside of the paper may be slightly rubbed with the finger; if then the paper be stripped off, the drawing and the entire film of starch will remain on the stone, the figures being reversed. Now the stone is to be treated in the common way with gum arabic and a weak etching, and will then be ready for printing. The whole process of transferring the drawing from the paper to the stone is simple, but requires practice and great care. This should therefore be left to the charge of a professional lithographer.

It may be thought that the zoologist, by taking on himself the execution of his plates, would have his labor excessively increased. This, however, is not really so. The drawing must at all events be made by the zoologist in one way or another before the lithographer or engraver can copy them, and it is of no material difference to the former whether he makes them with lead pencil or in the above described manner. The only difference is that he must himself arrange his figures on the plates, and not, as otherwise is the practice, leave this to the lithographer; and besides, he must draw all the figures that are to go on one plate in as far as possible a continuous sequence. But this increase of labor is of small account compared with the great and essential advantages offered by this method, viz:

1. *Cheapness.*—The expenses of such a plate are reduced simply to the cost of paper and printing, and will be even less than for a page of common printed matter. Thus any zoologist who publishes his researches can illustrate his papers with any number of plates, without meeting the insurmountable obstacle of enormous expense, which too often has rendered illustration of such papers impossible.

2. *Correctness.*—It avoids the errors that come from the copying of drawings by the engraver.

3. *Quick execution.*—The author and publisher are independent of the greater or smaller expedition of the engraver. I know of many instances of the delay of important researches from this cause for years, with great detriment to the author and his works. Nothing can be more unpleasant to a working zoologist than to be forestalled in this way in his researches. All this may be avoided by using this autographic method. The plates once drawn, the whole edition can be pushed through the press within the course of a few days.

Against these great and obvious advantages it may be said that only those zoologists can avail themselves of the process who know how to draw. To this it may be answered that the knowledge of drawing is indispensable to a zoologist now-a-days. In many instances even the best draughtsman is of no use as assistant to a zoologist. In many cases, especially in microscopical researches, only a momentary flash, so to say, illuminates certain questions of importance. Such a flash must be perceived by the zoologist and so fully understood that he immediately can give a representation on paper of what he has seen, and consequently it is generally necessary that the draughtsman should be a zoologist.

Some modern zoologists have, to save expense, tried to make their drawings directly on the stone. Such a plate will of course have the value of an autographic drawing. But it requires unusual practice and a special study of the lithographic art, which can be expected of only a very small number of zoologists. It is obvious that the same result is obtained by the above described method, and in a far easier way.

ART. XXXVIII.—*On the Iodates of Cobalt and Nickel; some Specific Gravity determinations; and an Analysis of Sylvanite from Colorado;* by F. W. CLARKE, Professor of Physics and Chemistry. Numbers IV, V, and VI, of Laboratory Notes, from the University of Cincinnati.

IV. *On the Iodates of Cobalt and Nickel.*

ABOUT forty years ago Rammelsberg described the iodates of cobalt and nickel.* He dissolved the freshly precipitated carbonates of the metals in an aqueous solution of iodic acid, and, upon concentrating, obtained the salts in the form of crystalline crusts. To the cobalt salt he assigned a quantity of water of crystallization represented by 1½ molecules, while the nickel iodate was found to be monohydrated.

During the winter of 1876–1877 I put one of my laboratory students, Mr. H. B. Fullerton, at work upon the iodates, requiring him, among other salts, to prepare the two in question. Rammelsberg's mode of preparation was followed, and results somewhat different from his obtained.

When cobalt carbonate is dissolved in aqueous iodic acid and the filtered solution evaporated rapidly over a flame, Rammelsberg's iodate readily separates out, nearly the whole of the salt being deposited in a very few moments. But when, on the other hand, the solution is allowed to evaporate spontaneously, small red crystals are formed, having the composition $CoI_2O_6 . 6H_2O$. This is evidently the normal iodate, since it contains the same number of molecules of water as are found in the chlorate, bromate, nitrate, chloride, bromide, iodide, hypophosphite, hyposulphite, dithionate, selenate, and numerous other salts. Indeed, a large majority of the known salts not only of cobalt and nickel, but also of zinc and magnesium, crystallize with six molecules of water. So general does this rule appear to be that all exceptions to it ought to receive the most careful scrutiny. Even the sulphates of these metals, crystallized at temperatures above 60° C., are well known to be hexhydrated.

The new cobalt iodate differs strongly in color from the one discovered by Rammelsberg, being not a true purple, but distinctly red like the nitrate. The percentage of cobalt found was 11·10, the theoretical quantity being 11·24. Heated to 135°, the salt loses 13·73 per cent of water. Four molecules correspond to 13·95 per cent. The remaining two molecules of water could not be expelled without partially decomposing the iodate. The specific gravity is 3·6426, at 16°; and 3·6893 at

* Poggendorff's Annalen, vol. xliv, p. 545.

21°. Rammelsberg's salt gave 5·0275 at 17°, and 4·9885 at 19°. These determinations were made by weighing in benzol with an ordinary specific gravity flask.

The iodate of nickel was prepared in a manner precisely corresponding to that which yielded the cobalt compound, and separated out in small green crystals resembling in color the nitrate. These also proved to be hexhydrated, and contained, according to Mr. Fullerton's analysis, 11·15 per cent of nickel. Theory, 11·41. Specific gravity, 3·6954 at 22°. Want of time prevented a more complete examination of this salt. An attempt was made to prepare the monohydrated iodate of Rammelsberg, but without success. I hope that at some time in the near future I may be able to get farther results concerning these and one or two other iodates, as there are various points about them which need to be cleared up. The work of Mr. Fullerton, however, shows conclusively that the true normal iodates of cobalt and nickel contain really six molecules of water of crystallization, and that they are essentially different from the salts obtained by Rammelsberg.

V. *Some Specific Gravity Determinations.*

During the past academic year the laboratory students in the University of Cincinnati have determined the densities of a considerable number of salts. Many of these salts had not been determined before; some of the determinations confirm the work of other investigators, and there are also some important corrections of older, published figures. The work has been done in connection with the regular laboratory routine, and upon the following plan. Every student, in addition to the usual exercises in qualitative analysis, has been required to do a certain amount of preparative work, and to determine the specific gravity of each substance prepared. It is understood by the student, in advance, that the substances to be chosen are as a rule those of which the density is unknown, and thus he realizes that his work is actually adding something to the data of science. In short, every student is absolutely required to determine some new fact for himself, and to determine it accurately. The work is done under my own personal supervision, and a sufficient number of checks are put upon it to render it reliable. The weighings, with a few exceptions, have been made in benzol, as in the case of the iodates already described. In three instances only were the weighings made in water. The figures, however, all refer to water as unity, taken at its temperature of maximum density.

To Mr. H. B. Fullerton, as I have already stated, was assigned the iodates. In addition to the figures for the cobalt and nickel salts, he obtained the following data.

Barium iodate, BaI_2O_6, precipitated and carefully dehydrated, 5·2179, 5·1853, 5·2855, at 18°.

Silver iodate, $AgIO_3$, precipitated, 5·4023, 16·5°. The same salt recrystallized from ammonia gave 5·6475, 14·5°.

Lead iodate, PbI_2O_6, precipitated, 6·1783, at 19°, and 6·1322, 21°. For this salt Schröder found 6·209. These three iodates were weighed in water.

Ammonium iodate, $NH_4.IO_3$, small crystals, 3·3085, 21°; and 3·3372, 12·5°.

Mr. Fullerton also determined the specific gravities of two iodides which had previously been examined by Bödeker. CdI_2, in very beautiful pearly scales, gave 5·9857 at 12°, and 5·9738 at 13·5°. Bödeker's figure is 4·576 at 10°, making the salt *lighter* than either of the elements contained in it. This fact of itself would tend to throw suspicion upon Bödeker's results.

Bismuth iodide, BiI_3, gave Mr. Fullerton 5·9225 at 16°, and 5·8813 at 17·5°. Bödeker found 5·652 at 10°. Here again I regard Mr. Fullerton's figures as the more trustworthy.

The following double and compound cyanides were determined by Mr. W. L. Dudley.

Nickel potassium cyanide, K_2NiCy_4, H_2O; 1·875, 11°; and 1·871, 14·5°.

Potassium platinocyanide, K_2PtCy_4, $3H_2O$, slightly moist, 2·5241, 13°, and 2·4548, 16°. The discrepancy between the two is undoubtedly due to the moisture which could not easily be removed.

Ammonium sulphocyanide, NH_4CyS, 1·299 and 1·316 at 13°.

Potassio-chromic sulphocyanide, $K_6CrCy_{12}S_{12}$, $8H_2O$, 1·7051, 17·5°; 1·7107, 16°.

Potassio-platinic sulphocyanide, $K_2PtCy_6S_6$, 2·370, 19°, and 2·342, 18°.

Sodium nitroprusside, 1·6869, 25°. Schröder found 1·710 and 1·716 for this salt.

Four nitrates were determined by Mr. H. Laws.

NiN_2O_6, $6H_2O$, gave 2·065, 14°, and 2·037, 22°.

ZnN_2O_6, $6H_2O$, gave 2·063, 13°, and 2·067, 15°.

CdN_2O_6, $4H_2O$, gave 2·450, 14°, and 2·460, 20°.

BiN_3O_9, $5H_2O$, well crystallized, gave 2·823 at 13°.

This salt has also been determined by Playfair and Joule, who found 2·736. Their method of working, however, was less reliable than that with the specific gravity bottle.

The bromates were taken up by Miss E. D. Storer, with the following results.

$KBrO_3$, 3·323 at 19°. Kremers found 3·271, and Topsoë 3·218. The agreement is tolerable.

$AgBrO_3$, 5·1983, 16°, and 5·2153, 18°.

$BaBr_2O_6$, carefully dehydrated, 4·0395, 17°, 3·9918, 18°.

Hyposulphites, measured by Mr. L. T. Richardson.

$CaS_2O_3, 6H_2O$, in fine crystals, 1·8715, 13·5°, and 1·8728, 16°.
$SrS_2O_3, 6H_2O$, in good crystals, 2·1566, 2·1991, both at 17°.
BaS_2O_3, H_2O, precipitated, 3·4461, 16° and 3·4486, 18°.

Mr. Richardson also made a determination for potassium sulphate, getting 2·653, 18°. This agrees closely with Pettersson's figure, 2·66.

Tungstates, examined by Mr. J. L. Davis. The sodium salt was a commercial product, and was therefore first analyzed to be certain of its character. The nickel and barium salts were prepared by the well-known method of fusion.

Na_2WO_4,	4·1743, 20·5°, and 4·1833, 18·5°.
$Na_2WO_4, 2H_2O$,	3·2588, 17·5°, and 3·2314, 19°.
$BaWO_4$,	5·0035, 13·5°, and 5·0422, 15°.
$NiWO_4$,	6·8846, 20·5°, and 6·8522, 22°.

Molybdates, prepared and determined by Mr. F. O. Marsh.

$BaMoO_4$, 4·6589, 17·5°, and 4·6483, 19·5°.
$SrMo_4$, 4·1554, 20·5°, and 4·1348, 21°.

Mr. C. A. Mohr worked upon phosphates and hypophosphites, as follows.

Barium hypophosphite, $BaP_2H_4O_4, H_2O$, 2·8718, 10°, and 2·8971, 17°.

Magnesium hypophosphite, $MgP_2H_4O_4, 6H_2O$, 1·5886, 12·5°, and 1·5681, 14·5°.

Sodium metaphosphate, $NaPO_3$, prepared by igniting microcosmic salt, 2·4756, 19·5°, and 2·4769, 18°.

Potassium metaphosphate, KPO_3, prepared by igniting the monopotassium ortho-salt, 2·2639, and 2·2513, both at 14·5°.

No other hypophosphites or metaphosphates have as yet had their densities determined.

Trisodium orthophosphate, anhydrous, Na_3PO_4, 2·5111, 12°; 2·5362, 17·5.

Sodium pyrophosphate, $Na_4P_2O_7, 10H_2O$, 1·7726, 21°. Playfair and Joule found 1·836.

The same salt, dehydrated by ignition, 2·3851 and 2·3613, 17°. Schröder's determination makes the salt 2·534, a widely different figure.

The following series of chromates was prepared and examined by Miss E. O. Abbot.

Magnesium chromate, $MgCrO_4, 7H_2O$, finely crystallized, 1·7613 at 16°. For this salt Bödeker found 1·75, and Kopp 1·66. The higher result is more probable. In her work on this compound Miss Abbot also determined another important fact, namely that, like the corresponding sulphate, magnesium chromate loses six molecules of water readily, holding the seventh with much greater firmness. Heated to 130° the salt loses 40·21 per cent of water, the theoretical quantity being for six molecules 40·52. Heated still hotter, say to 230°, more water, but not the whole, is expelled, the compound at the same time undergoing partial decomposition. The density of $MgCrO_4, H_2O$, was found to be 2·2886 and 2·2301, at 17°.

Ammonium chromate, $(NH_4)_2CrO_4$, crystallized, 1·9138 and 1·9203, 12°. Schröder makes it 1·860 to 1·871.

Ammonium dichromate, $(NH_4)_2Cr_2O_7$, 2·1223, 16°, and 2·1805, 17°. Schröder found 2·153; a close agreement.

Sodium chromate, Na_2CrO_4, 2·7358, 12°, and 2·7104, 16·5°. The decahydrated salt, $Na_2CrO_4, 10H_2O$, was also attempted, but with poor results. A single determination came out 1·4828 at 20°, a figure probably much too low. The difficulty in dealing with this body arises from the extreme instability of its water of crystallization.

Ammonium-magnesium chromate, $(NH_4)_2Mg(CrO_4)_2, 6H_2O$, well crystallized, 1·8278 and 1·8595 at 16°. Also 1·8293 at 17°. In preparing this compound, cold saturated solutions of the separate chromates were mixed. Instantly a heavy crystalline precipitate was formed, which dissolved up again upon heating. As the solution cooled, crystals were abundantly deposited. Evidently, then, the double salt is much less soluble than either of its components.

Potassium-magnesium chromate, $K_2Mg(CrO_4)_2, H_2O$, 2·5804, 19°; and 2·5966, 19·5°. Schröder gives 2·592 to 2·608, a close agreement.

These chromate determinations fill up some important gaps in this series of salts, and help us to arrive at some interesting conclusions. Pettersson has lately shown that selenates have molecular volumes exceeding those of the corresponding sulphates by 6 for each molecule of the acid radicle. Thus, the molecular volume of sodium selenate is that of the sulphate plus 6; that of a selenic alum exceeds that of the corresponding sulphuric alum by four times 6, and so on. Upon comparing these and other chromates with Pettersson's selenates we now find that the two series of salts have approximately equal molecular volumes; the difference, if any exists, being very slightly plus for the selenates. If regularities of this kind can be thoroughly established, it will be easy, having the density of a chromate, to calculate that of the corresponding sulphate or selenate, and *vice-versa*. This connection between chromates and selenates has already been suggested by Schröder, and Miss Abbot's figures do much towards confirming it. Miss Abbot has also redetermined the density of chromic chloride, Cr_2Cl_6, on a beautifully characterized specimen. She finds 2·3572, 17·5°, and 2·3766, 16·5°. Schafarik's figure for the substance being 3·03, I redetermined it again in person, and got 2·349 at 20°. My result thus confirms those of Miss Abbot, and the question is raised whether this compound may not exist in more than one modification as regards density.

The following series of pyrophosphates was worked up by Mr. G. W. Lewis. They were prepared by igniting the double ammoniacal orthophosphates.

$Mn_2P_2O_7$, 3·5847, 20°, and 3·5742, 26°.
$Mg_2P_2O_7$, 2·598, 22°, and 2·559, 18°. Schröder found 2·22.
$Zn_2P_2O_7$, 3·7538 and 3·7574, 23°.
$Co_2P_2O_7$, 3·746, 23°, and 3·710, 25°.
$Ni_2P_2O_7$, 3·9303, 25°, and 3·9064, 27°.

Some of the corresponding pyroarsenates were prepared by Miss Helena Stallo, as follows.

$Mn_2As_2O_7$, 3·6832 and 3·6927, 23°. Also 3·6625, 25°.
$Zn_2As_2O_7$, 4·7034 and 4·6989, 21°.
$Mg_2As_2O_7$, 3·7305, 15°, and 3·7649, 18°.

Miss Stallo also determined the anhydrous trisodium orthoarsenate, getting 2·8128 and 2·8577, 21°.

The following compounds, representing various series, may be regarded as scattering.

Glucinum sulphate, $GlSO_4$, $4H_2O$, 1·6743, 22°, Miss Stallo. Topsoë found for this salt, 1·725. The sample Miss Stallo worked with was slightly damp, which will account for the difference.

Potassio-chromic oxalate, $CrK_3C_6O_{12}$, $3H_2O$; 2·1039, 23°, and 2·1464, 24°; E. P. Bishop.

Stannous chloride, $SnCl_2$, $2H_2O$, 2·634, 24°, E. P. Bishop. The published figure obtained by Penny was 2·71, 15·5°.

Cupro-mercuric iodide, $HgI_2 . CuI$, 6·1602, 15°, and 6·1412, 13°, A. E. Heighway.

Mercuric chloride with ammonium dichromate, $HgCl_2 . Am_2Cr_2O_7 . H_2O$, in large crystals, 3·2336, 21°, and 3·1850, 18°, A. E. Heighway.

Mercuric acetate, $Hg(C_2H_3O_2)_2$, 3·2544, 22°, and 3·2861, 23°, John Hagemann.

This completes the list of determinations thus far made by my students. Sixty-three compounds are here given, forty-six among them not having been measured before. In concluding, I will give a few determinations of my own.

Potassium iodate, KIO_3. There are two published values for this salt, namely, 3·979, Kremers, and 2·601, Ditte. These vary from each other so widely that I thought it worth while to redetermine the salt, and I obtained the figure 3·802, 18°. This confirms Kremers.

Tellurium dioxide, TeO_2, 5·7559, 12·5°, and 5·7841, 14°. Schafarik found 5·93.

Tellurium trioxide, TeO_3, 5·0704, 14·5°; 5·0794, 10·5°. Another sample gave 5·1118, 11°.

Barium tellurate, $BaTeO_4$, feebly ignited, 4·5486, 10·5°; 4·5305, 10°. Another sample gave 4·4811, 16°. This salt, like the sulphate, becomes much denser by ignition. Unignited, but dried at 200°, its specific gravity is in the neighborhood of 4·2.

VI. *An Analysis of Sylvanite from Colorado.*

Having had occasion lately to analyze a sylvanite from the Grand View Mine, Colorado, I publish the result here, not because it contains anything novel, but because it seems to be desirable that such material should be preserved for future reference and discussion. The ore from this mine has, I believe, not been carefully analyzed before. The specimen was imbedded in quartz, associated with a little iron pyrites, and had all the usual characteristics of sylvanite.

The analysis came out as follows, after eliminating a little gangue.

Tellurium	52·96
Gold	26·39
Silver	10·55
Iron	4·45
Sulphur	5·62
	99·97

The sulphur was not estimated directly, but was calculated as pyrites to correspond with the amount of iron found. Eliminating the pyrites the analysis will stand thus.

Tellurium	58·91
Gold	29·35
Silver	11·74
	100·00

This sylvanite was kindly given me by Professor E. S. Wayne, of Cincinnati.

Art. XXXIX.—*Notes on the Analysis of Bituminous Coal;* by T. O'Conor Sloane, A.M., E.M., Ph.D.

The determination of ash in coal appears a very simple matter; yet I have on several occasions found much difficulty in reaching accurate results. I traced the error finally to insufficient pulverization of the coal.

A sample of coal was reduced to powder and passed through a fine wire sieve, number sixty, or eighty, mesh. I made a number of determinations of ash, using different weights of the coal, and got the following widely discordant results:

a. From 3 grams, 6·66 p. c.; *b.* 12 grams, 3·72 p. c.; *c.* 1 gram, 4·67 p. c.; *d.* 2 grams, 4·40 p. c.; *e.* 12 grams, 2·63 p. c.

I then took all that was left of the pulverized coal, spread it out upon a piece of glazed cloth, and divided it into two parts, each of about the same weight. I did this with the usual precautions adopted in sampling, so that the coal in each half would be exactly the same. One of these parts was ignited and incinerated. Its weight was 23·9665 grams. The ash weighed ·9920 grams, or determination *f.* 24 grams nearly, 4·14 per cent. The other portion was powdered in a porcelain mortar until of a full brown color. The ash was determined in one gram of it, giving 3·90 per cent, *e.* 1 gram, 3·90 per cent.

I have since this investigation subjected any coal I was about to analyze to a fine powdering in a porcelain mortar. I am of opinion that it would be well to prolong the operation in an agate mortar, but the process is too tedious. Though the coal be reduced to a brown powder, it is still quite difficult to obtain good duplicate results. I give below some instances:

	1.	2.
Coal A	4·50 p. c.	4·00 p. c.
B	5·25	5·12
C	13·86	14·10
D	5·82	5·75

The ash I generally determine in one gram of the coal. If the crucible, in which the incineration is taking place be supported on the triangle in an inclined position, and if the lid be so placed as to direct the exterior zone of the flame into it, the operation will be greatly abridged. By looking into the crucible while over the burner it can be seen when the right position has been reached. The cake of coke will appear bright, or ignited, on the surface. From time to time it may be rubbed, or broken up if possible, with a platinum wire. Before incineration the sample should be ignited in the same crucible with the cover on.

The sulphur may be conveniently determined by fusion with the salt flux (Fresenius, Vacher's Ed., p. 127). One gram of the coal is fused with a mixture of NaCl 24 grams, $NaNO_3$ 8 grams, Na_2CO_3, 4 grams. Frequently a mixture of equal parts of nitrate, and carbonate of soda is employed, sixteen parts of the mixture to one part of coal. With the salt flux the reaction is less violent, all can be at once introduced into the crucible, and immediately fused. The coal mixed with the deflagrating flux, the second described, has, on the contrary, to be thrown into the hot crucible a little at a time, so that it exacts more attention and trouble. The salt fusion, in two comparative determinations that I made, gave higher results on the same coal.

	Salt Fusion.	Deflagration.
Coal A	1·70 p. c.	1·37 p. c.
B	1·92	1·69

The specific gravity cannot be satisfactorily determined without the specific gravity bottle. By weighing lumps in air and in water all sorts of results will be obtained. I break up a sample in an iron mortar and pass it through a No. 4 or 6 sieve. I then shake it up in a finer, No. 15 or 20, sieve, so as to free it from the dust and fine particles. This seems a bad practice yet cannot well be avoided. The finely divided coal, if left in with the rest, will float on the surface of the water used in determining its specific gravity, and no amount of boiling will make it sink.

The coal thus prepared I place in a small beaker with some distilled water, and boil it. I then put the coal and water into the specific gravity flask, fill up with recently boiled distilled water, and cool it to about the temperature of the room. The last cooling is done in a beaker of water which is stirred once or twice, during the cooling, to make the water of uniform temperature. When the bottle and contents have attained this temperature, the bottle is carefully filled, the stopper put in, and the whole dried and weighed. The coal is then thrown out, the bottle filled with recently boiled distilled water, brought to the same temperature as before, and weighed. This careful reduction to one temperature is very important; by paying attention to it very close duplicates can be obtained.

The specific gravity of coal varies with the percentage of ash; yet the correspondence is not so perfect as to make the determination of the specific gravity a substitute for that of the latter constituent. As the degree of correspondence is a matter of some interest, I give below a number of parallel determinations of ash and specific gravity.

Specific gravity.	Ash.	Specific gravity.	Ash.
1·282	4·02 p. c.	1·327	7·23 p. c.
1·300	4·08	1·308	7·95
1·286	4·14	1·334	10·38
1·296	4·68	1·377	13·98
1·295	5·18	1·385	16·22
1·294	5·78		

Tracing Cloth instead of Glazed Paper.

For the purposes of sampling and pulverizing minerals, coals, fertilizers, &c., for analysis, glazed paper is generally employed. This soon wears out. I have adopted ordinary draughtsman's tracing cloth in its place. This lasts indefinitely, is just as smooth, and is much to be recommended for these purposes. In the assay laboratory, paper, used for mixing the weighed ores with the fluxes, soon wears out. Here, also, I would suggest the use of tracing cloth.

Laboratory N. Y. Gas Light Co., New York, August, 1877.

ART. XL.—*A Preliminary Catalogue of the Reptiles, Fishes and Leptocardians of the Bermudas, with descriptions of four species of Fishes believed to be new*; by G. BROWN GOODE.

IN a previous paper* I enumerated seventy-four species of fishes collected in the Bermudas in 1872. Another visit to these islands during the past winter has enabled me, with the coöperation of Mr. J. Matthew Jones, who kindly allowed me the use of his collections and note books, to increase the number to one hundred and sixty-three. Of these one hundred and forty-eight have been sufficiently studied to enable me to give their names in this preliminary list. I hope at an early day to discuss the fishes of the Bermudas in a more extended paper. Since there is a peculiar interest in the chorological relations of the members of an insular fauna, I have in a general way designated the distribution of each species by the use of letters. W. indicates the West Indian province, U. the eastern coast of the United States north of Georgia, E. the Eastern Atlantic, including Madeira, the Canary Islands and the Mediterranean, and P. the Indo-Pacific waters. These however do not show faunal relations accurately, since in this way it is impossible to distinguish those species which are resident in any particular district from mere stragglers. Those species which are peculiar to Bermuda are marked "B." and are eight in number; two of these, with *Carassius auratus*, introduced, occupy the land-locked brackish marshes. Two species, *Eucinostomus Lefroyi* and *Haliperca phœbe*, occur only in Bermuda and Cuba. The Bermudian fauna shares with the West Indies one hundred and sixteen species (or seventy-nine per cent), of which fifty-eight (or forty per cent) are peculiar to the West Indies, never having been recorded elsewhere, while a large number of others have their centers of distribution in that region, individuals having made their way in summer to the

* Catalogue of the Fishes of the Bermudas, based chiefly upon the collections of the United States National Museum. By G. Brown Goode, Assistant Curator U. S. National Museum. (Bulletin U. S. Nat. Mus., No. 5.) Washington: Government Printing Office. 82 pp. 8vo. 1876.

coasts of the United States or Europe. With the eastern United States, Bermuda shares forty-seven species, five of which are otherwise recorded only from our waters, all of these, viz: *Ceratacanthus aurantiacus*, *Zonichthys fasciatus*, *Lagodon rhomboides*, *Synodus fœtens*, and *Eulamia obscura*, will doubtless prove to be members of the West Indian fauna, and be found to occur in the islands adjoining the coast of Florida. With the waters of the Pacific and Indian Oceans, it has in common thirty-two species. Should *Glyphidodon cœlestinus* Solander, prove identical with *G. saxatilis*, another species will be added to this list.

The following are the numbers of species common to two or more faunas, the letters having significations as explained above:—B. W. U., 37; B. W. E., 36; B. W. P., 25; B. P. E, 22; B. U. E., 21; B. W. U. P., 3; B. W. U. E., 6; B. W. E. P., 7; B. W. U. P. E., 12.

The reptiles, it will be observed, are all pelagic except the lizard, which is peculiar to Bermuda and most closely related to the West African species of the genus.

CATALOGUE.

Class, REPTILIA.

Order, *Lacertilia*.

Eumeces longirostris *Cope*. Lizard. B.

Order, *Testudinata*.

Sphargis coriacea *Rond*. Leather Back Turtle.
Thalassochelys caouana *L*. Loggerhead Turtle.
Eretmochelys imbricata *L*. Hawksbill Turtle.
Chelonia mydas *Schw*. Green Turtle.

Class, PISCES.

Sub-class, TELEOSTEI.

Order, *Pediculati*.

Pterophryne picta (*Val.*) *Goode*. Devil Fish. W.
Pterophryne principis (*Val.*) *Goode*. W.

Order, *Plectognathi*.

Orthagoriscus mola (*L.*) *Schn*. Sun Fish. P. E. W. U.
Paradiodon hystrix (*L.*) *Blkr*. Sea Hedgehog. P. E. W.
Diodon novem-maculatus *Cuv*. P. W.
Chilomycterus reticulatus (*L.*) *Bibron*. Sea Porcupine. E. W.
Tetrodon rostratus *Bloch*. E.
Chilichthys Spengleri (*Bloch*) *Goode*. Swallow. E. W.
Ostracium quadricorne *L*. Cow Fish. E. W.
Ostracium triquetrum *L*. Cuckold. W.
Lactophrys trigonus (*L.*) *Poey*. U. W.
Balistes capriscus *Gmel*. Turbot. P. E. W. U.
Balistes vetula *L*. Blue Turbot. W. U.
Canthidermis maculatus (*Gmel.*) *Blkr*. Ocean Turbot. P. E. W.
Canthorhinus occidentalis (*Gthr.*) *Goode*. W. U.
Canthorhinus setifer *Benn*. var. beta. P. E. W. U.
Alutarius scriptus (*Osbeck*) *Blkr*. P. E. W.
Ceratacanthus aurantiacus (*Mitch.*) *Gill*. B. U.

Order, *Lophobranchii.*

Hippocampus antiquorum *Leach.* Sea Horse. P. E. W.
Hippocampus guttulatus *Cuv.* Sea Horse.
Syngnathus Jonesii *Gthr.* B.

Order, *Hemibranchii.*

Centriscus scolopax *L.* E. U.
Fistularia serrata *Cuv.* P. U. B.
Aulostoma maculatum *Val.* Trumpet Fish. W.

Order, *Teleocephali.*

Rhomboidichthys lunatus (*L.*) *Gthr.* Plaice. W.
Rhomboidichthys ocellatus (*Agass.*) *Gthr.* W.
Hemirhombus aramaca (*Cuv.*) *Gthr.* W.
Hemirhombus soleæformis (*Agass.*) *Gthr.* W.
Lefroyia bermudensis *Jones.* B.
Brotula barbata (*Schn.*) *Cuv.* W.
Undetermined gadoid fish.
Blennius crinitus *C. & V.* W.
Blennius (species undetermined).
Blennius (species undetermined).
Blennius (species undetermined).
Labrosomus nuchipinnis (*Q. & G.*) *Gill.* E. W. U.
Salarias texilis *Q. & G.* W.
Gobius soporator *C. & V.* Molly Miller. E. W.
Dactylopterus volitans (*L.*) *Cuv.* Flying Gurnard. E. W. U.
Scorpæna Plumieri *Schn.* Prickly Hind. W. U.
Scarus radians *Val.* Spanish Porgy. W.
Scarus Catesbyi *Lac.* W.
Pseudoscarus vetula (*Schn.*) *Gill.* Blumber. W.
Pseudoscarus quadrispinosus (*C. & V.*) *Guich.* Rainbow. W.
Pseudoscarus cœruleus (*Bloch*) *Gthr.* Gillingbore. W.
Pseudoscarus croicensis (*Bloch*) *Goode.* W.
Pseudoscarus psittacus (*L.*) *Gthr.* Parrot Fish. W.
? Pseudoscarus acutus *Poey.* Mud Belly. W.
Chœrojulis radiatus (*L.*) *Goode.* Blue Fish. W.
Chœrojulis bivittatus (*Bloch*) *Poey.* Slippery Dick. W.
Lachnolæmus falcatus (*L.*) *Val.* Hog Fish. W.
Harpe rufus (*L.*) *Gill.* Spanish Hog Fish; Spanish Lady Fish. E. W.
Julis bifasciatus (*Bloch*) *Gthr.* W.
Julis nitidissima *Goode*, (new species) 1. B.
Pomacentrus leucostictus *M. & T.* W.
Glyphidodon saxatilis *L.* Cow Pilot; Sergeant Major. E. W. U.
Eucinostomus gula (*C. & V.*) *Goode* Shad. W.
Eucinostomus Lefroyi *Goode.* Long Bone Shad. W.
Acanthurus nigricans (*L.*) *Gill.* Doctor Fish. W. U.
Sarothrodus bimaculatus (*Bloch*) *Poey.* Four-eyed Fish. W.
Sarothrodus capistratus (*L.*) *Poey.* W.
Holacanthus ciliaris (*L.*) *Lacep.* Angel Fish. W. U.
Holacanthus tricolor (*Bloch*) *Lacep.* Black Angel Fish. W.
Xiphias gladius *L.* Sword Fish. E. W. U.
Thyrsites prometheus (*C. & V.*) *Gthr.* Cat Fish. E.
Orcynus alliteratus (*Raf.*) *Gill.* Mackerel. E. P. W. U.
Orcynus thynnus (*L.*) E. U.
Auxis Rochei (*Risso*) *Gthr.* Frigate mackerel. E. P. W.
Decapterus punctatus (*Agass.*) *Gill.* Round Robin. W. U.
Trachurops crumenophthalmus (*Bloch*) *Gill.* Goggle-Eye. P. W. U.
Paratractus pisquetos (*C. & V.*) *Gill.* Jack. W. U.
Carangus (near C. falcatus). Gwelly.
Carangus carangus (*Bloch*) *C. & V.* P. E. W.
Carangus dentex (*Bloch*) *C. & V.* E. W.
Trachynotus ovatus (*L.*) *Gthr.* Alewife. P. E. W. U.

Trachynotus goreensis *C. & V.* E. W.
Naucrates ductor *L.* Pilot Fish. E. P. W. U.
Zonichthys fasciatus (*Bloch*) *Sw.* Bonito. U.
Seriola Dumerilii *Risso.* Bonito. E. P.
Coryphæna pelagica (*L.*) Risso. Dolphin. E.
Nomeus Gronovii (*Gmel.*) *Gthr.* P. E
Centrolophus (species undetermined). E.
Brama Rayi *Schn.* E.
Malacanthus Plumieri (*Bloch*) *C. & V.* Whiting. W.
Mulloides flavovittatus (*Poey*) *Gthr.* Goat Fish. W.
Hypeneus maculatus (*Bloch*) *Cuv.* Goat Fish W. U.
Holocentrum sogo *Bloch.* Squirrel. W. U.
Pareques acuminatus (*Schn.*) *Gill.* Cluck; Black Grunt. W.
Calamus megacephalus (*Sw.*) *Poey.* Goat's Head Porgy. W.
Calamus orbitarius *Poey.* Sheep's Head Porgy. W.
Sargus variegatus (*Lac.*) *Goode.* Bream. E.
Sargus argenteus *C. & V.* W.
Lagodon rhomboides, (*L.*) *Holbrook.* Spanish Porgy. U.
Pimelepterus Boscii *Lac.* Chub. E. U.
Pristipoma (species undetermined). Sailor's Choice.
Hæmylum capeuna (*Licht.*) *Goode.* White Grunt. W. U.
Hæmylum xanthopterum *C. & V.* Yellow Grunt. W.
Hæmylum macrostoma *Gthr.* Streaked Grunt. W.
Lutjanus caxis (*Schn.*) *Poey.* Gray Snapper. W.
Lutjanus buccanella (*C. & V.*). Black-Fin Red Snapper. W.
Lutjanus aya (*Bloch*) *Gill.* Red Snapper. W.
Lutjanus (species undetermined). Silk Snapper.
Lutjanus (species undetermined). Schoolmaster.
Ocyurus chrysurus (*Bloch*) *Gill.* Yellow Tail: Yelting. W.
Trisotropis undulosus (*Cuv.*) *Gill.* W.
 var. quadratus *Goode*, MS. Black Rock Fish.
 var. venatus *Goode*, MS. Geg.
 var. rubromaculatus *Goode*, MS.
Trisotropis guttatus (*Schn.*) *Gill.* Red Rock Fish. W.
Trisotropis (species undetermined). Salmon Rock Fish. W.
Epinephelus striatus (*Bloch*) *Gill.* Hamlet; Grouper. W.
Epinephelus guttatus (*Gmel.*) *Goode.* Hind. W.
Enneacentrus punctatus (*L.*) *Poey.* E. W.
 var. guativere *Goode*, MS. Coney; Butter Fish.
 var. ouatalibi *Goode*, MS. Nigger Fish.
Petrometopon guttatus (*L.*) *Gill.* W.
Serranus (species undetermined). Graysby.
Serranus (species undetermined). Mutton Hamlet.
Haliperca phœbe *Poey.* Phebe. W.
Hypoplectrus puella (*Cuv.*) *Gill.* Cataphebe. W.
Rhypticus saponaceus (*Schn.*) *Cuv.* Soap Fish. E. W. U.
Undetermined percoid fish.
Elacate canadus (*L.*) *Gill.* Cubby-yew. P. E. W. U.
Apogon imberbis (*L.*) *Gthr.*
Priacanthus macrophthalmus *C. & V.* E. W. U.
Echeneis remora *L.* Suck Fish. P. E. W. U.
Leptecheneis naucrates (*L.*) *Gill.* Suck Fish. P. E. W U.
Sphyræna spet (*Hauy*) *Goode.* Barracuda. E.
Sphyræna picuda *Schn.* Sennet. E. W.
Regalecus gladius (*Walb.*) *C. & V.* Sea Serpent. E. P.
Mugil liza *Val.* Mullet. W.
Atherina harringtonensis *Goode*, (new species) 3. Russ Fry. B.
Belone Jonesii *Goode*, (new species) 2. Hound Fish. B.
Belone hians *C. & V.* Long Gar Fish. W.
Hemirhamphus Pleii *Val.* Gar Fish. W.
Exocœtus exiliens *Gmel.* Butterfly Fish. W. U.
Exocœtus bahiensis *Ranz.* Flying Fish. P. W.

Exocœtus Roberti *M. & T.* Flying Fish. W.
Exocœtus Rondeletii *C. & V.* Flying Fish. E. W.
Cypselurus furcatus (*Mitch.*) *Weinl.* Flying Fish. P. W. U.
Fundulus Bermudæ *Gthr.* Pond Mullet. B.
Fundulus rhizophoræ *Goode*, (new species) 4. B.
Synodus lacerta *C. & V.* Snake Fish. E.
Synodus fœtens (*L.*) *Gill.* Snake Fish. U.
Trachinocephalus myops (*Schn.*) *Gill.* Snake Fish. P. U.
Albula conorhynchus *Schn.* Bone Fish. P. E. W. U.
Megalops thrissoides (*Schn.*) *Gthr.* Tarpum. W. U.
Sardinella anchovia *Val.* Anchovy. W.
Harengula macrophthalma (*Ranz.*) *Goode.* Pilchard. W.
Opisthonema thrissa (*L.*) *Gill.* Herring. W. U.
Engraulis chœrostomus *Goode.* Hog Mouth Fry. B.
Carassius auratus (*L.*) *Blkr.* Gold Fish.

Order, *Apodes.*

Anguilla rostrata (*Les.*) DeKay. Pond Eel. P. U.
Gymnothorax moringa (*Cuv.*) *Goode.* Speckled Maray. E. W.
Gymnothorax punctatus (*Cast.*) *Goode.* Small Yellow Spotted Maray. P.
Thyrsoidea maculipinnis *Kaup.* Green Maray. W.
Muræna Sanctæ-Helenæ, *Gthr.* E.
Echidna catenata (*Bloch*) *Blkr.* W.
Ophisurus longus *Poey.* Sand Eel. W.
Ophichthys triserialis (*Kaup.*) *Gthr.* Spotted Sand Eel. P. W.
Leptocephalus (species undetermined).

Sub-class, Ganoidea.

Order, *Glaniostomi.*

Acipenser, sp. Sturgeon.

Sub-class, Elasmobranchii.

Order, *Raiæ.*

Ætobatis narinari (*Euphr.*) *M. & H.* Whip Ray. P. W. U.

Order, *Squali.*

Isuropsis, sp. Mackerel Shark.
Sphyrna zygæna (*L.*) *M. & H.* Hammer-Head Shark. P. E. W. U.
Eulamia obscura (*Les.*) *Gill.* Shark. U.
Mustelus canis (*Mitch.*) *DeKay.* Nurse Shark. U.
Ginglymostoma cirratum (*Gmel.*) *M. & H.* W. U.
Curious form in collection of J. M. Jones, genus and species undetermined.

Class, LEPTOCARDII.

Order, *Cirrostomi.*

Branchiostoma lubricum *Costa.* P. E. W. U.

DESCRIPTIONS OF NEW SPECIES.

1. *Julis nitidissima*, sp. nov.

This species agrees in many particulars with that described by Dr. Gunther under the name *Julis nitida*, from Jamaican specimens in the British Museum.*. There are, however, various diagnostic characters which it seems desirable to express in the form of a description, at the same time designating the Bermuda fish by a distinct specific name which, by its similarity to that of the species which it so much resembles,

* Catalogue of Fishes in the British Museum, vol. iv, p. 190, 1862.

will indicate my suspicion that, upon comparison of the specimens, the two species may prove to be identical.

The fish is quite small, rarely exceeding three inches in length, and is very abundant among the outer reefs, swimming among the Gorgonias and Plexauras, six or eight fathoms below the surface, a very conspicuous object by reason of its brilliant yellow colors. It is extremely shy and it was only after repeated trials that I succeeded in capturing a single specimen, which took a small hook baited for chubs.

The diagnostic characters which separate *Julis nitida* from *Julis nitidissima* appear to consist in (1) the relative proportions of head and body, (2) the relative proportions of pectorals and ventral fins, (3) the number of rows of scales below lateral line, and (4) in the coloration. The latter character is, however, of minor importance, it being quite possible that a faded museum specimen of the fish before me might have assumed the colors described by Dr. Günther.

The specimen described is small, though apparently adult, its total length being about three and one-half inches (m. 0·103). The body is much compressed, its greatest width (m. 0·009) being about three-eighths of its greatest height (m. 0·023), which is contained in the total length about four and one half times. Length of head (m. 0·025) contained in total length four and one half times (in fresh specimen three and three-quarters, it having been contracted by preservation in spirits). No posterior canine teeth. Length of snout (m. 0·008) equal to length of operculum (m. 0·008) and to four-fifths of greatest width of head (m. 0·01). Width of interorbital area (m. 0·007) somewhat less. Orbit circular, its diameter (m. 0·005) equal to greatest height of dorsal.

Dorsal inserted slightly in advance of origin of ventral at a distance (m. 0·03) equal to three times the greatest width of the head, length of base (m. 0·027) slightly greater than length of head. Length of first dorsal spine (m. 0·004) half the length of snout; greatest height of spinous dorsal (m. 0·005) equal to diameter of orbit. Greatest height of soft dorsal (m. 0·008) double that of first dorsal spine.

Distance of anal from snout (m. 0·052) twice the length of head, which is about equal to length of anal base (m. 0·024). First anal spine (m. 0·003) half the length of second anal spine (m. 0·007) and one-third the length of longest ray (m. 0·01).

Caudal lobes slightly produced, their length (m. 0·016) two-thirds that of the head and twice that of the snout. Least height of tail (m. 0·012) equal to length of ventrals.

Pectoral inserted at a distance from the snout (m. 0·028) equal to the length of the base of the dorsal, its length (m. 0·021) slightly less than the greatest height of the body.

Ventrals inserted at a distance from the snout (m. 0·031) a trifle greater than the dorsal. Length (m. 0·012) three-sevenths of that of the pectorals, not two-thirds as in *Julis nitida*—the most important of the diagnostic characters.

Radial formula, D. viii, 13. A. ii, 11.

Number of scales in lateral line, 26; in transverse line, 2 : 9.

Coloration:—Top of head and back brilliant sulphur-yellow; this color, above the pectorals, extending to middle of row of scales beneath lateral line, also present upon cheeks, opercles, and lips, and to ventral fins. A semicircular spot of the same occupying the major part of the caudal fin, extending posteriorly quite to the margin. Throat, belly and sides of tail white with a rich, deep roseate tinge. A band of maroon, as wide as the eye, crossing the snout passes back through the eye nearly to the tip of the opercular flap. A series of six broad irregular blotches of bottle green, somewhat quadrate in outline, each covering about the width of four transvere rows of scales, extends from the opercle, above the pectorals and across the downward curve of the lateral line to the base of the caudal. The posterior blotch is prolonged upon the outer rays of the caudal to the tips forming a crescent shaped figure. Dorsal fin at margin transparent, white, at the base yellow, the intermediate space brownish green, deeper in shade anteriorly, and between the second and fifth ray, forming a blotch, similar to that indicated in the description of *Julis nitida.* Pectorals transparent. Anal rose color with yellow transparent margin. Ventrals yellow. Caudal, as hitherto described, yellow with exterior lobes brownish green.

2. *Belone Jonesii*, sp. nov.

The total length of the specimen selected as a type of the species is eighteen inches (m. 0·60).

The body is slightly compressed, its greatest height, above the ventrals (m. 0·03) one-twentieth of total length, its greatest width (m. 0·022) about one twenty-eighth of the same. Free portion of tail somewhat depressed, quadrate, its height (m. 0·01) one-third of greatest height of body. Caudal carinæ moderate.

Length of head (m. 0·196) contained about three and two-fifths times in total length, and about three and one-fourth of length without caudal. Upper surface of head somewhat depressed, striated, with a broad shallow median groove, which expands posteriorly into a wide, somewhat depressed triangular area. Superciliary region sharply striated.

Length of snout (m. 0·12) equal to length of maxillary (m. 0·12), contained five times in total length, and containing post-orbital length of head (m. 0·04) thrice. Length of mandible (m. 0·14) slightly less than distance from snout to nape (m.

0·157) and ten times the vertical diameter of the eyes (m. 0·014). Lower jaw projects four millimeters beyond the tip of upper jaw. Horizontal diameter of eye (m. 0·019) equal to width of interorbital area (m. 0·019) and to length of operculum (m. 0·019) and about one-eighth of length of head.

Teeth large, sharp, not very close. Maxillary teeth about sixty, the largest three millimeters in length; mandibular teeth about sixty, the largest two millimeters in length. Vomerine teeth none.

Distances from insertion of dorsal to snout (m. 0·433) slightly greater than that of anal (m. 0·431). Length of dorsal (m. 0·097) equal to distance from insertion of dorsal to insertion of ventral. Greatest height of dorsal (m. 0·026) equal to greatest width of head (m. 0·025).

Anterior rays longest, their length (m. 0·03) one-tenth of distance from ventral to snout. Length of last ray (m. 0·013) about one-third of that of anterior rays.

Length of anal (m. 0·085) less than that of dorsal. Posterior rays half the length (m. 0·007) of posterior dorsal ray. Anal fin terminating anteriorly to dorsal at a distance equal to length of first dorsal ray.

Ventrals inserted at distance from snout (m. 0·34) greater than half the length of body, and midway between anterior margin of orbit and base of median caudal rays. Length (m. 0·028) slightly exceeding greatest width of head.

Pectoral inserted at distance from snout (m. 0·191) equal to ten times width of interorbital space; its length (m. 0·045) slightly exceeding postorbital length of head.

Caudal forked, the length of inferior rays (m. 0·053) exceeding that of superior rays (m. 0·04) by about the length of median rays (m. 0 012).

Radial formula—D, 9 + 14 : A, 14 + 7 : C, 5 + 10—9 + 6 : P, 13 : V, 5.

Branchiostegals, 12.

Number of scales in lateral line (estimated), 380.

Coloration:—Above deep green, below silvery white, opercles and cheeks silvery white. Anterior rays of dorsal and pectoral fins, with caudal carinæ blackish.

I take great pleasure in giving to this species the name of my friend Mr. J. Matthew Jones, F.L.S., President of the Nova Scotian Institute of Natural Sciences, who has for two winters been associated with me in the study of the Bermudian fauna.

The "Hound Fish," as it is called in Bermuda, is a graceful, active species, attains the length of three feet or more. It frequents swift tide courses where it preys upon small fishes, particularly the schools of *Atherina* and *Engraulis*. It takes the hook well.

3. *Atherina Harringtonensis*, sp. nov.

The length of the specimen selected as type of the species is one and one-half inches (m. 0·055), the measurement being that of a specimen which has been in strong alcohol for four months. From the discrepancy between this measurement and a partial set of measurements taken from a fresh specimen of the same species I infer that the shrinkage in the length of the body has been quite considerable, probably from six to eight millimeters. The proportions given below are taken from the alcoholic specimen. In the study of fresh specimens allowance should be made for discrepancies caused by this shrinkage. The proportions of the head do not appear to have been changed by the alcohol.

The height of body (m. 0·07) is contained in length about eight times ($8\frac{1}{2}$ in fresh specimen), its width about twice in its height.

Length of head (m. 0·011) about equal to length of caudal peduncle (m. 0·01) and contained five times in total length ($5\frac{3}{4}$ in fresh specimen).

Diameter of eye (m. 0·004) about one-third the length of head, the length of snout somewhat less than that of post-orbital portion of head, also equal to length of maxillary, and slightly greater than width of inter-orbital area (m. 0·0037). Greatest width of head (m. 0·006) about double the length of snout. Length of mandible (m. 0·005) about equal to that of post-orbital portion of head. Cleft of mouth quite oblique, maxillary extending to the vertical from anterior margin of orbit. Lower jaw slightly the longer; mouth very protractile; teeth small, inconspicuous.

Spinous dorsal inserted behind extremity of ventral, at a distance from snout (m. 0·03) greater here than half the length of body. Anal directly beneath dorsal, their lengths of base (m. 0·007) being equal. Greatest height of anal (m. 0·005) greater than that of dorsal (m. 0·003).

Length of ventral (m. 0·006) two-thirds that of pectoral (m. 0·009) which exceeds three-fourths that of head.

Radial formula:—D. VII, I, 10: A. I, 11.

Number of scales in lateral line about forty-five; in transverse line about six.

Coloration:—Greenish white, a narrow silvery band extending from gill-opening to tail, covering the third row (from above) of scales and the edges of the contiguous rows above and below.

The "Russ Fry" occurs in immense quantities in all the lagoons and protected bays of the Bermudas. The schools swim near the surface of the water and are preyed upon by all the carnivorous species. They are particularly abundant in the beautiful little lagoon called Harrington Sound.

4. *Fundulus rhizophoræ*, sp. nov.

The length of the specimen selected as type is six centimeters. Height of body at insertion of pectorals (m. 0·015) one-fourth of total length, at ventral (m. 0·009) about one seventh, at base of caudal (m. 0·0075) one-eighth.

Head much depressed, its length (m. 0·017) contained three and one-eighth in total. Snout broad, obtuse, depressed, its length (m. 0·006) slightly longer than orbital diameter and contained in length of head about three times. Inter-orbital area broad and flat, its width (m. 0·007) less than length of post-orbital portion of head (m. 0·009) and greater than length of operculum (m. 0·006). Diameter of orbit (m. 0·0045) half the length of post-orbital tract.

Origin of dorsal fin equidistant from tip of caudal and anterior margin of snout, and over the eighteenth scale of lateral line. Distance from snout (m. 0·018) three-tenths of total length; extreme height (m. 0·006) one-tenth, and length of base (m. 0·008) two-fifteenths.

First anal ray below third dorsal ray; length of base (m. 0·005) one-twelfth of total length. Extreme height (m. 0·011) double length of base, and nearly double the extreme height of dorsal.

Ventral inserted slightly in advance of middle of body (distance from snout. m. 0·029), its length (m. 0·007) equal to width of inter-orbital area.

Pectoral inserted at distance from snout (m. 0·02) equal to one-third of total length; length (m. 0·009) equal to post-orbital length of head.

Length of caudal (m. 0·01) equal to height of anal and about one-sixth of total.

Radial formula :—D. 12 : A. 11.

Number of scales in lateral line thirty-five; rows in transverse line twelve or thirteen.

Coloration :—Ground color light tawny yellow with about fifteen regular transverse bands of greenish brown, each about two scales in width, obscure anteriorly but distinct upon posterior half of body.

This little minnow occurs abundantly in Basden Pond, a brackish marshy body of water at the eastern end of the main island, among the arching roots of the mangrove (*Rhizophora mangle*). It is known as the "Pond Mullet," but may more appropriately be called the Mangrove Minnow. The specimens described are young males, not in breeding colors.

ART. XLI.—*History of Cavern Exploration in Devonshire, England;* by W. PENGELLY, F.R.S., F.G.S., President of the Geological Section of the British Association at Plymouth.

* * * * AMONG the local geological papers read [before the British Association] in 1841 [at the time of its only previous visit to Plymouth,] none appear to have attracted so much attention as those on Lithodomous Perforations, Raised Beaches, Submerged Forests, and Caverns (see Athenæum for 7th to 28th of August, 1841); and, as an effort to connect the present with the past, I have decided on taking up one of these threads, and devoting the remarks I have now to offer to the History of Cavern-Exploration in Devonsire. I am not unmindful that there were giants in those days; and no one can deplore more than I do our loss of Buckland and De la Beche, among many others; nor can I forget the enormous strides opinion has made since 1841, when, in this Section, Dr. Buckland "contended that human remains had never been found under such circumstances as to prove their contemporaneous existence with the hyænas and bears of the caverns," and added that "in Kent's Hole the Celtic knives * * * * were found in holes *dug by art*, and which had disturbed the floor of the cave and the bones below it" (Athenæum, 14th Aug., 1841, p. 626). This scepticism, however, did the good service of inducing cavern explorers to conduct their researches with an accuracy which should place their results, whatever they might prove to be, amongst the undoubted additions to human knowledge.

The principal caverns in South Devon occur in the limestone districts of Plymouth, Yealmpton, Brixham, Torquay, Buckfastleigh, and Chudleigh; but as those in the last two localities have yielded nothing of importance to the anthropologist or the paleontologist, they will not be further noticed on this occasion. In dealing with the others it seems most simple to follow mainly the order of chronology; that is to say, to commence with the cavern which first caught scientific attention, and, having finished all that the time at my disposal will allow me to say about it, but not before, to proceed to the next, in the order thus defined; and so on through the series.

Oreston Caverns.—When Mr. Whidbey engaged to superintend the construction of the Plymouth Breakwater, Sir Joseph Banks, President of the Royal Society, requested him to examine narrowly any caverns he might meet with in the limestone-rock to be qarried a Oreston, near the mouth of the river Plym, not more than two miles from the room in which we are assembled, and have the bones or any other fossil remains that were met with carefully preserved (see Phil. Trans., 1817, pp.

176–182). This request was cheerfully complied with, and Mr. Whidbey had the pleasure of discovering bone-caves in November, 1816, November, 1820, August and November, 1822, and of sending the remains found in them to the Royal Society.

It is, perhaps, worthy of remark that, though cavern-researches received a great impulse from the discoveries in Kirkdale, Yorkshire, and especially from Dr. Buckland's well-known and graphic descriptions of them, such researches had originated many years before. The request by Sir Joseph Banks was made at least as early as 1812 (see Trans. Devon. Assoc., v, pp. 252, 253), and a paper on the Oreston discoveries was read to the Royal Society in February, 1817, whereas the Kirkdale Cavern was not discovered until 1821. British cave-hunting appears to have been a science of Devonshire birth.

The Oreston Caverns soon attracted a considerable number of able observers; they were visited in 1822 by Dr. Buckland and Mr. Warburton; and in a comparatively short time became the theme of a somewhat voluminous literature. Nothing of importance, however, seems to have been met with from 1822 until 1858, when another cavern, containing a large number of bones, was broken into. Unfortunately, there was no one at hand to superintend the exhumation of the specimens; the work was left entirely to the common workmen, and was badly done; many of the remains were dispersed beyond recovery; the matrix in which they were buried was never adequately examined; and we are utterly ignorant, and must for ever remain so, as to whether they did or did not contain indications of human existence. I visited the spot from time to time, and bought up everything to be met with; but other scientific work in another part of the county occupied me too closely to allow more than an occasional visit. The greater part of the specimens I secured were lodged in the British Museum, where they seem to have been forgotten, while a few remain in my private collection.

Some difference of opinion has existed respecting the character of the successive caverns, and much mystery has been imported into the question of the introduction of their contents. Mr. Whidbey, it is said, "saw no possibility of the cavern of 1816 having had any external communication through the rock in which it was inclosed" (Phil. Trans., 1817, pp. 176–182); but Dr. Buckland was of opinion that they were all at first fissures open at the top, and "that the openings had been long filled up with rubbish, mud, stalactite, or fragments of rock cemented, as sometimes happens, into a breccia as solid as the original rock, and overgrown with grass" (Phil. Trans., 1822, pp. 171–240).

The conclusion I arrived at, after studying so much of the roof of the cavern of 1858 as remained intact, was that Dr. Buckland's opinion was fully borne out by the facts; that, in short, the Oreston Caverns were *Fissure Caverns*, not *Tunnel Caverns.*

The cavern of 1858 was an almost vertical fissure, extending a length of about ninty feet from N.N.E. to S.S.W. It commenced at about eight feet below the surface of the plateau, continued thence to the base of the cliff, but how much farther was not known, and its ascertained height was about fifty-two feet. It was two feet wide at top, whence it gradually widened to ten feet at bottom. The roof, judging from that part which had not been destroyed, was a mass of limestone-breccia, made up of large angular fragments cemented with carbonate of lime, and requiring to be blasted as much as ordinary limestone. The cavern was completely filled with deposits of various kinds.

The uppermost eight feet consisted of loose angular pieces of limestone, none of which exceeded ten pounds in weight, mixed with a comparatively small amount of such sand as is common in dolomitic limestone districts, but without a trace of stalagmite or fossil of any kind. The thirty-two feet next below were occupied with similar materials, with the addition of a considerable quantity of tough, dark, unctuous clay. Between this mass and the outer wall of the cavern was a nearly vertical plate of stalagmite, usually about two feet thick, and containing, at by no means wide intervals, firmly cemented masses of breccia identical in composition with the adjacent bed just mentioned. The bones the cavern yielded were all found within these thirty-two feet; and were met with equally in the loose and the coherent breccia, as well as in the stalagmite. A somewhat considerable number of ellipsoidal balls of clay, from 1·5 to 2·5 inches in greatest diameter, occurred in the clay of this bone-bed, but not elsewhere. Still lower was a mass of dark, tough, unctuous clay, containing a very few, small, angular stones, but otherwise perfectly homogeneous, and known to be twelve feet deep, but how much more was undetermined.

The osseous remains found at Oreston prior to 1858 have been described by Sir E. Home, Mr. Clift, Dr. Buckland, Professor Owen, Mr. Busk, and others. The animals represented were *Ursus priscus*, *U. spelæus*, weasel (?), wolf, fox, cave hyæna, cave lion, *Rhinoceros leptorhinus*, *Equus fossilis*, *E. plicidens*, *Asinus fossilis*, *Bison minor*, *Bos longifrons*, and, according to the late Mr. Bellamy, mammoth and hippopotamus (see Nat. Hist. of S. Devon, 1839, p. 82). With regard to hippopotamus, I can only say that I have never met with satisfactory evidence of its occurrence in Devonshire; but the mammoth was certainly found at Oreston in 1858; and, unless I am greatly in error, remains of *Rhinoceros tichorhinus* were also met with there, and lodged by me in the British Museum. It may be added that the skull and other relics of a hog were exhumed on that occasion, and now belong to my collection. There was nothing to suggest that the cavern had been the home of the hyæna; and whilst I fully accept Dr. Buckland's opinion that animals had fallen into the open fissures and there perished, and that the remains had subsequently been washed thence into the lower vaultings ("Reliq. Dil.," 2d ed., 1834, p. 78), I venture to add that some of the animals may have retired thither to die; a few may have been dragged or pursued there by beasts of prey; whilst rains, such as are not quite unknown in Devonshire in the present day, probably washed in some of the bones of such as died near at hand on the adjacent plateau. Nothing appears to have been met with suggestive of human visits.

Kent's Hole.—About a mile due east from Torquay harbor and half a mile north from Torbay there is a small wooded limestone hill, the eastern side of which is, for the uppermost thirty feet, a vertical cliff, having at its base, and fifty-four feet apart, two apertures leading into one and the same vast cavity in the interior of the hill, known as Kent's Hole or Cavern. These openings are about 200 feet above mean sea-level, and from them the hill slopes rapidly to the valley at its foot, at a level of from sixty to seventy feet below.

There seems to be neither record nor tradition of the discovery of the cavern. Richardson, in the 8th edition of "A Tour through the Island of Great Britain," published in 1778, speaks of it as "perhaps the greatest natural curiosity" in the county. Its name occurs on a map dated 1769; it is mentioned in a lease 1659; visitors cut their names and dates on the stalagmite from 1571 down to the present century; judging from numerous objects found on the floor, it was visited by man through mediæval back to pre-Roman times; and, unless the facts exhumed by explorers have been misinterpreted, it was a human home during the era of the mammoth and his contemporaries.

In 1824 Mr. Northmore, of Cleve, near Exeter, was led to make a few diggings in the cavern, and was the first to find fossil bones there. He was soon followed by Mr. (now Sir) W. C. Trevelyan, who not only found bones, but had a plate of them engraved. In 1825, the Rev. J. MacEnery, an Irish Roman Catholic priest residing in the family of Mr. Cary, of Tor Abby, Torquay, first visited the cavern, when he, too, found teeth and bones, of which he published a plate. Soon after, be made another visit, accompanied by Dr. Buckland, when he had the good fortune to discover a flint implement; the first instance, he tells us, of such a relic being noticed in any cavern (see Trans. Devon. Assoc., iii, p. 441). Before the close of 1825, he commenced a series of more or less systematic diggings, and continued them until, and perhaps after, the summer of 1829 (ibid., p. 295). Preparations appear to have been made to publish the results of his labors; a prospectus was issued, numerous plates were lithographed, it was generally believed that the MS. was almost ready, and the only thing needed was a list of subscribers sufficient to justify publication, when, alas! on February 18, 1841, before the printer had received any "copy," before even the world of science had accepted his anthropological discoveries, before the value of his labors was known to more than a very few, Mr. MacEnery died at Torquay.

After his decease his MS. could not be discovered, and its loss was duly deplored. Nevertheless, it was found after several years, and, having undergone varieties of fortune, became the property of Mr. Vivian, of Torquay, who, having published portions of it in 1859, presented it in 1867 to the Torquay Natural History Society, whose property it still remains. In 1869 I had the pleasure of printing the whole, in the Transactions of the Devonshire Association.

Whilst Mr. MacEnery was conducting his researches, a few independent diggings, on a less extensive scale, were taken by other gentlemen. The principal of these was Mr. Godwin-Austen, the well-known geologist, whose papers fully bore out all that MacEnery had stated. (See Trans. Geol. Soc. Lond., 2d series, vi, 446). In 1846, a sub-committee of the Torquay Natural History Society undertook the careful exploration of very small parts of the cavern, and their report was entirely confirmatory of the statements of their predecessor—that undoubted flint implements did occur, mixed with the remains of extinct mammals, in the cave-earth, beneath a thick floor of stalagmite. The sceptical position of the authorities in geological science remained unaffected, however, until 1858, when the discovery and systematic exploration of a comparatively small virgin cavern on Windmill Hill, at Brixham, led to a sudden and complete revolution; for it was seen that whatever were the facts elsewhere, there had undoubtedly been found at Brixham flint implements commingled with remains of the mammoth and his companions, and in such a way as to render it impossible to doubt that man occupied Devonshire before the extinction of the cave mammals.

Under the feeling that the statements made by MacEnery and his followers respecting Kent's Hole were perhaps, after all, to be accepted as verities, the British Association, in 1864, appointed a committee to make a complete, systematic, and accurate exploration of the cavern, in which it was known that very extensive portions remained entirely intact. This committee commenced its labors on March 28, 1865; it has been re-appointed, year after year, with sufficient grants of money, up to the present time; the work has gone on continuously throughout the entire thirteen years; and the result has been, not only a complete confirmation of Mr. MacEnery's statements, but the discovery of far older deposits than he suspected—deposits implying great changes of, at least, local geographical conditions; changes in the fauna of the district; and yielding evidence of men more ancient and far ruder than even those who made the oldest flint tools found in Kent's Hole prior to the appointment of the committee.

The cavern consists of a series of chambers and passages, which resolve themselves into two main *divisions*, extending from nearly north to south in parallel lines, but passing into each other near their extremities, and throwing off branches, occasionally of considerable size.

The successive deposits, in descending order, were:—

1st, or uppermost. Fragments and blocks of limestone from an ounce to upwards of 100 tons weight each, which had fallen from the roof from time to time, and were, in some instances, cemented with carbonate of lime.

2d. Beneath and between these blocks lay a dark-colored mud or mould, consisting largely of decayed leaves and other vegetable matter. It was from three to twelve inches thick, and known as the *black mould.* This occupied the entire eastern division, with the exception of a small chamber in its south-western end only, but was not found in the other, the remoter, parts of the cavern.

3d. Under this was a stalagmitic floor, commonly of granular texture, and frequently laminated, from less than an inch to fully five feet in thickness, and termed the *granular stalagmite.*

4th. An almost black layer, about four inches thick, composed mainly of small fragments of charred wood, and distinguished as the *black band*, occupied an area of about 100 square feet, immediately under the granular stalagmite, and, at the nearest point, not more than twenty-two feet from one of the entrances to the cavern. Nothing of the kind has occurred elsewhere.

5th. Immediately under the granular stalagmite and the black band lay a light red clay, containing usually about fifty per cent of small angular fragments of limestone, and somewhat numerous blocks of the same rock as large as those lying on the black mould. In this deposit, known as the *cave-earth*, many of the stones and bones were, at all depths, invested with thin stalagmitic films. The cave-earth was of unknown depth near the entrances, where its base had never been reached; but in the remoter parts of the cavern it did not usually exceed a foot, and in a few localities it "thinned out" entirely.

6th. Beneath the cave-earth there was usually found a floor of stalagmite having a crystalline texture, and termed on that account the *crystalline stalagmite.* It was commonly thicker than the granular floor, and in one instance but little short of twelve feet.

7th. Below the whole occurred, so far as is at present known, the oldest of the cavern deposits. It was composed of subangular and rounded pieces of dark-red grit, embedded in a sandy paste of the same color. Small angular fragments of limestone, and investing films of stalagmite, both prevalent in the cave-earth, were extremely rare. Large blocks of limestone were occasionally met with; and the deposit, to which the name of *breccia* was given, was of a depth exceeding that to which the exploration has yet been carried.

Except in a very few small branches, the bottom of the cavern has nowhere been reached. In the cases in which there was no cave-earth, the granular stalagmite rested immediately on the crystalline; and where the crystalline stalagmite was not present the cave-earth and breccia were in direct contact. Large isolated masses of the crystalline stalagmite, as well as concreted lumps of the breccia, were occasionally met with in the cave-earth, thus showing that the older deposits had, in portions of the cavern, been partially broken up, dislodged, and re-deposited. No instance was met with of the incorporation in a lower bed of fragments derived from an upper one. In short, wherever all the deposits were found in one and the same vertical section, the order of superposition was clear and invariable; and elsewhere the succession, though defective, was never transgressed.

Excepting the overlying blocks of limestone, of course, all the deposits contained remains of animals, which, however, were not abundant in the stalagmites.

The black mould, the uppermost bed, yielded teeth and bones of man, dog, fox, badger, brown bear, *Bos longifrons*, roedeer, sheep, goat, pig, hare, rabbit and seal—species still existing, and almost all of them in Devonshire. This has been called the *Ovine* bed, the remains of sheep being restricted to it. In it were also found numerous flint flakes and "strike-lights," stone spindle-whorls, fragments of curvilineal pieces of slate, amber beads, bone tools, including awls, chisels and combs; bronze articles, such as rings, a fibula, a spoon, a spear-head, a socketed celt, and a pin; pieces of smelted copper, and a great number and variety of potsherds, including fragments of Samian ware.

The granular stalagmite, black band, and cave-earth, taken together as belonging to one and the same biological period, may be termed the *Hyænine* beds, the cave hyæna being their most prevalent species, and found in them alone. So far as they have been identified, the remains belong to the cave hyæna, *Equus caballus*, *Rhinoceros tichorhinus*, gigantic Irish deer, *Bos primigenius*, *Bison priscus*, red deer, mammoth, badger, cave bear, grizzly bear, brown bear, cave lion, wolf, fox, reindeer, beaver, glutton, *Machairodus latidens*, and man—the last being a part of a jaw with teeth, in the granular stalagmite. In the same beds were found unpolished *ovate* and *lanceolate* implements made from *flakes*, not *nodules*, of flint and chert; flint flakes, chips, and "cores;" "whetstones," a "hammer-stone," "dead" shells of *Pecten*, bits of charcoal, and bone tools, including a needle or bodkin having a well-formed eye, a pin, an awl, three harpoons, and a perforated tooth of badger. The artificial objects, of both bone and stone, were found at all depths in each of the hyænine beds, but were much more numerous below the stalagmite than in it.

The relics found in the crystalline stalagmite and the breccia, in some places extremely abundant, were almost exclusively those of bear, the only exceptions being a very few remains of cave line and fox. Hence these have been termed the *Ursine* beds. It will be remembered that teeth and bones of bear were also met with in both the hyænine and the ovine beds; and it should be understood that this biological classification is intended to apply to Kent's Cavern only. The ursine deposits, or rather the breccia, the lowest of them, also yielded evidences of human existence; but they were exclusively tools made from *nodules*, not *flakes*, of flint and chert.

Ansty's-Cove Cavern.—About three furlongs from Kent's Hole toward N.N.E., near the top of the lofty cliff forming the northern boundary of the beautiful Ansty's Cove, Torquay, there is a cavern where, simultaneously with those in Kent's Cavern, Mr. MacEnery conducted some researches, of which he has left a brief account (see Trans. Devon. Assoc., vi, pp. 61–69). I have visited it several times, but it seems to be frequently kept under lock and key, as a tool and powder-house, by the workmen in a neighboring quarry. It is a simple gallery, and, according to Mr. MacEnery, sixty-three feet long, from three to nine feet high, and from three to six feet broad. Beneath some angular stones he found a stalagmitic floor fourteen inches thick, and in the deposit below remains of deer, horse, bear, fox, hyæna (?), coprolites, a few marine and land shells, one white flint tool with fragments of others, a Roman coin, and potsherds.

In a letter to Sir W. C. Trevelyan, dated December 16th, 1825, Dr. Buckland states that Mr. MacEnery had found in this cave "bones of all sorts of beasts, and also flint knives and Roman coins; in short, an open-mouthed cave, which has been inhabited by animals of all kinds, quadruped and biped, in all successive generations, and who have all deposited their exuviæ one upon another" (ibid., p. 69).

Yealm-Bridge Cavern.—About the year 1832 the workmen broke into a bone cavern in Yealm-Bridge Quarry, about one mile from the village of Yealmpton, and eight miles E.S.E. from Plymouth; and through their operations it was so nearly destroyed that but a small arm of it remained in 1835, when it was visited by Mr. J. C. Bellamy, who at once wrote an account of it, from which it appears that, so far as he could learn, the cavern was about thirty feet below the original limestone surface, and was filled to from one foot to six feet of the roof (see "Nat. Hist. S. Devon.," 1839, pp. 86–105). In the same year, but subsequently, it was examined by Capt. (afterwards Col.) Mudge, who states that there were originally three openings into the cave, each about twelve feet above the river Yealm; that the deposits were, in descending order:—

1. Loam with bones and stones	3·5	feet.
2. Stiff whitish clay	2·5	"
3. Sand	6·0	"
4. Red clay	3·5	"
5. Argillaceous sand	6 to 18·0	"

and that, where they did not reach the roof, the deposits were covered with stalagmite.

On the authority of Mr. Clift and Prof. Owen, Capt. Mudge mentions relics of elephant, rhinoceros, horse, ox, sheep, hyæna, dog, wolf, fox, bear, hare and water-vole. The bones, and especially the teeth, of the hyæna exceeded in number those of all the other animals, though remains of horse and ox were very abundant. Mr. Bellamy, whilst also mentioning all the foregoing forms, with the exception of dog only, adds deer, pig, glutton, weasel and mouse. He also speaks of the abundance of bones and teeth of hyæna, but seems to regard the fox as being almost as fully represented; and next in order he places horse, deer, sheep, and rabbit or hare; whilst the relics of elephant, wolf, bear, pig and glutton are spoken of as very rare. The bones, he says, were found in the uppermost bed only. They were frequently mere fragments and splinters, some being undoubtedly gnawed, and all had become very adherent through loss of their animal matter. Those of cylindrical form were without their extremities; there was no approach to anatomical juxtaposition; and the remains belonged to individuals of all ages. Reliquiæ of carnivorous animals greatly exceeded those of the herbivora. and teeth were very abundant. Coprolites occurred at some depth below the stalagmite, in the upper bed, which also contained granitic and trappean pebbles, and lumps of breccia made up of fragments of rock, bones, pebbles, and stalagmite. The bones found prior to 1835 had been removed as rubbish, and some good specimens were recovered from materials employed in making a pathway. Nothing indicating the presence of man appears to have been found.

The Ash-Hole.—On the southern shore of Torbay, midway between the town of Brixham and Berry Head, and about half a mile from each, there is a cavern known as the *Ash-Hole.* It was partially explored, probably about, or soon after, the time Mr. MacEnery was engaged in Kent's Hole, by the late Rev. H. F. Lyte, who, unfortunately, does not appear to have left any account of the results. The earliest mention of this cavern I have been able to find is a very brief one in Bellamy's "Natural History of South Devon," published in 1839 (p. 14). During the Plymouth Meeting in 1841, Mr. George Bartlett, a native of Brixham, who assisted Mr. Lyte, described to this Section the objects of interest the Ash-Hole had yielded (see Report Brit. Assoc. 1851, Trans. Sections, p. 61). So far as was then known the cave was thirty yards long and six yards broad. Below a recent accumulation, four feet deep, of loam and earth, with land and marine shells, bones of the domestic fowl and of man, pottery, and various implements, lay a true cave-earth, abounding in the remains of elephant. Prof. Owen, who identified, from this lower bed, relics of badger, polecat, stoat, water-vole, rabbit and reindeer, remarks, that for the first good evidence of the reindeer in this island he had been indebted to Mr. Bartlett, who stated that the remains were found in this cavern (see "Brit. Foss. Mam." 1846, pp. 109–110, 113–114, 116, 204, 212, 479–480). I have made numerous visits to the spot, which, when Mr. Lyte began his diggings, must have been a shaft-like fissure, accessible from the top only. A lateral opening, however, has been quarried into it; there is a narrow tunnel extending westward, in which the deposit is covered with a thick sheet of stalagmite, and where one is tempted to believe that a few weeks' labor might be well invested.

(To be continued.)

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a modification of Dumas's Vapor-density method.*—Habermann has suggested a modification in the method proposed by Dumas for estimating vapor-densities, which consists in applying to this method the improvement in Gay Lussac's method suggested by Hofmann, of making the experiment under reduced pressure. For this purpose the neck of the balloon, which is made thick at the end, is connected, first with a double-bulb tube which serves as a receiver, and then through this with a Bunsen pump furnished with a manometer to indicate the residual tension. After the substance—about one gram—is introduced into the balloon, and this is lowered into the bath and connected to the pump, an exhaustion of 500 or 600 millimeters is effected, the cock to the pump is closed and the heating is proceeded with, a temperature higher than that at which the substance boils, never being required. After this point has been for a short time reached, the exhaustion is returned to its former point, the neck of the balloon is sealed by the blowpipe, and the thermometer, barometer and manometer read. The calculation is made as usual, only using instead of the barometric height at the time of sealing, the difference between this and that of the manometer, in the calculation for the reduction of volume.—*Liebig's Ann.*, clxxxvii, 341, June, 1877. G. F. B.

2. *On the action of Phosphoric chloride on Tungstic oxide.*—Teclu has proved that the sole products of the action of tungstic oxide upon phosphoric chloride are phosphoryl chloride and tungstic chloride (tungsten hexachloride). Equivalent weights—three molecules PCl_5 and one of WO_3—of the pure substances were sealed in glass tubes, well shaken, and heated in a paraffin bath to 200° C., for six or eight hours. On cooling, brilliant metallic steel-blue crystals appeared in the tubes, which swelled up in the air by attracting moisture and were rapidly decomposed. They were slightly soluble in absolute alcohol, more so in ether, and easily soluble in carbon disulphide. The contents of a tube was submitted to distillation, and the distillate proved to be phosphoryl chloride. The residue was heated to 120° and a current of dry carbon dioxide gas was passed over it. The last traces of $PO\,Cl_3$ were thus removed and the crystals obtained pure. For quantitative analysis, a weighed quantity was heated to 100° in a sealed tube with water and nitric acid, and the chlorine determined as usual. The result showed the crystals to be tungsten hexachloride. By slow cooling of the phosphoryl chloride solution, in the tubes where they are formed, the crystals may be obtained of considerable size. The crystals are isometric, and fuse at 189°. The reaction is given by the equation:—$WO_3+(PCl_5)_3=WCl_6+(POCl_3)_3$.—*Liebig's Ann.*, clxxxvii, 255, June, 1877. G. F. B.

3. *On the production of Tartronic from Pyruvic acid.*—GRIMAUX, in attempting to replace the two atoms of bromine in dibrom-pyruvic acid, by one of oxygen, by acting upon the acid by barium hydrate, has produced not $C_3H_2O_4$, the acid wished, but $C_3H_4O_5$, tartronic acid. The dibrom-pyruvic acid was dissolved in two or three times its weight of water, and barium hydrate gradually added, the temperature being kept at 30° to 40°. A white precipitate soon formed, which, decomposed by sulphuric acid, yielded a crystallized acid, very soluble in water and alcohol, fusing about 142°, and yielding the above formula on analysis. The author thinks that the mesoxalic aldehyde-acid CHO—CO—COOH is first formed, but that this body being at the same time an aldehyde and an acetone, is oxidized on its aldehydic side and reduced on its acetonic. Hence it is hydrated and gives COOH—CHOH—COOH, which is tartronic acid. The reaction is

$$\begin{matrix} CHBr_2 \\ | \\ CO \\ | \\ COOH \end{matrix} + (H_2O)_2 = \begin{matrix} COOH \\ | \\ CHOH \\ | \\ COOH \end{matrix} + (HBr)_2,$$

analogous to the transformation of dichloracetone into lactic acid. —*Bull. Soc. Ch.*, II, xxvii, 440, May, 1877. G. F. B.

4. *On a Hexyl Chloral.*—PINNER has subjected to a more careful examination an oily body of high boiling point, first observed by him nearly two years ago in the distillation of crude butyl chloral. From a kilogram of this oil from the factory of Schering, he has prepared half a pound of the oil boiling between 212° and 220°, the rest being butyl chloral. Further fractioning gave him a portion boiling at 212°—214°, which gave on analysis the formula $C_6H_9Cl_3O$. It does not unite with water to form a hydrate and is decomposed by strong bases into a formate and chloride of the base and into $C_5H_8Cl_2$. It is oxidized by nitric acid and yields trichlorcapronic acid, $C_6H_9Cl_3O_2$. Reducing agents, such as zinc powder, reduce this acid to hexylenic acid $C_6H_{10}O_2$, which crystallizes from ether in brilliant white needles, fuses at 39°, is almost insoluble in water, and does not appear to be identical with any of the three known acids having the same empirical formula.—*Ber. Berl. Chem. Ges.*, x, 1052, June, 1877.

G. F. B.

5. *On the Conversion of Aurin into Rosaniline.*—DALE and SCHORLEMMER have discovered that red aurin or peonin, heated for several days to 150° with alcoholic, or to 200° with aqueous ammonia, loses its red color and gives a yellow solution, which contains a colorless crystalline base possessing all the properties of rosaniline, giving the well-known magnificent red color with acetic acid and a dark yellow solution with hydrochloric acid, which becomes red on dilution and gives a spectrum identical with that of rosaniline hydrochlorate. Conversion into Hofmann's violet, aniline green and aniline blue still farther confirmed this identity. The reaction is given as follows:—$C_{20}H_{14}O_3 + (NH_3)_3 = C_{20}H_{17}N_3 + (H_2O)_3$. The authors regard aurin and

rosolic acid as identical.—*Ber. Berl. Chem. Ges.*, x, 1052, June, 1877. G. F. B.

6. *On Hematin.*—CAZENEUVE has prepared hematin and examined its properties. For its preparation, defibrinated blood was treated with twice its volume of commercial ether, allowed to stand twenty-four hours, the ether decanted from the clot, and this clot exhausted by the ether containing now two per cent of oxalic acid. The etherial solution, colored a brownish-red by the hematin, was exactly saturated by ether charged with ammonia gas, and the precipitated hematin was collected, washed with water, alcohol and ether and then dried. The product is pure hematin. In presence of alcohol and ether, it combines readily with hydrochloric, hydrobromic, and hydriodic acids, giving crystallized compounds. On analysis, it afforded 64·18 per cent of carbon, 5·67 hydrogen, 9·03 nitrogen, 8·74 iron and 12·38 of oxygen, corresponding to the formula $C_{68}H_{70}N_8Fe_2O_{10}$. Though it combines with alkalies, it yields no crystalline products. Its ammonia compound is stable at 100°. With lead, zinc, and aluminum hydrates, it gives greenish lakes. It does not disengage ammonia, when boiled with a concentrated solution of potash in alcohol for hours. Heated to 150° for two hours in a sealed tube with concentrated hydrochloric acid, the solution becomes remarkably dichroic; and the hematin splits into two substances (A) and (B). The first is obtained pure by the dialysis of the solution till it is no longer acid. It exists as suspended flocks, the liquid being precipitated completely by a single drop of ammonia, yielding a gelatinous mass containing 37·62 per cent of iron. Its spectrum is peculiar; in acid solutions, it consists of two strong absorption bands in the yellow and yellow-green, in alkaline solutions, it gives four bands, one in the red, one in the yellow-green, one in the blue and one in the violet. The other substance (B) is the part insoluble in hydrochloric acid. On washing it, dissolving it in soda and precipitating by acetic acid, it is purified. It contains only 2·08 per cent of iron, and its solution in acid alcohol gives a one-banded spectrum, in alkalies, a four-banded one.—*Bull. Soc. Ch.*, II, xxvii, 485, June, 1877. G. F. B.

7. *On the Nature of what is commonly termed a "Vacuum;"* by G. JOHNSTONE STONEY, Queen's University, Dublin, August 19, 1877.—The readers of Mr. Preston's paper in the August number of the Philosophical Magazine, "On the Nature of what is commonly termed a 'Vacuum,'" might perhaps suppose with him that the subject is one which had not been previously noticed, and conclude that we are as yet without an explanation of "Crookes's force," in which the vast multitude of the gaseous molecules that are present has been taken into account.

The subject is one which cannot, I should think, have been overlooked by any real student of the molecular theory of gases; and in particular your readers will find it thus treated in a paper that I presented ten years ago to the Royal Society (see Phil. Mag. [IV], vol. xxxvi, p. 141):—"It is therefore probable that there are not fewer than something like a unit-eighteen of molecules" [i. e. 1,000000,000000,000000] "in each cubic millimeter of a gas at ordinary temperatures and pressures. Hence we may see how entirely remote from a state of emptiness that which usually passes under the name of a vacuum-chamber really is. If there be a unit-eighteen of molecules in every cubic millimeter of the air about us, there will remain a unit-fifteen" [i. e. a thousand millions of millions] "in every cubic millimeter of the best vacuums of our ordinary air-pumps. The molecules are still closely packed, within about an eighth-meter of one another; i. e. there are about sixty of them in a wave-length of orange light." And in two papers published in last year's Philosophical Magazine [V], vol. i, pp. 177 and 305, I offered an explanation of the mechanical stresses within Crookes's radiometers based upon this very consideration: see in particular page 178, where the following words occur:—"I cannot refrain from observing here how entirely remote such a chamber" [viz. a Sprengel vacuum indicated by one-tenth of a millimeter of mercury] "is from being empty. It follows from what we know of the number of molecules in gases at ordinary pressures, that the number remaining in this so-called vacuum will be somewhere about a unit-fourteen, i. e. one hundred millions of millions, in every cubic millimeter." After which I quote, in proof of this assertion, the determinations of the mean interval at which the molecules of gases are spaced, by Professor Loschmidt in 1865, by myself in 1867, and by Sir William Thomson in 1870.

It is plain, however, that Mr. Preston has done good service by recalling attention to the immense number of the molecules, and the consequent shortness of the excursions of each molecule between its successive encounters with other molecules; since the subject was new to himself, and had been overlooked by some of the writers upon Crookes's radiometer.—*Phil. Mag.*, Sept. 1877, p. 222.

8. *Note on the Telephone;* by Paget Higgs.—In the present agitation concerning speaking or telephonic telegraphs, the following extract from M. Le Comte du Moncel's "Exposé des Applications de l'Electricité," edition of the year 1857, vol. iii, p.110, may be interesting as pointing out how nearly the idea has been forestalled.

"*The Electric Transmission of Speech.*—I did not wish to bring forward in the chapter of the electric telegraph a fantastic conception of a certain M. Ch. B——, who believes that it will be possible to transmit speech electrically, because it might have been asked why I had classed among so many remarkable inventions an idea that, presented by the author as it is, is not more than a dream. However, to be faithful to the *rôle* that I have imposed upon myself of speaking of all the applications of electricity that have become known to me, I wish to quote here the information which the author has published on this subject.

'After the marvelous telegraphs which are able to reproduce at a distance writing of this or that individual, and designs more or less complicated, it seemed impossible, said M. B——, to advance further in the region of the marvellous. Nevertheless, essaying to do something more, I asked, for example, if speech itself would not be capable of transmission by electricity; in a word, if one would not be able to speak at Vienna and be heard at Paris. The thing is practicable. This is how: Sounds, it is known, are formed by vibrations and carried to the ear by these same vibrations, which are reproduced by the intermediate media.

'But the intensity of these vibrations diminishes very rapidly with the distance, from which it follows, even in the employment of speaking trumpets, tubes, and of acoustical horns, the limits which cannot be surpassed are very restricted. *Imagine that one speaks near a mobile plate, flexible enough not to lose any of the vibrations produced by the voice, that this plate establishes and interrupts successively the communication with a battery. You would be able to have at a distance another plate which would execute at the same time the same vibration.*

'*It is true that the intensity of the sounds produced would be variable at the point of departure where the plate is vibrated by the voice, and constant at the point of arrival where it is vibrated by electricity.* But it is demonstrable that this would not alter the sounds.

'It is evident from the first that the sounds would reproduce themselves with the same pitch in the scale. The actual condition of acoustical science does not permit of saying, *à priori*, whether the same conditions would hold good for all syllables articulated by the human voice. The manner in which these syllables are produced is not yet sufficiently well known.

. . . .

'In any case it is impossible to demonstrate, in the present state of science, that the electric transmission of sounds is impossible. Every probability, on the contrary, is for the possibility. An electric battery, two vibrating plates, and a metallic wire will suffice.

. . . .

'It is certain that, at a time more or less distant, speech will be transmitted to a distance by electricity. I have commenced some experiments to that effect, they are delicate and require time and patience. But the approximations obtained point toward a favorable result.' "—*Nature*, of Aug. 30.

II. Geology and Mineralogy.

1. *Archæan of Canada.* (Letter from Mr. Henry G. Vennor, of the Geological Survey of Canada, to J. D. Dana, dated Buckingham, July 10th, 1877.)—I take the liberty of addressing this letter to you, on a subject in which I have for some years been particularly interested, viz: the stratigraphical position of the economic minerals in what we have hitherto called the Lower Laurentian system of rocks.

I may briefly give you the results arrived at, after now some ten years' work in Eastern Ontario and the adjoining portion of the Province of Quebec, namely, Pontiac and Ottawa counties. We find that there still exists a great *Azoic* formation, consisting of syenite and gneiss (?) without crystalline limestones. In this there are but little indications of stratification. Occasionally a limited surface presents an approach to an *obscure stratification*, but this does not appear to be due to the deposition of sediment. This rock forms the back-bone of Canada. On it there has been deposited a great series of gneisses, schists, slates, crystalline limestones and dolomites, which, although heretofore grouped with the former, is clearly distinct and unconformable. This second system contains *all of the economics* of any importance; none having been found in the old fundamental red gneiss system. All of these economics are in close proximity and have close relationship to each of the four or five great bands of crystalline limestone.

Eozoon Canadense belongs undoubtedly in the main to the highest band of crystalline limestone yet found, although this fossil may, and indeed has been sparingly found in some of the lower limestones. The celebrated Petite Nation locality for *Eozoon*, has now been proved to be on this highest band of limestone, and in fact in *the most recent portion of my second system;* the zone of limestone in which this fossil occurs is especially characterized by an abundance of serpentine and chrysotile. It is further traversed by veins filled with baryta and galena, and these also extend up through the Potsdam and Calciferous formations, but do not enter far into the crystalline rocks, both minerals rapidly giving out as we descend into these older rocks; while the fissures themselves narrow to threads and bifurcate. This fact has been proved by a close and careful investigation in Rossie, N. Y., and Lansdowne, Loughbon, Bedford, Madoc, and Tudor, in Canada.

Immediately beneath the *Eozoon* limestone the apatite-bearing belt of rocks come in with horizons of both hematitic and magnetic iron ores—chiefly the former; and immediately below these again a great belt of plumbago-bearing rock (extensively wrought for this mineral in Buckingham and Lochaber, Ottawa county), an important volume of crystalline limestone filled with rust-colored lumps and beds. This band of limestone is the second in descending order. A short distance beneath this last (some twenty or thirty chains), is an important and well-marked horizon of magnetic iron ore—occasionally with layers of hematite, in which occur a number of promising mines (e. g. the Baldwyn and Forsythe mines, Hull, P. Q.; the Christies' Lake and Silver Lake mines in South Sherbrooke, Lanark county, Ontario, etc.)

On a still lower horizon and close to the third belt of limestone, there is another iron ore horizon of coarsely crystalline magnetite with apatite intimately associated, which has now been identified and followed continuously for upwards of one hundred miles.

Lastly, in a still lower, fourth and last important volume of limestone, we find some large deposits of hematite iron ore (e. g. the Cowan mine in Dalhousie township, Lanark county), but these in so far as investigated, are superficial deposits, only penetrating some fifty or eighty feet into the limestone; but the particular layer in which they occur may be followed by its deep hematite red color throughout a great extent of country.

The order then thus given to the economic minerals, just mentioned, is, in ascending order, as follows:—1st, hematitic iron ore; 2d, magnetite and apatite (unimportant); 3d, magnetite and hematite (important); 4th, plumbago (very extensive); 5th, phosphate of lime, with iron ores (an important and extensively worked belt; and then 6th, *Eozoon Canadense* in abundance with serpentine, chrysotile and veins of baryta and galena.

You will thus observe that iron ore runs through the series, though most important in one horizon; that plumbago (with a great deal of pyrites cobaltiferous) is toward the upper portion; while the great body of apatite-bearing rock is at the very summit.

Having established this important sequence my thoughts at once flew back to the discoveries of phosphatic nodules and shells in the Lower Silurian rocks at the Allumettes Rapids (Geology of Canada, page 125), and in several places in the eastern townships and elsewhere. Is it not probable that the source of our mineral apatite is in the Lower Silurian rocks, whence it has penetrated into the upper portion of the *second division* of the Laurentian system? Or, may the *Eozoon* not have furnished a considerable portion of the supply? Possibly *Lingulæ* may have abounded along with the Eozoon, but if so their remains have been entirely obliterated by crystallization or other metamorphism. I think that the gap between the Lower Silurian and uppermost crystalline rocks of the Laurentian is considerably lessened by the results of our explorations, particularly as we can show that the same veins which cut the former, affect the latter, but do not reach the fundamental *Azoic* system, to which I must now (in my section) restrict the term Lower Laurentian. I cannot now enlarge, but I may simply state that I consider both the Huronian and Upper Laurentian of Sir W. E. Logan to belong rightly to my second division, which I must for the present call Upper Laurentian. Should an Upper Laurentian yet be found above and unconformable to *my series*, then I have been working on a middle series, to which the term Huronian might as well be applied as any other.

I have found Labradorite rocks clearly interstratified with several of my bands of limestone, and I fail entirely to discover Sir William's upper distinct system—yet I have been over the same ground.

The *Huronian and Hastings series of rocks* I believe to be simply an altered condition, on their westward extension, of the lower portion of my *second system;* and this alteration commences as this portion reaches Hastings county, where you will remember Hunt, Macfarlane and others likened them to the Huronian, while Sir William thought they more resembled some portions of the Devonian.

2. *The Geology of New Hampshire.* C. H. HITCHCOCK, State Geologist, J. H. HUNTINGTON, WARREN UPHAM, and G. W. HAWES, Assistants. Part II, Stratigraphical Geology. 684 pp. Royal 8vo, with many maps, plates, and sections. Concord, 1877. —This large volume consists mainly of chapters by Professor Hitchcock. The geology of the Coös and Essex Topographical district and of the west part of the Merrimac district, and some other brief sections are by Mr. J. H. Huntington.

The difficulties of the survey have been great on account of the extent of the surface covered by unbroken forests, and the disturbed crystalline condition of the rocks. But, through great labor, the distribution of the several kinds of metamorphic rocks has been to a large extent made out, and is carefully described in the Report. Professor Hitchcock has carried forward the work with energy and fidelity, and has presented not only his own views, but also, with fairness, as far as he has understood them, the views of others. As to the conclusions from the facts presented in the volume, Professor Hitchcock is aware that the writer differs from him in many points; and if in the remarks beyond some of these differences are mentioned it will be without the assumption on the writer's part that he is always right.

Professor Hitchcock refers the crystalline rocks of New Hampshire—taking his latest conclusions from the closing pages of the volume—to the following groups in ascending order:—Laurentian; Montalban (inferior to Huronian, and so named from the Latin for White Mountains); Lower and Upper Huronian; above these, Paleozoic with a query; Cambrian; the Coös group; the Calciferous mica schist; and above these, the Lower Helderberg. Besides, there are various areas of eruptive granite recognized, including those of the "Conway granite," "Albany granite," "Chocorua series," and others.

The *Laurentian* includes a porphyritic gneiss, Bethlehem gneiss, Lake Winnipiseogee gneiss; the *Montalban*, Concord granite, feldspathic mica schists, the associated gneisses, fibrolite schists; the *Upper Huronian*, hornblende schist, chlorite schist, greenstones, and other rocks; the *Coös*, staurolite slate, staurolitic mica schist, quartzyte; overlying the Coös, Calciferous mica schist, in which obscure crinoidal fragments have been found.

The age of these rocks, the Helderberg excluded, has been determined by Prof. Hitchcock mainly by lithological characteristics—a species of evidence not yet proved to be satisfactory. The writer is led by his observations among New England rocks to conclude that, so far as lithological distinctions go, all the metamorphic rocks of the White Mountains, with perhaps one or two exceptions, might belong to one of the ages in geology: (and that even one stratum may, after metamorphism, be, in its different parts, andalusite slate, mica schist, andalusitic mica schist, gneiss, porphyritic gneiss, granite). As to what age, or whether to one, or to more than one, the facts thus far collected afford no satisfactory basis, as the writer believes, for a decisive opinion. Further: observations in different parts of New England have convinced him that the granites, supposed by Professor Hitchcock to be eruptive, may be for the most part, if not in all cases, metamorphic; and this appears to be sustained by the facts, as to position and relation to the other rocks, connected with the granite of Mt. Willard (one of the areas made eruptive), as is pointed out beyond.

The account of the White Mountain region occupies 170 pages of the Report, and will attract especial attention. Following this comes a chapter on the geology of the Connecticut Valley, which also is of prominent importance in connection with New England geological investigations.

The chief facts of interest in the valley region is the occurrence at three places of limestone containing Lower Helderberg fossils—corals, crinoids, or brachiopods, associated with various metamorphic rocks. These places are in Littleton and North Lisbon, New Hampshire, and in Bernardston, Massachusetts. The limits of the Helderberg areas are laid down with some acknowledged doubts as to whether the group does not embrace also the "Coös group;" and there is room left for a query whether they should not include also what is called the "Lisbon group" (chlorite schist, chlorite rocks or greenstones, with some hydromica slate, etc.), and the "Lyman group." The section given on page 326 of the Littleton rocks represents a synclinal of slate (the uppermost bed), limestone, and quartzyte, with beds of the "Lisbon group" and "Lyman group" essentially *conformable* to the limestone. Plate XV (facing p. 385), contains another section of this region, showing the same conformability of the Lyman, Lisbon, and Helderberg groups. On pages 329 and 331, this conformability is again exhibited in sections, and also on plate XIII. Professor Hitchcock, however, calls the Lisbon and Lyman groups Huronian, a conclusion that is not suggested by the above-mentioned sections.

The relations of the Helderberg limestone of Bernardston to the associated micaceous, hornblendic and other rocks the writer has interpreted very differently from Professor Hitchcock, and he will give the results of new observations in another number of this Journal.

Some of the most interesting facts in the White Mountain region are those observed along the valley west of the Mount Washington range of peaks. This valley, at the Notch and south of it (here trending about north-and-south), has Mount Willard and Mount Willey on the west (the latter two miles south of the former), and Mount Webster on the east, opposite Mount Willey. The rocks of the west side in this part are, going southward, a light-colored well characterized granite ("Conway Granite"), the chief constituent of Mount Willard, in view above the Notch;

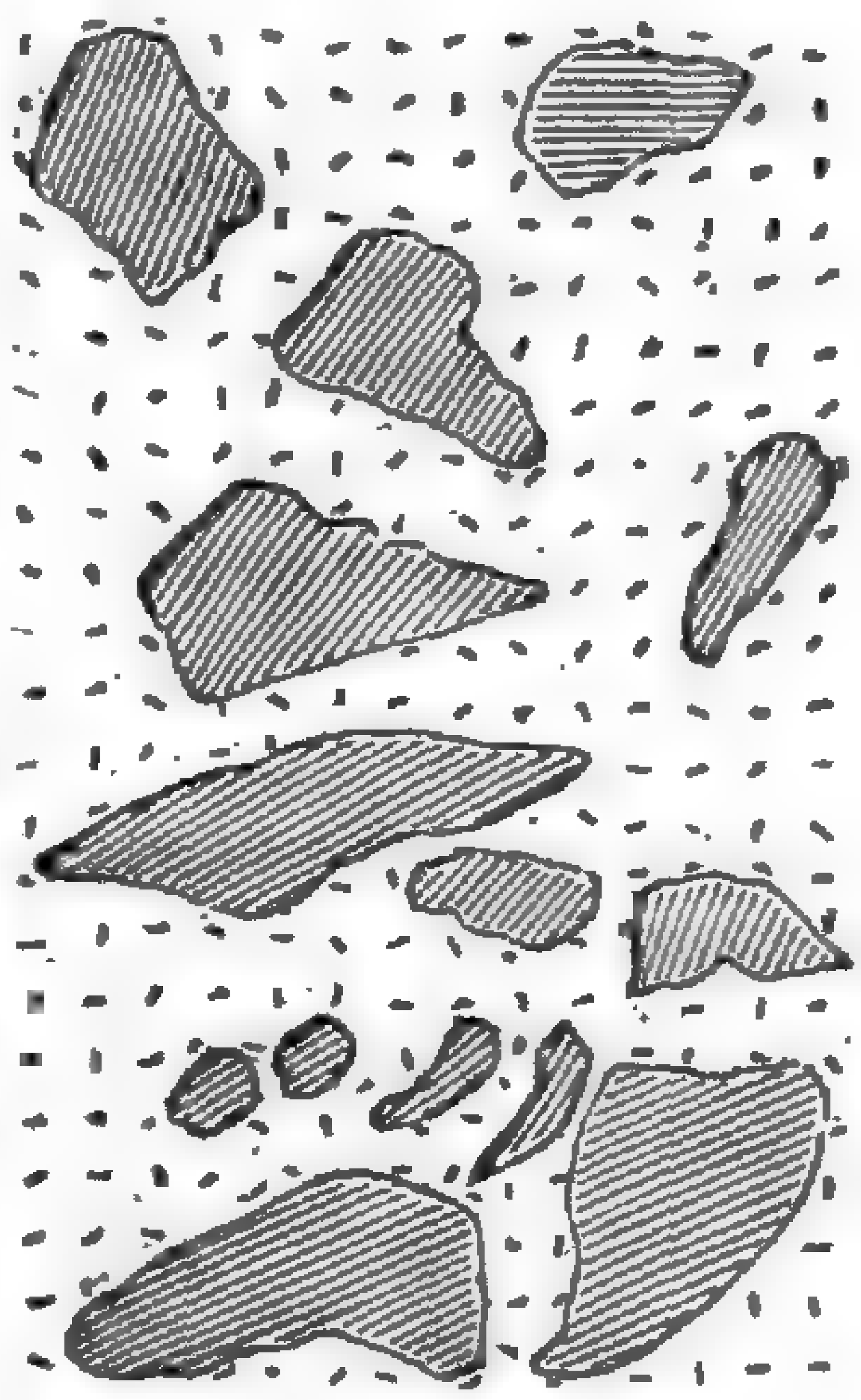
a hard siliceous granitoid gneiss, varying into true granite, forming the eastern foot of Mount Willard, to the east of the Mount Willard granite, in the Notch; then, continuing southward, but at first a little westward, andalusite slate, meeting the Mount Willard granite parallel with its bedding, as if conformable to it, and extending southward to the top of Mount Willey; then, on the southeast side and foot of Mount Willey, the Mount Willard granite again, which becomes, five miles south of the Notch, at the Frankenstein cliff, a dark gray granite for some distance, and then changes abruptly to syenyte.* The andalusite slate where it adjoins the Mount Willard granite is, for a varying width—twenty feet below and two hundred feet above—an argyllyte-porphyry, it containing orthoclase and quartz, both of which minerals are in distinct crystals within a few yards of the granite.

The rocks of the *east* side of the valley are, just north of the Notch, well characterized gneiss; then, at the Notch and below it, the same hard granitoid gneiss that occurs on the west side, seldom distinct in dip and strike; then farther south, Conway or Mount Willard granite, at the base and up the slope of Mount Webster; and above this, far up the sides of this mountain, the "Montalban schists" (feldspathic mica schist chiefly), the characterizing rock of the Mount Washington range. The rocks of the region and of Mount Washington dip, with some local exceptions, to the westward.

The above facts respecting the rocks are here cited from the Report, as an introduction to a point of very prominent interest—the existence in the valley of a long series of great veins of coarse granite, and of a remarkable range of "breccia-granite." These veins are numerous and large at the Notch; and they occur also to the south, on nearly the same line, far up the western slope of Mount Webster, where some of them are twenty to thirty feet wide. The breccia-granite has the same general range with the veins. Just below the Notch, on its western side, there is a large exposure of it, and it here extends, Professor Hitchcock observes, "1,200 feet along the railway." Going southward in the gorge or valley, this breccia-granite appears at the outlet of Dismal Pool, and then, south of this, in a cliff on the west side of Mount Webster, at a height equal to that of the top of Mount Willard, where it has a thickness of two hundred to three hundred feet. Its course, southerly from the Notch, "is not in a right line, on account of various shiftings of the rock, not fully understood." This breccia-granite is made up of large and small masses of chiefly a dark micaceous gneiss, in a paste of granite, some of the masses a yard in length.

* According to the writer's observations at the place, the granite becomes syenyte by a substitution of hornblende for black mica (biotite). The other ingredients are precisely the same—gray feldspar and gray quartz, so that the two rocks are stratigraphically one. It is an interesting example of the abrupt transition between these two rocks, and is well worthy of a visit from those who are interested in lithological questions. The idea that the two rocks were perhaps upper and lower parts of one original stratum or successive strata was considered, but without finding reason to sustain it.

Again: a similar breccia-granite occurs one to two miles north of the Notch, (pp. 163, 165). Two miles southwest of Crawford's, on Cascade Brook, the Mount Willard granite "contains many fragments of the hard Montalban schists, sometimes from twelve to fourteen feet long; and several of them seem to carry andalusite quite abundantly."* Half a mile farther west up this same brook, andalusite slate succeeds to the granite (but with an intermediate porphyritic junction-rock, like that observed in Mount Willard), and it continues up Mount Tom.



The writer had the pleasure, in 1875, of examining this part of the White Mountain region with Professor Hitchcock, and adds here a cut representing a portion, six feet wide, of the surface of breccia-granite, just below the Notch.

The great number and large size of the granite veins extending along the gorge in a north-and-south direction, and the extensive range of breccia-granite following the same course, seem to sustain the opinion, which Professor Hitchcock quotes in his Report from the writer, that the gorge, like most valleys of the Appalachians, was probably the course of a lofty anticlinal, the fractures in which led to degradation and so determined the formation of the valley. And if this conclusion be right, the Mount Washington range may correspond to a nearly parallel synclinal. From the position of the rocks in the gorge above described, it seems probable that the hard siliceous granitoid gneiss of the Notch is the central and lowest rock of the anticlinal; that the Mount Willard (or Conway) granite is the next metamorphic stratum on *both* the east and west sides, it lying conformably against the slate in Mount Willard and elsewhere; and that the andalusite slate on the west and the Montalban schists (often andalusitic, and part an andalusitic slate) together on the east, constitute the succeeding stratum. The dissimilarity in the eastern and western portions of this last stratum may be a consequence of a small variation from east to west in the constitution of the sediments and of differences in the degree of metamorphism. The dissimilarity is chemically small; for the analysis of the andalusitic slate from this region by Mr. G. W. Hawes (Report, p. 233) found it to consist (No. 1, below) of—

	SiO_2	$\ddot{A}lO_3$	$\ddot{F}eO_3$	FeO	MnO	MgO	K_2O	Na_2O	TiO_2	H_2O
1.	46·01	30·56	1·44	6·85	0·10	1·42	6·66	1·12	1·91	4·13=100·22
2.	46·23	33·08	3·48	---	---	2·10	8·87	1·45	---	4·12= 99·28

which corresponds very nearly to the constitution of common mica (muscovite), or rather the hydrous variety margarodite, one

* A similar breccia-granite occurs in the Franconia Notch, near the Basin, where (p. 137 of Professor Hitchcock's Report) masses "of porphyritic granite, dark gneiss, hornblendic and other siliceous rocks, are cemented together by a light-colored feldspathic paste." Other localities also are mentioned.

analysis of which is cited in No. 2; and also, for half of it, as Mr. Hawes suggests, to that of common feldspar (orthoclase). The slate is peculiar in affording so large a percentage of alkali (7·78), and so small of silica; but it varies in its silica, being in some places an "argillaceous quartzyte;" in others a "felsitic slate," weathering white.

This view that the andalusite-slates and Montalban schists (which also are often andalusitic) correspond to a stratum *higher* in the series than the Mount Willard granite is sustained by the occurrence of masses of them in the bed of granite on Cascade Brook (see above); for in the fracturing and crushing of the rocks, the detached masses would naturally fall to the level of the lower strata from those above. The breccia-granite the writer attributes to a crushing of the walls of great fractures during the period of upturning and metamorphism,—the metamorphism of the fragments and of the rock fractured, and the making of the granite, having gone on in the same epoch, like the making of the granitic veins; and not, as held by Professor Hitchcock, to the breaking up of schists long before made by metamorphism, and the including of the fragments in eruptive granite. The crushing was on a vast scale; and it may have been far beyond what is now indicated; for we cannot know to what extent the stratum which is now Mount Willard granite was crushed, all trace of bedding being obliterated. What is apparent shows where the heat required for metamorphism, and for the making of granite, came from.

The strike of the andalusite slate from its southern point at the summit of Mount Willey, northward, is, according to Professor Hitchcock, N. 10° E., and it varies little from this except adjoining the Mount Willard granite, where for one or two hundred rods it has a bend to the westward. The northern limit of the narrow slate area is in the high region northwest of Mount Willard, the whole length being about ten miles. A finely porphyrytic or "spotted" granite named the "Albany granite," is stated to bound it on the west and to occur where it disappears to the north. Whether the slate disappears by dipping beneath the granite, or by passage into it, is not stated. This Albany granite is in the larger part a granite without quartz (p. 143), and hence may have nearly the constitution of the slate.

Professor Hitchcock states that the porphyritic granitoid rock, ten to two hundred feet wide, which marks the junction in Mount Willard of the andalusite slate and Mount Willard granite, resembles the "Albany granite." This peculiar junction-rock indicates, in the writer's view, that the stratum of granitic mud or sand from which the Mount Willard granite was made, and that from which the andalusitic slate proceeded, had some beds of passage; there was a transition in the metamorphic products because of a transition in the material and in other conditions.

The structure of the White Mountains is so exceedingly complex, that it may reasonably give rise to widely diverse explanations. The view the writer has here presented seems at least to be worth considering in the future study of the region.

The volume also treats of the rocks of the Merrimack district, the Lake district, the Coast district, and the district of northern New Hampshire.

The Geological Map, illustrating this volume, is in the hands of the engraver. It is on a scale of two and a half inches to the mile.

The third and last volume of the Survey will contain a report by Mr. Warren Upham on the Quaternary of New Hampshire; and one by Mr. George W. Hawes, on the Lithology of the State, both chemically and microscopically considered. J. D. D.

3. *Preliminary Report on the Paleontology of the Black Hills*, by R. P. WHITFIELD. U. S. Geogr. and Geol. Survey of the Rocky Mountain region, J. W. POWELL in Charge. 50 pages, 8vo, July, 1877. Washington.—This valuable report contains descriptions of new species of fossils from Primordial, Jurassic and Cretaceous formations; and in the final report on the paleontology of the Black Hills, it will be accompanied with sixteen lithographic plates. The new Primordial fossils include besides a fucoid, two species of *Lingulepis*, and two of trilobites of the genus *Crepicephalus* (*Loganellus*), *C. centralis*, and *C. planus;* the new Jurassic, species of *Pecten*, *Pseudomonotis*, *Mytilus*, *Trapezium*, *Pleuromya*, *Tancredia*, *Dosinia*, *Psammobia*, *Neæra*, *Saxicava;* and besides there are eighteen new species of Cretaceous fossils. In all, the number of Jurassic species recognized from the Black Hills by Mr. Whitfield, is thirty-three, and of Cretaceous species, seventy. The sixteen lithographic plates are full of well-drawn and finely engraved figures.

4. *The Age of the Tejon group, California.*—The following is from a paper by Dr. J. G. COOPER in the Proceedings of the California Academy of Sciences, for Nov. 16, 1874—The evidence of the age of the Tejon group is so far derived from only a few marine fossils which have been referred by different authors to the Cretaceous, the Eocene, and the Miocene. Conrad, the Nestor of American paleontologists, over twenty years ago, described as unmistakably Eocene, a group of fossils, now known as the Tejon group, among which he thought was the *Cardita planicosta*, "that finger-post of the Eocene, both in Europe and America." Mr. Gabb, finding from better specimens that this shell differed from *Cardita planicosta*, described it as new, and referred the Tejon group to the Cretaceous, finding in it a very few species which he considered identical with the lower beds, proved to be Cretaceous by the presence of numerous Ammonites. He also stated, in an article in our Proceedings, published November, 1866, that "a solitary ammonite, represented by half a dozen specimens, has been found by myself *in place*, even to the very top of the formation." This slender evidence (which might be rejected after finding a Carboniferous fossil in a Pliocene deposit) is all the proof we have of the Tejon beds being Cretaceous; and that it is quite arbitrary is shown by the other fossils found with it being nearly all different from the lower ones, less than one-tenth of the Cretaceous shells being

common to both according to Gabb, of which several *may be* distinct. On the other hand, many of the Tejon group are scarcely distinguishable from Tertiary and living forms. One, *Aturia Mathewsonii*, is so near the Eocene *A. zigzag*, as to have been taken for it, no other Cretaceous *Aturia* being known.

I may add that the ammonite (*A. jugalis* Gabb) was found by me in a stratum just beneath the Mt. Diablo coal, and apparently on the same level as those from Clayton and "Curry's," found by Gabb, so that its existence above the Coal, or in the Tejon group itself, is perhaps accidental. But, to pass by this doubtful fact, we have still later strata, referred to the Eocene by Conrad, near the mouth of the Columbia, where we would expect the first Tertiary to rise near the surface, and this time the Eocene *Aturia zigzag* again appears, though with a different group of shells. Mr. Gabb, while admitting that this time it is the true *zigzag*, is so opposed to recognizing any Eocene here, that he calls the formation Miocene. The general character of these fossils, of which there are several in the Academy's Museum, shows, however, that they are of a more tropical growth than any of our Miocene species, the *Aturia* itself being very similar to the *Nautili* now living in the tropics. Though perhaps mixed with Miocene species among the broken rocks so numerous on the lower Columbia shores, it is most probable that true Eocene strata exist there, and, as shown by the Academy's specimens, extend south nearly to California, where later strata cover them. From all we yet know, we may assume that the gap between the Cretaceous and Tertiary, so marked on the Atlantic shores, was bridged over in part by the existence here of the "Tejon Group," continuing Cretaceous forms of mollusca down so as to be contemporaneous with the Eocene epoch there, or the earlier part of it, just as we find the flora and fauna of Australia resembling forms fossil in the Eocene formation of Europe, but continued to the present epoch. After, perhaps, a short geological period of convulsion and death, we find the Eocene mollusca appearing in Oregon, just preceding the Miocene, nearly like those of the Atlantic basin.

5. *Fossil Tertiary Insects of Quesnel, British Columbia.*—Mr. S. H. SCUDDER has described, in the Canada Geological Report for 1875–76, the following Columbian Tertiary species of insects. HYMNOPTERS: *Formica arcaria*, *Pimpla saxea*, *P. senecta*, *Calyptites* (n. gen.) *antediluvianum*. DIPTERS: *Boletina sepulta*, *Brachypeza abita*, *B. procera*, *Trichonta Dawsoni*, *Anthomyia inanimata*, *A. Burgessi*, *Heteromyza senilis*, *Sciomyza revelata*, *Lithortalis* (n. gen.) *picta*, *Lonchœa senescens*, *Palloptera morticina*. COLEOPTERA: *Prometopia depilis*. HEMIPTERA: the Aphid, *Lachnus petrosum*, with mention of an imperfect specimen of a Neuropter.

6. *On the first discovered traces of Fossil Insects in American Tertiaries, and on new Carabidæ from the interglacial deposits of Scarborough Heights, near Toronto, Canada*, by SAMUEL H. SCUDDER. From the Bulletin of the U. S. Geol. and Geogr. Survey, F.

V. Hayden, U. S. Geol.-in-Charge.—The Tertiary Insects described by Mr. Scudder include species of Hymenoptera of the families *Formicidæ*, and *Ichneumonidæ;* Diptera of the families *Culicidæ, Chironomidæ, Cecidomyidæ, Tipulidæ, Mycetophilidæ, Cyrtidæ, Synphidæ, Muscidæ* and *Helomyzidæ;* various Coleoptera and Hemiptera; and a Neuropter of the genus *Phryganea*.

7. *Geological Survey of Victoria*, No. IV. *Report of Progress* by the SECRETARY OF MINES, *with Reports on the Geology, Mineralogy and Physical Structure of various parts of the Colony*, by R. A. F. MURRAY, F. M. KRAUSÉ, N. TAYLOR, A. W. HOWITT, W. NICHOLAS, J. COSMO NEWBERY, and Professor F. McCOY.—The Report of Progress states the following facts brought out in Decade IV of the Prodromus of the Paleontology of Victoria by Professor McCoy, which is nearly ready for issue. Three plates are devoted to the *Diprotodon* which, "like the Megatherium of South America, was obviously a feeder on the twigs and foliage of trees, like their diminutive representatives of modern times." On Plate V are represented *Favosites Goldfussi*, "agreeing in every respect with the European Devonian coral," *Spirifera lævicosta*, a species also of England and abounding in the Middle Devonian limestones of the Eifel, *Chonetes Australis*, "closely allied to the *C. sarcinulata* of the Rhenish Devonian beds," *Asterolepis ornata*, "almost identical with specimens found in the Russian Old Red Sandstone;" on Plate VI are figures of *Archæopteris Howitti, Sphenopteris Iguanensis*, and *Cordaites Australis*, from the Upper Devonian of Gippsland.

Mr. Howitt describes the basalts, and other rocks of North Gippsland, and gives figures of thin slices of the rocks, with detailed descriptions. The volume contains also facts on other formations in Victoria, and much on auriferous veins.

8. *Tantalite.*—I have lately had sent to me a mass of tantalite, weighing about 500 grams, coming from Professor Eugene A. Smith, State Geologist of Alabama; its exact locality in Alabama is not given. It is the first time that tantalite has been found in the United States; its specific gravity is over 7·2. It is a surface specimen, and has undergone partial decomposition in the crevices. It is an important discovery at the present time, while this class of minerals is exciting interest. J. LAWRENCE SMITH.

9. *Geognostische und geographische Beobachtungen im Staate Minnesota.* Doctorate Inaugural dissertation by J. H. KLOOS, Mining Engineer of Amsterdam. 58 pp. 8vo. Berlin, 1877.

III. BOTANY AND ZOOLOGY.

1. *Morphology of the Dentary System in the Human Race.*—Dr. E. LAMBERT, of Brussels, has given the characteristics of the teeth in the different races of Man a careful study, and has arrived at the following important conclusions, here derived from the Bulletin of the Royal Academy of Belgium, 46th year, No. 5, 1877.

In the *white race*, the triturating surface of the canines does not project beyond that of the other teeth, the two premolars are equal in volume, the first true molar is the largest, and the last or wisdom tooth is the smallest. In the *black race*, the contrary is true in all these points, the canines projecting beyond the teeth adjoining, the posterior premolar being the largest, and the true molars increasing in size posteriorly.

In the white race, the molars have ordinarily only four cusps; in the black, five. If in the white race there are five, it is the first molar which has them; while in the black it is the last.

In the yellow race, there is usually a slight increase in the size of the molars from the interior to the posterior, as in the black race; and, as in the black race, there is a fifth cusp on the wisdom tooth.

In the black race, the diameters of the incisors are larger than in the white race, and the triturating surface of the canines is larger than that of the teeth adjoining.

In the black race, there is a slight diastema, which does not exist in the white race, and the inner tubercle of the premolar is less developed than the outer—as in the man-apes. In the inferior premolars, the first has often an inner tubercle feebly developed, which again manifests a slight approximation toward the man-apes.

In the black race, the superior molars have the antero-posterior diameter equal to the bi-lateral; in the white race, it is always smaller, and, in the yellow, the form is intermediate.

There is more difference in the teeth between the black race and the yellow than between the yellow and the white. However, the Malay branch, the type of the brown race of D'Omalius, seems to be transitional between the black and the yellow as regards the general volume of the teeth, the number of cusps of the large inferior molars, and the tendency to an increase of size of molars posteriorly.

The American race—the red race of D' Omalius usually united with the yellow—presents so nearly the dentary characters of the black race that Dr. Lambert unites the two. The Australians, Tasmanians, and New Caledonians present, in some respects, an exaggeration of the dentary characters of the African negro, and also stronger prognathism.

The crania from the caves of Furfooz (Belgium), have the inferior molars decreasing in size backward, as in the white race; and it is the same with the seventy neolithic crania exhumed at Hastières. But the Paleolithic lower jaw from Naulette (Belgium), as has been remarked by MM. Prüner Bey, Broca and Carter Blake, approximates most that of the Australian and New Caledonian races, showing a resemblance in the age of the mammoth between man in Belgium and the existing races of their antipodes. Dr. Lambert's paper is published at length in the Bulletin of the Academy.

2. *Arbeiten aus dem zoologische-zootomischen Institut im Würtzburg.* 8vo. Herausgegeben von Prof. Dr. Carl Semper.—

The third volume contains the following elaborate papers: The Uranogenital system of the Amphibia, by Dr. J. W. SPRENGEL, 114 pages, with 3 folded plates; Strobilation and Segmentation in articulate animals, with special reference to the homologies between Vertebrates, Annelids, and Anthropods, by C. SEMPER, 290 pages, with 12 folded plates; Studies on the Turbellaria (on the Plathelminthids) by CHARLES SEDGWICK MINOT, of Boston, 62 pages, with 5 plates; on the saliva and cement glands of the Decapods, by Dr. M. BRAUN, 8 pages, with 1 plate; Remarks on the "Nephrofneusten" of v. Ihering, by C. SEMPER.

3. *On the Brain of Chimæra monstrosa*, by B. G. WILDER, Proc. Acad. Nat. Sci. Philad., May 29, 1877. 34 pp. 8vo, with a plate.

IV. ASTRONOMY.

1. *New Planets.*—In a letter to the editors Prof. Watson says: "The following are the places, from the observations provisionally reduced, of the two planets recently discovered by me.

Planet (174) discovered August 8th, magnitude 10·3.

Ann Arbor.	Mean Time. h m s	(174)α. h m s	(174)δ. ° ′ ″	No. Comp.
1877, August 8,	10 50 0	21 22 39·10	−16 4 7·0	2
16,	13 48 1	21 13 57·94	15 46 6·0	5
17,	9 39 25	21 13 5·89	15 44 8·0	5
18,	10 40 5	21 12 0·29	15 41 34·8	5
20,	11 11 13	21 9 55·43	15 36 30·4	5
26,	9 56 30	21 4 9·13	15 19 58·1	5
30,	12 15 30	21 0 33·55	15 7 29·1	2
Sept. 1,	9 48 4	20 59 3·24	15 1 27·9	9
3,	8 53 48	20 57 34·90	14 54 53·6	5

Planet (175) discovered September 2d, magnitude 11·5.

Ann Arbor.	Mean Time. h m s	(175)α.	(175)δ. ° ′ ″	No. Comp.
1877, Sept. 2,	11 2 58	23 10 4·80	+0 44 59·1	5
2,	13 50 35	23 9 58·39	0 44 50·2	5
3,	10 40 9	23 9 10·38	0 43 36·9	6
4,	10 11 56	23 8 16·21	+0 42 11·3	5

Observatory, Ann Arbor, September 10, 1877.

2. *Time of Rotation of Saturn.*—Professor HALL discovered on the night of December 7th, a bright spot on the ball of Saturn. Notice was sent to various astronomers and the spot was observed at Poughkeepsie, Albany, Hartford, etc. The spot was followed, and its position measured at Washington until Jan. 2d, or through more than sixty revolutions. Assuming that the spot had no proper motion on the surface of Saturn, Professor Hall obtains for the time of one revolution on its axis

$$10^h\ 14^m\ 23^s{\cdot}8 \pm 2^s{\cdot}30.$$

The only earlier determination of this quantity was made by Sir Wm. Herschel in 1793–4 who found it to be $10^h\ 16^m\ 0^s{\cdot}4$, which he believed could not be in error as much as two minutes. By a curious mistake his time for the rotation of the ring, or $10^h\ 29^m\ 16^s{\cdot}8$, has been hitherto given in almost all treatises on astronomy as the time of rotation of the planet itself.

3. *The newly discovered satellites of Mars.*—The announcement of this remarkable discovery made by Prof. Hall was too late to appear in the body of the September number of the Journal, but was given upon the third page of the cover. It is of such exceptional importance that we give in full Admiral Rodgers' Report to the Secretary of the Navy, dated August 21st.

"Sir: the outer satellite of Mars was first observed by Professor Asaph Hall, U. S. N., on the night of the 11th of August, 1877. Cloudy weather prevented the certain recognition of its true character at that time. On August 16th it was again observed, and its motion was established by observations extending through an interval of two hours, during which the planet moved over thirty seconds of arc. The inner satellite was first observed on the night of August 17th, and was also discovered by Professor Hall. On Saturday, August 18th, the discoveries were telegraphed to Alvan Clark and sons, Cambridgeport, Mass., in order that if the weather should be cloudy at Washington, they might confirm the existence of the satellites with the 26-inch telescope of Mr. McCormick, which is in their hands. This discovery was confirmed by Professor Pickering and his assistants, at Cambridge, Mass., and by the Messrs. Clark, at Cambridgeport. On August 19th the discovery was communicated to the Smithsonian Institution, by which it was announced to the American and European observatories in the following dispatch:

Two satellites of Mars discovered by Hall, at Washington. First, elongation west, August 18, *eleven hours, Washington time. Distance eighty seconds. Period, thirty hours. Distance of second, fifty seconds.*

It will be seen hereafter that the statement of fifty seconds as the distance of the inner one was erroneous. The observations hitherto made are as follows:

The First Satellite.

Date	h m	p (°)		h m	s (")		Obs.
1877, Aug. 11,	14 40,	p= 59·6	(2);	14 45,	s=70·57	(2)	Obs., Hall.
16,	11 42,				s=77·6:	(1)	" Hall.
	13 7,	p= 71·9	(2)		s=80·83	(4)	" Hall.
	13 36,				s=80·4	(1)	" Hall.
17,	16 2,	p= 85·5	(2);	16 19,	s=63·24	(3)	" Hall.
18,	10 28,	p=251·7	(3);	10 18,	s=82·93	(8)	" Newcomb.
	10 57,	p=244·5	(1);	11 5,	s=81·6	(1)	" Harkness.
	11 50,	p=246·6	(4);	11 57,	s=81·77	(4)	" Hall.
	14 32,	p=232·1	(4);	14 39,	s=61·04	(4)	" Hall.
19,	11 42,	p=283·2	(2);	11 49,	s=46·20	(4)	" Hall.
	15 43,	p=255·4	(4);	15 52,	s=81·37	(6)	" Hall.
20,	10 28,	p= 61·1	(3);	10 33,	s=76·07	(2)	" Hall.
	11 57,	p= 52·1	(4);	12 7,	s=59·93	(4)	" Hall.

The Second Satellite.

Date	h m	p (°)		h m	s (")		Obs.
1877, Aug. 17,	16 6,	p= 73·0	(2);	16 21,	s=30·81	(4)	Obs., Hall.
18,	11 31,	p=248·8	(2);	11 37,	s=34·65	(4)	" Hall.
19,	11 25,	p=226·8	(2);	11 30,	s=24·08	(2)	" Hall.
20,	13 15,	p= 67·1	(1);	13 26,	s=31·95	(3)	" Hall.
	13 56,				s=27·02	(4)	" Hall.
	14 22,	p= 70	(est.);	14 22,	s=19·16	(3)	" Hall.
	16 19,	p=250	(est.);	16 19,	s=15·15	(7)	" Hall.
	16 35,				s=16·70	(7)	" Hall.

From these observations Professor Newcomb has derived the following approximate circular elements of the orbits. The probable errors assigned are only very rough estimates.

The Outer Satellite.

Major semi-axis of apparent orbit seen at distance [9·5930]	82·″5 ± 0·″5
Minor semi-axis of apparent orbit seen at distance [9·5930]	27·″7 ± 2·″
Major semi-axis of orbit seen at distance unity	32·″3
Position angles of apsides of apparent orbit	70°, 250° ± 2°
Passage through the west apsis ($p=250°$), Aug. 19, 16·6h, W. m. t.	
Period of revolution	30h 14m ± 2m
Hourly motion in Areocentric longitude	11·°907
Inclination of true orbit to the ecliptic	25·°4 ± 2°
Longitude of ascending node	82·°8 ± 3°
Position of pole of orbit in celestial sphere	Long. 352·°8
	Lat. + 64·6
	R.A. 316·1
	Decl. + 53·8
These elements gave for the mass of Mars	$\frac{1}{3,090,000}$

The Inner Satellite.

Major semi-axis of apparent orbit at distance [9·5930]	33·″0 ± 1″
Period of revolution	7h 38·5m ± 0·5m
Hourly motion in Areocentric longitude	47·°11
Passage through the eastern apsis ($p=70°$), Aug. 20, 13·0h, W. m. t.	

4. *The American Ephemeris and Nautical Almanac for the year* 1880, has been issued, under the superintendence of Professor Coffin, by the Bureau of Navigation at Washington.

5. *Does the Motion of the inner satellite of Mars disprove the Nebular Hypothesis?* by Professor DANIEL KIRKWOOD. (Letter to the Editors.)—From eight measurements of the position and distance of the inner satellite of Mars as taken by Professor Hall within three days from the date of his first observation, Professor Newcomb found the period to be seven hours and thirty-eight minutes. On the theory, therefore, of a circular orbit the satellite is within 3400 miles of the planet's surface. Professor Hall remarks that the diameters of the Martial satellites are extremely small, probably not more than 50 or 100 miles. It is interesting to observe that even with the larger limit the bodies are smaller in comparison with their primary than any other secondaries in the solar system. According to Proctor, Mars revolves on its axis in 24^h 37^m $22{\cdot}735^s$. The inner satellite, therefore, completes three orbital revolutions in less than a Martial day. How is this remarkable fact to be reconciled with the cosmogony of Laplace?

Although the period of no other satellite is less than that of the rotation of its primary, the case can hardly be regarded as wholly unique. The rings of Saturn are clouds of extremely minute secondary planetoids revolving about the primary in approximate accordance with Kepler's third law. The periods of those in the outermost ring, like that of the exterior satellite of Mars, are somewhat greater than the rotation period of the primary. Those near the outer edge of the interior bright ring revolve in the same time with Saturn, and those at the inner visible edge of the dusky ring complete a revolution in about eight hours. "These rings of Saturn, like everything cosmical, must be gradually decaying, because in the course of their motion round the planet there must be continual impacts amongst the separate portions of the mass; and of two which impinge, one may be accelerated, but it will be accelerated at the expense of the other. The other falls out of the race, as it were, and is gradually drawn in towards the planet. The consequence is that, possibly not so much on account of the improvement of telescopes of late years, but perhaps simply in consequence of this gradual closing in of the whole system, a new ring of Saturn has been observed inside the two old ones,—what is called from its appearance the crape ring, which was narrow when first observed, but is gradually becoming broader. That is formed of the laggards, as it were, which have been thrown out of the race, and which are gradually falling in towards the planet's surface."*

The process by which, in the case of Saturn's rings, the period of revolution has become less than that of the planet's rotation is here clearly indicated. It is not impossible that a similar process may have been in operation during the forming period of the Martial system. Unless some such explanation as this can be given, the short period of the inner satellite will doubtless be regarded as a conclusive argument against the nebular hypothesis.

Bloomington, Indiana, August 27th, 1877.

V. Miscellaneous Scientific Intelligence.

1. *American Association for the Advancement of Science.*—The twenty-sixth meeting of the American Association opened at Nashville, on Wednesday, August 29th. Professor Newcomb, of Washington, was the President of the meeting. The local committee, consisting of Messrs. Lindsley, Lupton, Safford and others, citizens of Nashville, contributed greatly to the success of the meeting by the arrangements they had made for the reception and entertainment of the members, and for the convenience of the several sessions. The hospitality of the people was unbounded, and the provisions for excursions were of the most generous kind. The attendance was large, though not equal to that of some meetings, owing to the season of the year for a place so far south, and the distance (over a thousand miles) from the Atlantic sea-board.

Through the generosity of Mr. Samuel Watkins, of Nashville, and others of the local committee, there were sent to the association, for distribution among its members, 400 copies of a volume containing as follows: Second Annual report of the Board of Health, gotten out with special reference to this Association; report on the Topography of Nashville, by Major Wilbur F. Foster, illustrated with a map embracing an area of three miles; report on the Geology of Nashville, by Professor Safford, State Geologist; report on the Water-supply, with a careful analysis, by Professor

* Tate's Recent Advances in Phys. Sci., p. 259.

Lupton; report upon the Climate of Nashville, by Dr. A. C. Ford, of the Signal Service; interesting facts in Nashville's history, taken from the newspapers and other sources, by Anson Nelson, Secretary of the Tennessee Historical Society; report by the Health officer upon the Sanitary condition of Nashville; a complete index, by Dr. George Blackie. Dr. Lindsley, through whom the gift was made, said that it was intended as a memorial volume. The gift was received with a hearty vote of thanks.

The place appointed for the meeting in 1878 was St. Louis, and the time, the third Wednesday in August. Professor O. C. MARSH was elected President for the ensuing year; R. B. THURSTON, of Hoboken, New Jersey, Vice-President of Section A; A. R. GROTE, of Buffalo, Vice-President of Section B; and H. C. BOLTON, General Secretary.

The retiring President, Professor W. B. Rogers, was unable to be present at the meeting, and hence the occasion failed of a Presidential Address, which in this case was looked for with high expectations.

The evening session of Wednesday was occupied with a lecture, by Professor Newcomb, on the recent astronomical discoveries—that of the Satellites of Mars by Professor Asaph Hall, and that of oxygen in the atmosphere of the sun by Professor Henry Draper; remarks, by Professor James Hall, on the history of the Association, and the work it had done; a lecture, by Professor J. Lawrence Smith, on meteoric stones; and a paper, by Professor A. R. Grote, on an International Scientific Service.

Professor Marsh, the Vice-President of Section B, occupied Thursday evening with a discourse on the "Introduction and Succession of Vertebrate Life in America," which was rich in facts from his own hard work among the vertebrate fossils of the Rocky Mountain region and other parts of the continent, also from the extended observations of Leidy, Cope, and other investigators in the same field, and which set forth the succession of vertebrate life, and the bearing of the whole on its introduction, with a fulness, as regards mammals, before unequalled. Professor Marsh's paper will appear in the following number of this Journal. On Monday a very valuable discourse was delivered by Professor Daniel Wilson "on the races of America."

The number of important papers read in the several sections was small. The following is a list of those read or accepted for reading.

I. *Section of Mathematics, Astronomy and Physics.*

On a New Type of Steam Engine, theoretically capable of utilizing the full Mechanical Equivalent of Heat Energy; and on some points of Theory indicating its practicability, R. H. THURSTON.—On a new method of planning researches, and of representing to the Eye the Results of Combination of three or more Elements in all possible proportions, id.—The work of the U. S. Board appointed to test iron, steel and other metals, id.

On the proper motion of the Trifid Nebula, M. 20, G. C. 4355, etc., E. S. HOLDEN.

A new Quadruple Objective for Astronomical Telescopes, E. GUNDLACH.—A new Periscopic Eye-piece, id.

On the arbitrary coefficient A (²) in Laplace's expression for the semi-diurnal tide, J. G. BARNARD.

Mechanics of the flight of birds, A. C. CAMPBELL.

The Physics of the Mississippi river below the Red river, C. G. FORSHEY.—The Physics of the Gulf of Mexico, id.

On a Measurement of the wave-length of the Blue line of the Spectrum of Indium, T. C. MENDENHALL.—On the proposed modification in the Metric System in its Introduction into the United States, id.

Improvement in use of the Reflecting Goniometer, H. W. WILEY.

A novel Radiometer, Mr. JEFFREY.

The Monetary Question, E. B. ELLIOTT.—On Standard Time, id.

On the Relation of Organ to Function; or of Form in general to Mode of Energy Received and Exerted, R. L. KIRKPATRICK.

II. *Subsection of Chemistry and Mineralogy.*

A Steam blast for general use in laboratories, with illustrations of same, J. L. SMITH.—Use of a current of steam in boiling liquids with and without precipitates for use in the analytical laboratory, id.—Some remarks on Phosphorus in Iron, id. —A peculiar Silicide of Iron with remarks on artificial Silicides of the metal, id. —On the general methods adopted in the analyses of the American Columbates, id.—On an American tantalite, id.

The action of Dilute Acid upon Ferrous Sulphide made from Cast-iron, F. P. DUNNINGTON.—The Minerals of a Deposit of Antimony Ores in Sevier County, Arkansas, id.

Ethers of some Bile Acids, and specimens, A. SPRINGER.

On the use of Hyposulphite of Soda for the precipitation of Alumina, C. L. MEES.

The various methods of separating and determining Barium, Strontium and Calcium. Part I. Determination of Strontium, P. SCHWEITZER.—On some interesting deductions from the solubility of difficultly soluble substances, id.

Note on the Separation of Iron from Cobalt and Nickel, A. H. ELLIOTT.

On the manufacture of steel by the open hearth process, B. S. HEDRICK.

III. *Section of Geology and Natural History.*

Our Knowledge of the Cotton Worm, A. R. GROTE. — A new Lepidopterous Insect Injurious to Vegetation, id.

On Sex in Flowers, T. MEEHAN.

The Law of Repetition, Miss VIRGINIA K. BOWERS.

On the Respiration of Amia, B. G. WILDER.

Agamous reproduction among the Cynipidæ, H. F. BASSETT.

On the Origin of Structural Variation, E. D. COPE.—On the Classification of the Extinct Fishes of the Lower types, id.

On the Silurian Island of the Cincinnati uplift with reference to its part in Tennessee, J. M. SAFFORD.—Notice of a specimen of Cyrtodonta ventricosa from the Lower Silurian, id.

On the Geographical and Geological Distribution of the genus Beatricea, and of certain other Fossil Corals in the Rocks of the Cincinnati Group, N. S. SHALER. —On the Original Connection of the Eastern and Western Coal-fields of the Ohio Valley, id.—On the continuation of the folds of the Alleghany Chain to the North of the Delaware River, id.—On the Recent Formation of a small Anticlinal Axis in Lincoln County, Kentucky, id.

New specimens from the Water Lime Group at Buffalo, A. R. GROTE and W. H. PITT.

On Geodes, S. J. WALLACE.

On the Annual Deposits of the Missouri River during the Post-Pliocene, J. E. TODD.

The Structure of Eruptive Mountains, J. W. POWELL.—Overplacement, id.

The Variation of certain Fresh Water Mollusks of the United States and their Geographical Distribution, A. G. WETHERBY.

Notes on the Silurian waters of Washoe, Nevada, T. STERRY HUNT.—Notes on the Geology of the Rocky Mountains, id.

Geology and Topography of the Oil Region of Tennessee and the Oil Springs and Wells, J. B. KILLEBREW.

Geology of the Region on the Headwaters of the Androscoggin River, J. H. HUNTINGTON.

A section of McKinny Hill, Tennessee, E. L. DRAKE.

Geological position and mode of origin of Hydrated brown oxide of Iron, E. T. Cox.

On the Fibre of Gossipeum herbaceum (cotton plant) considered with reference to a practical application of its manufacture, J. A. RIDLEY.

On the use to be made of the Post Route Maps in the advancement of Science, B. S. HEDRICK.

Atmospheric Concussion as a Means of Disinfection, Mrs. H. R. INGRAM.

IV. *Subsection of Anthropology.*

On the Origin of the Japanese, S. ISAWA.

The former and present numbers of our Indians, G. MALLERY.

Additional Facts concerning Artificial Perforation of the Cranium in Ancient Mounds in Michigan, H. GILMAN.

Habits of the Moqui Tribe, E. A. BARBER.

Some Popular Errors concerning the North American Indians, J. W. POWELL. —Introduction to the Study of Indian Language, id.

On the ancient excavations in Western North Carolina, A. A. JULIEN.

Report on the Exploration of the Graves of the Mound Builders in Scott and Mississippi Counties, Missouri, H. N. RUST.

Observations on the skull of the Comanche, T. O. SUMMERS, Jr.

2. *Distant Points visible from Mt. Washington;* by W. H. PICKERING. (Read October 11, 1876). If an observer were to go up four particular peaks in the White Mountains, he could see all the distant points visible from any of the other summits, together with a good many more not visible from them. These four peaks are Washington, Moosilauke, Passaconnaway and Lafayette. I name them in the order of the extent of the distant views obtained from them alone. Now looking at the subject the other way, no matter from what distant point the White Mountains are seen, one of these four peaks must always be the most conspicuous object in the view, provided no near hills intervene. By means of the following formulæ the distance visible from any mountain may be readily calculated, and also the elevation a mountain must have in order to see a certain distance: $d = \frac{1}{10}\sqrt{175h}, h = \frac{4}{7}d^2$, where $d =$ distance in miles, and $h =$ elevation in feet. They may also be used to calculate mountain profiles as seen from distant points.

The following is a list of some of the more interesting distant points to be seen from Mt. Washington, many of them being visible only on rare occasions.

Mt. Belœil, Canada: distance 135 miles, position north 45° west, and nearly over Prospect Hill, Lancaster. It is quite a high mountain near Montreal, and is said to be visible. Lake Memphremagog, north border of Vermont: distance 70 miles, position north 40° west, and over Jefferson Hill. It requires a very clear day, as distant water is difficult to distinguish.

Mt. Carmel, Maine: distance 65 miles, position north 10° east, and just over Mt. Adams. It is very near the northern border of Maine, and is readily recognized by the steep slope on the eastern side. It is said that a very fine view may be obtained from it. Mt. Bigelow: distance 70 miles, position north 35° east, and nearly over Mt. Hayes. It appears as three rounded hills. Just to the south of it and far beyond is a mountain with a very sharp apex, which is sometimes called Katahdin, but this is a mistake. Mt. Abraham: distance 65 miles, position north 40° east, and somewhat to the right of Mt. Hayes. A long serrated ridge, also sometimes called Katahdin. Mt. Katahdin, Maine: distance 163 miles, position north 45° east, and about half way between Mt. Hayes and Mt. Moriah. It is said to appear rising over a nearer saddle-shaped mountain, and to be recognized by its sharp peak—the sharpest in all the view from Washington. If visible at all in summer, it would be far the faintest object in sight in that direction. Mt. Blue, Maine: distance 57 miles, position north 57° east, and half way between Surprise and Moriah. It is quite a conspicuous pyramidal peak, and is near Farmington, Maine. It is used as a Coast Survey Station.

Portland, Maine: distance 65 miles, position south 51° east, and over the northern summit of Doublehead. It appears as a low white hill, with a long light blue line beyond it. With a telescope the hill resolves itself into a mass of closely packed white houses, and the blue line is seen to be thickly studded with sails. The Ocean, however, is not as often seen as some more distant objects in other directions, partly on account of the difficulty of distinguishing distant water, and partly because the atmosphere in this direction seems generally to be somewhat thicker than elsewhere. Lake Sebago, Maine: distance 43 miles, position south 48° east, and over Mt. Gemini. It is 14 miles long, and about 11 wide. Mt. Agamenticus, Maine: distance 80 miles, position south 24° east. A flat rounded hill of considerable height in the southern part of Maine, and forms a conspicuous landmark for sailors. Isles of Shoals, coast of New Hampshire: distance 97 miles, position south 22° east. They are very difficult to see, and are situated on the horizon just to the right of Agamenticus. Mt. Uncanoonuc, New Hampshire: distance 92 miles, position south 9° west, and half way between Mts. Crawford and Passaconnaway. Twin summits near Manchester. Mt. Wachusett, Massachusetts; distance 126·5 miles, position south 13° west, and just to the right of Whiteface, if it is visible. Mt. Monadnock, New Hampshire: distance 104·5 miles, position south 22° west, and a little to the right of Sandwich Dome. A very regular rounded summit. Mt. Kearsarge, New Hampshire: distance 70 miles, position south 24° west, and half way between Sandwich Dome and Carrigain.

Mt. Graylock, western Massachusetts: distance 147 miles, position south 40° west, and just over the summit of Mt. Webster. It has a pointed summit and is situated in the northwest corner of Massachusetts, near the Hoosac Tunnel, and is the highest mountain in the State, being 3,505 feet high, or about the same as Chocorua. It is extremely difficult to see, as it is, next to Katahdin, the most distant point visible. The Guide Book says it is 160 miles distant; this, however, is an error.

Mt. Ascutney, Vermont: distance 85 miles, position south 45° west. Situated in Windsor, Vermont, close to the Connecticut

River. Killington Peaks, Green Mountains: distance 91 miles, position south 59° west, and between Mts. Liberty and Blue. Twin peaked summits near Rutland, Vermont. Camel's Hump, Green Mountains: distance 80 miles, position north 87° west, and just over Bethlehem Street. It is a striking looking mountain, shaped like a truncated cone, with very steep sides. Readily visible at sunset on a clear day. Mt. Whiteface, Adirondack Mountains: distance 130 miles, position north 86° west. It is just barely visible, hardly rising above the right hand slope of Camel's Hump. This is one of the highest of the Adirondacks, rising to a height of 4,900 feet. Two lower peaks are seen just to the right, and three more some distance to the left. These however have not yet been identified, but if Mt. Marcy and any of the other higher summits are visible, they should appear about 7° to the south of Whiteface and nearly over the Fabyan House. Mt. Mansfield, Green Mountains: distance 78 miles, position north 78° west, and between the twin Mountain House and Mt. Deception. It is the highest of the Green Mountains, being 4,300 feet high, and appears as a long ridge bearing a fancied resemblance to a human face.—*Appalachia,* No. 2, March, 1877.

3. *Caution to Archæologists.*—The Archæological Section of the Academy of Sciences of St. Louis has issued a circular dated St. Louis, Mo., June 12, 1877, calling the attention of all lovers of science to the following statement of facts:—

"It is well known to all Archæologists that the Mississippi Valley contains a greater number of pre-historic remains than any other portion of the United States. It is the object of this Section to preserve these relics from destruction, and to keep such a record of their discovery and exhumation, as may render them available for scientific purposes. They find this work very much impeded by the operations of persons, who, under the direction of unprincipled traders, in this and other cities, are destroying in every direction the most interesting earthworks and other remains of the ancient races, with the sole object of making money by the sale of such articles as may be found therein.

Attention is also called to the fact, that imitations of the pottery from the Missouri Mounds are also being manufactured, and offered for sale as genuine antiquities. All who purchase collections from dealers thus obtain specimens that may be worthless; or, at best, have a greatly depreciated value, from the absence of the scientific data connected with their discovery.

To remedy this evil as far as possible, the Section has employed properly qualified persons to conduct explorations under their especial direction, and is willing to furnish to scientific bodies, or individuals interested in Archæology, specimens from the duplicates of its collection, either in exchange for articles from other localities, or by sale at a price sufficient only to cover the cost of procuring them. It is hoped that all who are desirous of promoting the interests of scientific enquiry, will aid the Section in its efforts, by refusing to purchase, or in any way countenance the mercenary traffic in antiquities."

The Secretary of the Society is Mr. F. F. Hilder, 604 North Fourth Street, St. Louis.

4. WILSON: *Handbook of Hygiene and Sanitary Science.* 3d edition, enlarged and re-written. 490 pp. 12mo. Philadelphia, 1877. (Lindsay and Blakiston.)—Dr. Wilson's well-known work is now placed, in its original English dress, before American readers. This is a clear, concise and sufficiently full description of the entire range of Sanitary Science, by a man of large experience as a health officer in the public service in Great Britain. The author has no pet theories to sustain and consequently is able to give to all matters falling under his review a fair consideration, while constant reference is made to authorities for fuller data than the limits of his work could admit. The subjeets are treated in a systematic manner and the style makes agreeable reading of even the most technical portions. B. S.

5. *British Association.*—The meeting of the British Association for 1877, opened at Plymouth, on Wednesday, the 15th of August, and the address of the President, Professor Allen Thomson, was delivered on the evening of that day. The address of F. Galton before the section of Anthropology, and that of Mr. Pengelly before that of Geology, are republished on the preceding pages of this volume, from *Nature* of August 16 and 23. Sir William Thomson presented a paper advocating the doctrine suggested briefly in his Presidential address of 1875, that a meteorite might become the vehicle of animal life to this earth from another planet or heavenly body, and "was evidently listened to with much enjoyment." Much amusement was caused by his saying that "though the outside shell of a meteoric stone might be incandescent from the friction caused by its flight through the terrestrial atmosphere, yet within a crevice of that stone might be concealed a Colorado beetle, which, falling on the earth, might become the father of a large and prosperous family." A disbeliever in the doctrine, Professor Haughton, followed with objections, but said "that still he didn't care how many papa beetles came, so long as the mamma beetles were left at home." Among the more valuable papers were the following: on the rate of progression of groups of waves, and the rate at which energy is transmitted by waves, by Osborne Reynolds; on the effect of transverse stress on the magnetic susceptibility of iron, by Sir Wm. Thomson; unit of light for photometry, by A. Vernon Harcourt; on gallium, by Prof. Odling; a new method for studying the optical characters of minerals, by H. C. Sorby; result of tidal observations in the recent Arctic Expedition, by Prof. Haughton; also, by the same, on the best possible number of limbs for an animal; on the results of the North German Exploring Expedition in the west of Siberia, by Dr. Otto Finsch; on the Physical properties of solids and liquids in connection with the Earth's structure, by Professor Hennessy.

It was decided that the fiftieth or jubilee meeting of the Association—in 1881—be held in York, in consideration of the fact that its first meeting—that of 1831—was at that place.

6. *New Constructions in Graphical Statics;* by H. T. Eddy. Van Nostrand, New York: 1877. 8vo, pp. 62 and 9 folding plates. —This work is an application of the methods of Graphical Statics to the arch rib with and without joints, the suspension cable, the continuous girder, the retaining wall, the dome, etc.

The following publications of the U. S. Geological Survey of the Territories, F. V. Hayden in charge, have been received and will be noticed in another number; also other volumes whose titles follow:

Ninth Annual Report, embracing Colorado and parts of adjacent Territories, being a report of progress of the exploration for the year 1875, by F. V. Hayden. 827 pp. 8vo. Washington, 1877.

Report of the United States Geological Survey of the Territories, volume XI. Monographs of North American Rodentia, by Elliott Coues, Secretary and Naturalist of the Survey, and Joel Asaph Allen, Special Collaborator of the Survey. 1091 pp. 4to.

Miscellaneous Publications.—No. 7. Ethnography and Philology of the Hidatsa Indians, by Washington Matthews, Assistant Surgeon U. S. A. 239 pp. 8vo. —No. 8. Fur-bearing Animals: A Monograph of North American Mustelidæ, by Elliott Coues, Captain and Assistant Surgeon U. S. A. 348 pp. 8vo, with twenty plates.

Bulletin of the U. S. Geological and Geographical Survey of the Territories. Volume III, Number 4, August 5th, 1877.

Bulletin of the U. S. National Museum; No. 8.—Index to the names which have been applied to the subdivisions of the class Brachiopoda, by W. H. Dall. 88 pp. 8vo. Washington, 1877.

China: Ergebnisse eigener Reisen und darauf gegründeter Studien von Ferdinand Freiherrn von Richthofen; Band I, 758 pp. 4to, Berlin (New York, L. W. Schmidt).

Mesmerism, Spiritualism, etc. Historically and scientifically considered; being two Lectures delivered at the London Institution, by William B. Carpenter, C.B., etc. 158 pp. 8vo. New York, 1877. (D. Appleton & Co.)

Proceedings of the Davenport Academy of Natural Sciences, Volume I, Part I; January, 1876—June, 1877. Davenport, Iowa.

Jahres-Bericht des Naturhistorischen Vereins von Wisconsin für das Jahr 1876–77. Milwaukee.

The Western Review of Science and Industry, by Theodore S. Case. A monthly of 64 pages, published at Kansas City, Missouri, popular in its character.

Proceedings of the American Association for the Advancement of Science. Twenty-fifth meeting, held at Buffalo, N. Y., August, 1876. 368 pp. 8vo. 1877.

OBITUARY.

Professor Henry Newton, E.M., Ph.D., Professor elect of Mining Engineering and Metallurgy of the Agricultural and Mechanical College of Ohio, at Columbus, died at Deadwood, Dak., on August 5th, in the 32d year of his age. Professor Newton was engaged in a geological examination of the Black Hills, which, begun two years ago, as Assistant Geologist to the United States Black Hills Expedition of the Interior Department. He was endeavoring to bring to completion this season, under the auspices of that branch of the geological explorations of the territories, in charge of Major Powell. Meanwhile Professor Newton, with great assiduity, had prepared a full report of his geological study of that region, with plates of fossils, and numerous drawings of sections and other important illustrations. The publication of this valuable report by the department, as it has more than once happened before with other reports of the same kind, had been grievously delayed—much to the annoyance and disappointment of its young and enthusiastic author, whose health became impaired under such an additional strain upon his nervous system, immediately after very close confinement to office-work. Uninitiated in the ways of the departments at Washington, Professor Newton found no means to proceed to the publication of his report for many months after its date--of the disadvantage of which circumstance he was no less conscious, than apprehensive of the likelihood of having devoted two years of solid work to no purpose. Its publication was provided for last spring, as a part of the series of reports of geological explorations of the territories in charge of Major Powell. With the object of bringing his work down to date, and of revising it by the light of recent industrial developments, Professor Newton returned this season to the Black Hills, where he was fatally stricken with mountain fever, while prosecuting his work.

Professor Newton was for a number of years attached to the School of Mines of Columbia College, where he received his degrees and was Assistant in Geology. During the same period he did excellent service upon the Geological Survey of Ohio. J. P. K.

MOSES STRONG, Assistant Geologist in the Geological Survey of Wisconsin, died on the 18th of last August. Mr. Strong was engaged in a geological examination of the branches of the Chippewa River, and was endeavoring to pass in a skiff some rapids on the Flambeau branch, when the boat was upset, and he was drowned in an attempt to save a young companion who was unable to swim. Earlier in the season, he had explored a large tract occupied by the copper-bearing formation in the region of the Upper St. Croix River, and had examined the Huronian formation of Barron County, and just before his last excursion in behalf of the Geological Survey, he had revised the proof of his contribution to the forthcoming Report of the Geological Survey on his results of the year past. He had also completed and revised the proofs of his report on the Lead region, "which is accompanied by a series of topographical and geological maps that have commanded the unqualified admiration of all who have seen them." Professor T. C. Chamberlain, the director of the survey, states further, that "as a co-laborer in the scientific investigation of the structure of the State, he enjoyed the unhesitating confidence and admiration of his associates. In character he was modest and unassuming, and commanded respect rather by the merits he could not conceal than by any that were assumed. To attractive personal traits he added an integrity that was absolutely above question and a candor and honesty of expression that was eminent."

Mr. Strong, after graduation at Yale College, with the class of 1867, pursued scientific studies at a German University, and had thus thoroughly fitted himself for the work in which he was engaged. He leaves a young wife and children.

Professor ADOLF ERMAN, an eminent German physicist, Professor in the Berlin University, died on the 13th of July, at the age of seventy-one.

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[THIRD SERIES.]

ART. XLII.—*Introduction and Succession of Vertebrate Life in America*; by O. C. MARSH.

[Address before the American Association for the Advancement of Science, at Nashville, Tenn., August 30, 1877.]

THE origin of life, and the order of succession in which its various forms have appeared upon the earth, offer to science its most inviting and most difficult field of research. Although the primal origin of life is unknown, and may perhaps never be known, yet no one has a right to say how much of the mystery now surrounding it science cannot remove. It is certainly within the domain of science to determine when the earth was first fitted to receive life, and in what form the earliest life began. To trace that life in its manifold changes through past ages to the present is a more difficult task, but one from which modern science does not shrink. In this wide field, every earnest effort will meet some degree of success; every year will add new and important facts; and every generation will bring to light some law, in accordance with which ancient life has been changed into life as we see it around us to-day. That such a development has taken place, no one will doubt who has carefully traced any single group of animals through its past history, as recorded in the crust of the earth. The evidence will be especially conclusive, if the group selected belongs to the higher forms of life, which are sensitive to every change in their surroundings. But I am sure I need offer here no argument for evolution; since to doubt evolution to-day is to doubt science, and science is only another name for truth.

Taking, then, evolution as a key to the mysteries of past life on the earth, I invite your attention to the subject I have chosen: THE INTRODUCTION AND SUCCESSION OF VERTEBRATE LIFE IN AMERICA.

In the brief hour allotted to me, I could hardly hope to give more than a very incomplete sketch of what is now known on this subject. I shall, therefore, pass rapidly over the lower groups, and speak more particularly of the higher vertebrates, which have an especial interest to us all, in so far as they approach man in structure, and thus indicate his probable origin. These higher vertebrates, moreover, are most important witnesses of the past, since their superior organization made them ready victims to slight climatic changes, which would otherwise have remained unrecorded.

In considering the ancient life of America, it is important to bear in mind that I can only offer you a brief record of a few of the countless forms that once occupied this continent. The review I can bring before you will not be like that of a great army, when regiment after regiment with full ranks moves by in orderly succession, until the entire host has passed. My review must be more like the roll-call after a battle, when only a few scarred and crippled veterans remain to answer to their names. Or rather, it must resemble an array of relics, dug from the field of some old Trojan combat, long after the contest, when no survivor remains to tell the tale of the strife. From such an ancient battle-field, a Schliemann might unearth together the bronze shield, lance-head, and gilded helmet of a prehistoric leader, and learn from them with certainty his race and rank. Perhaps the skull might still retain the barbaric stone weapon by which his northern foe had slain him. Near by, the explorer might bring to light the commingled coat of mail and trappings of a horse and rider, so strangely different from the equipment of the chief, as to suggest a foreign ally. From these, and from the more common implements of war that fill the soil, the antiquary could determine, by patient study, what nations fought, and, perhaps, when, and why.

By this same method of research, the more ancient strata of the earth have been explored, and, in our Western wilds, veritable battle-fields, strown with the fossil skeletons of the slain, and guarded faithfully by savage superstition, have been despoiled, yielding to science treasures more rare than bronze or gold. Without such spoils, from many fields, I could not have chosen the present theme for my address to-night.

According to present knowledge, no vertebrate life is known to have existed on this continent in the Archæan, Cambrian, or Silurian periods; yet during this time, more than half of the thickness of American stratified rocks was deposited. It by no means follows that vertebrate animals of some kind did not exist here in those remote ages. Fishes are known from the Upper Silurian of Europe, and there is every probability that they will yet be discovered in our strata of the same age, if not at a still lower horizon.

In the shore deposits of the early Devonian sea, known as the Schoharie Grit, characteristic remains of Fishes were preserved, and in the deeper sea that followed, in which the Corniferous limestone was laid down, this class was well represented. During the remainder of the Devonian, Fishes continue abundant in the shallower seas, and, so far as now known, were the only type of vertebrate life. These fishes were mainly Ganoids, a group, represented in our present waters by the Gar-pike (*Lepidosteus*) and Sturgeon (*Acipenser*), but, in the Devonian sea, chiefly by the Placoderms, the exact affinities of which are somewhat in doubt. With these were Elasmobranchs, or the Shark tribe, and among them a few Chimæroids, a peculiar type, of which one or two members still survive. The Placoderms were the monarchs of the ocean. All were well protected by a massive coat of armor, and some of them attained huge dimensions. The American Devonian fishes now known are not as numerous as those of Europe, but they were larger in size, and mostly inhabitants of the open sea. Some twenty genera and forty species have been described.

The more important genera of Placoderms are, *Dinichthys*, *Aspidichthys*, and *Diplognathus*, our largest Palæozoic fishes. Others are, *Acanthaspis*. *Acantholepis*, *Coccosteus*, *Macropetalichthys*, and *Onychodus*. Among the Elasmobranchs were, *Cladodus*, *Ctenacanthus*, *Machæracanthus*, *Rhynchodus*, and *Ptyctodus*, the last two being regarded as Chimæroids. In the Chemung epoch, the great Dipterian family was introduced with *Dipterus*, *Heliodus*, and possibly *Ceratodus*. Species of the European genera, *Bothriolepis* and *Holoptychius*, have likewise been found in our Devonian deposits.

With the close of the Devonian, came the almost total extinction of the great group of Placoderms, while the Elasmobranchs, which had hitherto occupied a subordinate position, increase in numbers and size, and appear to be represented by Sharks, Rays, and Chimæras. Among the members of this group from the Carboniferous, were numerous Cestracionts, species of *Cochliodus* of large size, with others of the genera *Deltodus*, *Helodus*, *Psammodus* and *Sandalodus*. Of the Petalodonts, there were *Antliodus*, *Chomatodus*, *Ctenoptychius*, *Petalodus* and

Petalorhynchus; and of the Hybodonts, the genera *Cladodus, Carcharopsis* and *Diplodus.* These Elasmobranchs were the rulers of the Carboniferous open sea, and more than one hundred species have been found in the lower part of this formation alone. The Ganoids, although still abundant, were of smaller size, and denizens of the more shallow and confined waters. The latter group of fishes was represented by true Lepidostidæ, of the genera *Palæoniscus*, *Amblypterus*, *Platysomus* and *Eurylepis.* Other genera are, *Rhizodus*, *Megalichthys*, *Ctenodus*, *Edestus*, *Orodus*, *Ctenacanthus*, *Gyracanthus*, and *Cœlacanthus.* Most of these genera occur also in Europe.

From the Permian rocks of America, no vertebrate remains are known, although in the same formation of Europe Ganoids are abundant; and with them are remains of Sharks, and some other fishes, the affinities of which are doubtful. The Palæozoic fishes at present known from this country are quite as numerous as those found in Europe.

In the Mesozoic age, the Fishes of America begin to show a decided approach to those of our present waters. From the Triassic rocks, Ganoids only are known, and they are all more or less closely related to the modern Gar-pike, or *Lepidosteus.* They are of small size, and the number of individuals preserved is very large. The characteristic genera are, *Catopterus*, *Ischypterus*, *Ptycholepis*, *Rhabdolepis*, and *Turseodus.* From the Jurassic deposits, no remains of fishes are known, but in the Cretaceous, ichthyic life assumed many and various forms; and the first representatives of the Teleosts, or bony fishes, the characteristic fishes of to-day, make their appearance. In the deep open sea of this age, Elasmobranchs were the prevailing forms, Sharks and Chimæroids being most numerous. In the great inland Cretaceous sea of North America, true osseous fishes were most abundant, and among them were some of carnivorous habits, and immense size. The more sheltered bays and rivers were shared by the Ganoids and Teleosts, as their remains testify. The more common genera of Cretaceous Elasmobranchs were, *Otodus*, *Oxyrhina*, *Galeocerdo*, *Lamna* and *Ptychodus.* Among the osseous fishes, *Beryx*, *Enchodus*, *Portheus* and *Saurocephalus* were especially common, while the most important genus of Ganoids was *Lepidotus.*

The Tertiary fishes are nearly all of modern types, and from the beginning of this period there was comparatively little change. In the marine beds, Sharks, Rays and Chimæroids maintained their supremacy, although Teleosts were abundant, and many of them of large size. The Ganoids were comparatively few in number. In the earliest Eocene fresh-water deposits, it is interesting to find that the modern Gar-pike, and *Amia,* the Dog-fish of our western lakes, which by their structure are seen to be remnants of a very early type, are well represented by species so closely allied to them that only an anatomist could separate the ancient from the modern. In the succeeding beds, these fishes are still abundant, and with them are Siluroids nearly related to the modern Cat-fish (*Pimelodus*). Many small fishes, allied apparently to the modern herring (*Clupea*), left their remains in great numbers in the same deposits, and, with them has been recently found a land-locked Ray (*Heliobatis*).

The almost total absence of remains of fishes from the Miocene lake-basins of the West is a remarkable fact, and perhaps may best be explained by the theory that these inland waters, like many of the smaller lakes in the same region to-day, were so impregnated with mineral matters as to render the existence of vertebrate life in them impossible. No one who has tasted such waters, or has attempted to ford one of the modern alkaline lakes which are often met with on the present surface of the same deposits, will doubt the efficiency of this cause, or the easy entombment of the higher vertebrates that ventured within their borders. In the Pliocene lake-basins of the same region, remains of fishes were not uncommon, and in some of them are very numerous. These are all of modern types, and most of them are Cyprinoids, related to the modern Carp. The Post-pliocene fishes are essentially those of to-day.

In this brief synopsis of the past ichthyic life of this Continent, I have mentioned only a few of the more important facts, but sufficient, I trust, to give an outline of its history. Of this history, it is evident that we have as yet only a very imperfect record. We have seen that the earliest remains of fishes known in this country, are from the lower Devonian; but these old fishes show so great a diversity of form and structure, as to clearly indicate for the class a much earlier origin. In this connection, we must bear in mind that the two lowest groups of existing fishes are entirely without osseous skeletons, and hence, however abundant, would leave no permanent record in the deposits in which remains of fishes are usually preserved. It is safe to infer, from the knowledge which we now possess of the simpler forms of life, that even more of the early fishes were cartilaginous, or so destitute of hard parts as to leave no enduring traces of their existence. Without positive knowledge of such forms, and considering the great diversity of those we have, it would seem a hopeless task at present to attempt to trace successfully the genealogy of this class. One line, however, appears to be direct, from our modern Gar-pike, through the lower Eocene *Lepidosteus* to the *Lepidotus* of the Cretaceous, and perhaps on through the Triassic *Ischypterus* and Carboniferous *Palæoniscus;* but beyond this, in our rocks, it is lost. The living Chimæra of our Pacific coast has nearly allied forms in the Tertiary and Cretaceous, more distant relatives in the Carboniferous, and a possible ancestor in the Devonian *Rhynchodus.* Our Sharks likewise can be traced with some certainty back to the Palæozoic; and even the *Lepidosiren*, of South America, although its immediate predecessors are unknown, has some peculiar characters which strongly point to a Devonian ancestry. These suggestive lines indicate a rich field for investigation in the ancient life-history of American fishes.

The Amphibians, the next higher class of vertebrates, are so closely related to the fishes in structure, that some peculiar forms of the latter have been considered by anatomists as belonging to this group. The earliest evidence of Amphibian existence, on this continent, is in the Sub-Carboniferous, where foot-prints have been found which were probably made by Labyrinthodonts, the most ancient representatives of the class. Well preserved remains are abundant in the Coal Measures, and show that the Labyrinthodonts differed in important particulars from all modern Amphibians, the group which includes our frogs and salamanders. Some of these ancient animals resembled a salamander in shape, while others were serpent-like in form. None of those yet discovered were frog-like, or without a tail, although the restored Labyrinthodont of the text books is thus represented. All were protected by large pectoral bony plates, and an armor of small scutes on the ventral surface of the body. The walls of their teeth were more or less folded, whence the name Labyrinthodont. The American Amphibians known from osseous remains are all of moderate size, but the foot-prints attributed to this group indicate animals larger than any of the class yet found in the old world. The Carboniferous Amphibians were abundant in the swampy tropical forests of that period, and their remains have been found imbedded in the coal then deposited, as well as in hollow stumps of the trees left standing.

The principal genera of this group from American Carboniferous rocks, are, *Sauropus*, known only from footprints, *Baphetes*, *Dendrerpeton*, *Hylonomus*, *Hylerpeton*, *Raniceps*, *Pelion*, *Leptophractus*, *Molgophis*, *Ptyonius*, *Amphibamus*, *Cocytinus*, and *Ceraterpeton*. The last genus occurs also in Europe. Certain of these genera have been considered by some writers to be more nearly related to the Lizards, among true reptiles. Some other genera known from fragmentary remains or footprints in this formation have likewise been referred to the true reptiles, but this question can perhaps be settled only by future discoveries.

No Amphibia are known from American Permian strata, but in the Triassic, a few characteristic remains have been found. The three genera, *Dictyocephalus*, *Dispelor* and *Pariostegus*, have been described, but, although apparently all Labyrinthodonts, the remains preserved are not sufficient to add much to our knowledge of the group. The Triassic foot-prints which have been attributed to Amphibians are still more unsatisfactory, and at present no important conclusions in regard to this class can be based upon them. From the Jurassic and Cretaceous beds of this Continent, no remains of Amphibians are known. A few only have been found in the Tertiary, and these are all of modern types.

The Amphibia are so nearly allied to the Ganoid fishes, that we can hardly doubt their descent from some member of that group. With our present limited knowledge of the extinct forms, however, it would be unprofitable to attempt to trace in detail their probable genealogy.

The authors to whom especial credit is due for our knowledge of American fossil Fishes and Amphibians, are Newberry, Leidy, Cope, Dawson, Agassiz, St. John, Gibbes, Wyman, Redfield, and Emmons, and the principal literature of the subject will be found in their publications.

Reptiles and Birds form the next great division of vertebrates, the Sauropsida, and of these the Reptiles are the older type, and may be first considered. While it may be stated with certainty that there is at present no evidence of the existence of this group in American rocks older than the Carboniferous, there is some doubt in regard to their appearance even in this period. Various foot-prints which strongly resemble those made by Lizards; a few well preserved remains similar to the corresponding bones in that group; and a few characteristic specimens, nearly identical with those from another order of this class, are known from American Coal Measures. These facts, and some others which point in the same direction, render it probable that we may soon have conclusive evidence of the presence of true Reptiles in this formation, and in our overlying Permian, which is essentially a part of the same series. In the Permian rocks of Europe, true Reptiles have been found.

The Mesozoic Period has been called the Age of Reptiles, and during its continuance some of the strangest forms of reptilian life made their appearance, and became extinct. Near its commencement, while the Triassic shales and sandstones were being deposited, true reptiles were abundant. Among the most characteristic remains discovered are those of the genus *Belodon*, which is well known also in the Trias of Europe. It belongs to the Thecodont division of Reptiles, which have teeth in distinct sockets, and its nearest affinities are with the Crocodilia, of which order it may be considered the oldest known representative. In the same strata in which the Belodonts occur, remains of Dinosaurs are found, and it is a most interesting fact that these highest of reptiles should make their appearance, even in a generalized form, at this stage of the earth's history. The Dinosaurs, although true reptiles in all their more important characters, show certain well marked points of resemblance to existing birds of the order *Ratitæ*, a group which includes the Ostriches; and it is not improbable that they were the parent stock from which birds originated.

During Triassic time, the Dinosaurs attained in America an enormous development both in variety of forms and in size. Although comparatively few of their bones have as yet been discovered in the rocks of this country, they have left unmistakable evidence of their presence in the foot-prints and other impressions upon the shores of the waters which they frequented. The Triassic sandstone of the Connecticut Valley has long been famous for its fossil foot-prints, especially the so-called "bird-tracks," which are generally supposed to have been made by birds, the tracks of which many of them closely resemble. A careful investigation, however, of nearly all the specimens yet discovered, has convinced me that there is not a particle of evidence that any of these fossil impressions were made by birds. Most of these three-toed tracks were certainly not made by birds; but by quadrupeds, which usually walked upon their hind feet alone, and only occasionally put to the ground their smaller anterior extremities. I have myself detected the impressions of these anterior limbs in connection with the posterior foot-prints of nearly all of the supposed "bird-tracks" described, and have little doubt that they will eventually be found with all. These double impressions are precisely the kind which Dinosaurian reptiles would make, and as the only characteristic bones yet found in the same rocks belong to animals of this group, it is but fair to attribute all these foot-prints to Dinosaurs, even where no impressions of fore-feet have been detected, until some evidence appears that they were made by Birds. I have no doubt that Birds existed at this time, although at present the proof is wanting.

The principal genera of Triassic Reptiles known from osseous remains in this country are, *Amphisaurus* (*Megadactylus*), from the Connecticut Valley, *Bathygnathus*, from Prince Edward's Island, *Belodon* and *Clepsysaurus*. Other generic names which have been applied to foot-prints and to fragmentary remains, need not be here enumerated. A few remains of Reptiles have been found in undoubted Jurassic rocks of America, but they are not sufficiently well determined to be of service in this connection. Others have been reported from supposed Jurassic strata, which are now known to be Cretaceous. It will thus be seen that, although reptilian life was especially abundant during the Triassic and Jurassic periods, but few bones have been found. This is owing in part to the character of most of the rocks then formed, which were not well fitted for preserving such remains, although admirably adapted to retain foot-prints.

During the Cretaceous Period, Reptilian life in America attained its greatest development, and the sediments laid down in the open seas and estuaries were usually most favorable for the preservation of a faithful record of its various phases. Without such a perfect matrix as some of these deposits afford, many of the most interesting vertebrates recently brought to light from this formation would probably have remained unknown. The vast extent of these beds ensures, moreover, many future discoveries of interest.

In the lowest Cretaceous strata of the Rocky Mountain region, the Dakota group, part of which at least represents the Wealden of Europe, remains of *Chelonia*, or Turtles, Crocodiles, and Dinosaurs occur, the last being especially abundant. The *Chelonia*, although known from the Jurassic of Europe, here appear for the first time in American rocks. Some of the earliest forms are allied to the modern genus *Trionyx*. In the higher Cretaceous beds, some Chelonians of enormous size have been found. They belong to the genus *Atlantochelys*, which has the ribs separate, as in the existing *Sphargis*, and presents other embryonic characters. A few genera appear to be related to the modern genus *Chelone*. The remaining Cretaceous species were mostly of the Emydoid type; and others were related to *Chelydra*. The more important genera of Cretaceous Chelonians known from characteristic specimens are, *Atlantochelys* (*Protostega*), *Adocus*, *Bothremys*, *Compsemys*, *Plastomenus*, *Osteopygis*, *Propleura*, *Lytoloma*, and *Taphrosphys*. Most of these genera were represented by several species, and the individuals were numerous. No land Tortoises have as yet been found in this formation. In American Tertiary deposits, Chelonians are abundant, especially in the fresh-water beds. They all show near affinities with modern types, and most of them can be referred to existing genera. In the Tertiary lake-basins of the West, land Tortoises are very numerous, and with them are many fresh-water forms of *Trionyx* and allied genera.

A striking feature of the American Cretaceous fauna, as contrasted with that of Europe, is the almost entire absence in our strata of species of *Ichthyosaurus* and *Plesiosaurus*, which abound in many other regions, but here seem to be replaced by the Mosasaurs. A few fragmentary remains have indeed been referred to these genera, but the determination may fairly be questioned. This is more than true of the proposed new order *Streptosauria*, which was founded wholly on error. The order *Plesiosauria*, however, is well represented, but mainly by forms more nearly related to the genus *Pliosaurus* than to the type of the group. These were marine reptiles, all of large size, while some of them attained vast dimensions. So far as at present identified, they may be referred to the genera, *Cimoliosaurus*, *Discosaurus* (*Elasmosaurus*), and *Pliosaurus*. The number of species is comparatively few, and none are known above the Cretaceous. The important suggestion of Gegenbaur, that the *Halisauria*, which include the Plesiosaurs, branched off from the Fishes before the Amphibians, finds some support in American specimens recently discovered.

The Reptiles most characteristic of our American Cretaceous strata are the *Mosasauria*, a group with very few representatives in other parts of the world. In our Cretaceous seas, they ruled supreme, as their numbers, size, and carnivorous habits, enabled them to easily vanquish all rivals. Some were at least sixty feet in length, and the smallest ten or twelve. In the inland Cretaceous sea from which the Rocky Mountains were beginning to emerge, these ancient "Sea Serpents" abounded; and many were entombed in its muddy bottom. On one occasion, as I rode through a valley washed out of this old ocean bed, I saw no less than seven different skeletons of these monsters in sight at once. The Mosasaurs were essentially swimming Lizards, with four well developed paddles, and they had little affinity with modern serpents, to which they have been compared. The species are quite numerous, but they belong to comparatively few genera, of which *Mosasaurus*, *Tylosaurus*, *Lestosaurus* and *Edestosaurus*, have alone been identified with certainty. The genus *Mosasaurus* was first found in Europe. All the known species of the group are Cretaceous.

The *Crocodilia* are abundant in rocks of Cretaceous age in America, and two distinct types are represented. The older type, which is foreshadowed by *Belodon* of the Trias, has biconcave vertebræ, and shows marked affinities with the genus *Teleosaurus*, from the Jura of Europe. The best known genus is *Hyposaurus*, of which there are several species, all more or less resembling in form the modern Gavial of the Ganges. A peculiar intermediate form is seen in *Diplosaurus*, from the Wealden of the Rocky Mountains. The second type, which now makes its appearance for the first time, has procœlian vertebræ, and in other respects resembles existing Crocodiles. The genera described are *Bottosaurus*, *Holops* and *Thoracosaurus*, none of which, so far as known, pass above the

Cretaceous. Of *Crocodilia* with opisthocœlous vertebræ, America, so far as we know, has none. Specimens similar to those so termed in Europe, are not uncommon here, but they pertain to Dinosaurs.

In the Eocene fresh-water beds of the West, Crocodilians are especially abundant, and all, with the exception of *Limnosaurus*, belong apparently to the genus *Crocodilus*, although some species show certain points of resemblance to existing Alligators. The Miocene lake-basins of the same region contain no remains of Crocodiles, so far as known, and the Pliocene deposits have afforded only a single species. The Tertiary marine beds of the Atlantic Coast contain comparatively few Crocodilian remains, and all are of modern types; the genus *Gavialis* having one Eocene species, and the Alligator being represented only in the latest deposits.

It is worthy of special mention in this connection, that no true *Lacertilia*, or Lizards, and no *Ophidia*, or Serpents, have yet been detected in American Cretaceous beds; although their remains, if present, would hardly have escaped observation in the regions explored. The former will doubtless be found, as several species occur in the Mesozoic of Europe; and perhaps the latter, although the Ophidians are apparently a more modern type. In the Eocene lake-basins of Western America, remains of Lizards are very numerous, and indicate species much larger than any existing to-day. Some of these, the *Glyptosauridæ*, were protected by a highly ornamented bony coat of mail, and others were covered with scales, like recent Lizards. A few resembled, in their more important characters, the modern Iguana. The genera best represented in the Eocene, are, *Glyptosaurus*, *Iguanavus*, *Oreosaurus*, *Thinosaurus*, *Tinosaurus* and *Saniva*. Some of these genera appear to have continued into the Miocene, but here, as well as in the Pliocene, few remains of this group have been found. It is not improbable that some of our extinct Reptiles may prove to belong to *Rynchocephala*, but at present this is uncertain. The genus *Notosaurus*, from Brazil, has biconcave vertebræ, and some other characters which point to that group. No Dicynodonts or Theriodonts have as yet been found in this country.

The first American Serpents, so far as now known, appear in the Eocene, which contains also the oldest European species. On the Atlantic border, the genus *Titanophis* (*Dinophis*) is represented by several species of large size, one at least thirty feet in length, and all doubtless inhabitants of the sea. In the fresh-water Western Eocene, remains of snakes are abundant, but all are of moderate size. The largest of these were related to the modern Boa Constrictors. The genera described are *Boavus*, *Lithophis* and *Limnophis*. The Miocene and Pliocene

Snakes from the same region are known only from a few fragmentary remains.

The *Pterosauria*, or flying Lizards, are among the most interesting Reptiles of Mesozoic time, and many of them left their remains in the soft sediments of our inland Cretaceous sea. These were veritable Dragons, having a spread of wings of from ten to twenty-five feet. They differed essentially from the smaller Pterodactyls found in the old world, in the entire absence of teeth, showing in this respect a resemblance to modern birds; and they possess other distinctive characters. They have therefore been placed in a new order, *Pteranodontia*, from the typical genus *Pteranodon*, of which five species are known. The only other genus is *Nyctosaurus*, represented by a single species. All the specimens yet found are from essentially the same horizon, in the Chalk of Kansas. The reported discovery of remains of this order from older formations in this country is without foundation.

The strange Reptiles known as *Dinosauria*, which, as we have seen, were numerous during the deposition of our Triassic shales and sandstones, have not yet been found in American Jurassic, but were well represented here throughout the Cretaceous, and at its close became extinct. These animals possess a peculiar interest to the anatomist, since, although reptilian in all their main characters, they show clear affinities with the Birds, and have some features which may point to Mammals. The Cretaceous Dinosaurs were all of large size, and most of them walked on the hind feet alone, like modern Struthious birds. Two well marked types may be distinguished among the remains discovered in deposits of this age: the herbivorous forms, represented mainly by *Hadrosaurus*, a near ally of the *Iguanodon* of Europe; and their carnivorous enemies, of which *Dryptosaurus* (*Lælaps*) may be considered typical in this country, and *Megalosaurus* in Europe. Near the base of our Cretaceous formation, in beds which I regard as the equivalent of the European Wealden, the most gigantic forms of this order yet discovered have recently been brought to light. One of these monsters (*Titanosaurus montanus*), from Colorado, is by far the largest land animal yet discovered; its dimensions being greater than was supposed possible, in an animal that lived and moved upon the land. It was some fifty or sixty feet in length, and, when erect, at least thirty feet in height. It doubtless fed upon the foliage of the mountain forests, portions of which are preserved with its remains. With *Titanosaurus*, the bones of smaller Dinosaurs, one (*Nanosaurus*) not larger than a Cat, as well as those of Crocodiles and Turtles, are not uncommon. The recent discovery of these interesting remains, many and various, in strata that had long been pronounced by professional explorers barren of vertebrate fossils, should teach caution to those who decline to accept the imperfection of our knowledge to-day as a fair plea for the supposed absence of intermediate forms.

In the marine Cretaceous beds of the West, only a single Dinosaur (*Hadrosaurus agilis*), has been found, but in the higher fresh-water beds, which mark the close of this formation, their remains are numerous, and indicate several well marked species, if not genera. In the marine beds on the Atlantic Coast, the bones of Dinosaurs are frequently met with, and in the Upper Cretaceous Greensand of New Jersey, the type specimens of *Hadrosaurus* and *Dryptosaurus* were found. In Cretaceous fresh-water deposits on the coast of Brazil, remains of this order occur, but the specimens hitherto discovered are not sufficiently characteristic for accurate determination. This is unfortunately true of many Dinosaurian fossils from North America, but the great number of these Reptiles which lived here during the Cretaceous Period promises many future discoveries, and substantial additions to our present knowledge of the group.

The first appearance of Birds in America, according to our present knowledge, was during the Cretaceous Period, although many announcements have been made of their existence in preceding epochs. The evidence of their presence in the Trias, based on footprints and other impressions, is, at present, as we have seen, without value: although we may confidently await their discovery there, if not in older formations. *Archæopteryx*, from the European Jura, the oldest bird known, and now fortunately represented by more than a single specimen, clearly indicates a much higher antiquity for the class. The earliest American forms, at present known, are the *Odontornithes*, or Birds with teeth, which have been exhumed within the last few years, from the Chalk of Kansas. The two genera, *Hesperornis* and *Ichthyornis*, are types of distinct orders, and differ from each other and from *Archæopteryx* much more than do any existing birds among themselves; thus showing that Birds are now a closed type, and that the key to the history of the class must be sought for in the distant past.

In *Hesperornis*, we have a large aquatic bird, nearly six feet in length, with a strange combination of characters. The jaws are provided with teeth, set in grooves; the wings were rudimentary, and useless; while the legs were very similar to those of modern diving birds. This last feature was merely an adaptation, as the more important characters are Struthious, showing that *Hesperornis* was essentially a carnivorous swimming Ostrich. *Ichthyornis*, a small flying bird, was stranger still, as the teeth were in sockets; and the vertebræ biconcave, as in Fishes, and a few Reptiles. *Apatornis* and other allied forms occur in the same beds, and probably all were provided with teeth. It is strange that the companions of these ancient toothed Birds should have been Pterodactyls without teeth. In the later Cretaceous beds of the Atlantic Coast, various remains of aquatic Birds have been found, but all are apparently distinct from those of the West. The known genera of American Cretaceous birds are, *Apatornis*, *Baptornis*, *Graculavus*, *Hesperornis*, *Ichthyornis*, *Laornis*, *Lestornis*, *Palæotringa* and *Telmatornis*. These are represented by some twenty species. In Europe, but two species of Cretaceous birds are known, and both are based upon fragmentary specimens.

During the Tertiary period, Birds were numerous in this country, and all yet discovered appear to have belonged to modern types. The Eocene species described are mostly wading birds, but here, and in the later Tertiary deposits, some characteristic American forms make their appearance, strongly foreshadowing our present avian fauna. The extinct genera are the Eocene *Uintornis*, related to the Woodpeckers, and *Aletornis*, which includes several species of Waders. Among the existing genera found in our Tertiary beds are, *Aquila*, *Bubo*, *Meleagris*, *Grus*, *Graculus*, *Puffinus, and Catarractes.* The Great Auk (*Alca impennis*), which was once very abundant on our Northeast Coast, has become extinct within a few years.

In this brief summary of the past life of Reptiles and Birds in America, I have endeavored to exclude doubtful forms, and those very imperfectly known, preferring to present the conclusions reached by careful study, incomplete though they be, rather than weary you with a descriptive catalogue of all the fossils to which names have been applied. Even this condensed review can hardly fail to give you some conception of the wealth of our continent in the extinct forms of these groups, and thus to suggest what its actual life must have been.

Although the Trias offers at present the first unquestioned evidence of true Reptiles, we certainly should not be justified in supposing for a moment that older forms did not exist. So too in considering the different groups of Reptiles, which seem to make their first appearance at certain horizons, flourish for a time, and then decline, or disappear, every day brings evidence to show that they are but fragments of the unraveled strands which converge in the past to form the mystic cord uniting all life. If the attempt is made to follow back any single thread, and thus trace the lineage of a group, we are met by difficulties which the science of to-day can only partially remove. And yet the anatomist constantly sees in the fragments which he studies hints of relationship which are to him sure prophecies of future discoveries.

The genealogy of the *Chelonia* is at present unknown, and our American extinct forms, so far as we now have them, throw little light on their ancestry. This is essentially true, also, of our *Plesiosauria*, *Lacertilia* and *Ophidia*, although suggestive facts are not wanting to indicate possible lines of descent. With the *Crocodilia*, however, the case seems to be different, and Huxley has clearly pointed out the path for investigation. It is probable that material already exists in our museums for tracing the group through several important steps in its development. We have already seen that the modern procœlian type of this order goes back only to the Upper Cretaceous, while the *Belodonts*, of our Triassic rocks, with their biconcave vertebræ, are the oldest known Crocodilians. Our Jurassic, unfortunately, throws but little light on the intermediate forms, but we know that the line was continued, as it was in the old world through *Teleosaurus*. The beds of the Rocky Mountain Wealden have just furnished us with a genuine "missing link," a saurian (*Diplosaurus*) with essentially the skull and teeth of a modern Crocodile, and the vertebræ of its predecessor from the Trias. This peculiar reptile clearly represents an important stage in the progressive series, and evidently one soon after the separation of the Crocodile branch from the main stem. The modern Gavial type appears to have been developed about the same time, as the form was well established in the Upper Cretaceous genus, *Thoracosaurus*. The Teleosaurian group, with biconcave vertebræ, evidently the parent stock of Crocodilians, became extinct with *Hyposaurus* of the same horizon, leaving the Crocodile and Gavial, with their more perfect procœlian vertebræ, to contend for the supremacy. In the early Eocene, both of these types were abundant, but some of the Crocodiles possessed characters pointing towards the Alligators, which do not appear to have been completely differentiated until later.

Nothing is really known to-day of the earlier genealogy of the *Pterosauria*, but our American forms, without teeth, are clearly the last stage in their development before this peculiar group became extinct. The oldest European form, *Dimorphodon*, from the Lower Lias, had the entire jaws armed with teeth, and was provided with a long tail. The later genus *Pterodactylus* retained the teeth, but had essentially lost the tail; while *Ramphorhynchus* had retained the elongated tail, but had lost the teeth from the fore part of both jaws. In the genus *Pteranodon* from the American Cretaceous, the teeth are entirely absent, and the tail is a mere rudiment. In the gradual loss of the teeth and tail, these reptiles followed the same path as Birds, and might thus seem to approach them, as many have supposed. This resemblance, however, is only a superficial one, as a study of the more important characters of the Pterodactyls shows that they are an aberrant type of Reptiles, totally off the line through which the Birds were developed. The announcement made not long since in Europe, and accepted by some American authors, that the *Pterosauria*, in consequence of certain points in their structure, were essentially Birds, is directly disproved by American specimens, far more perfect than those on which the conclusion was based.

It is now generally admitted by biologists who have made a study of the vertebrates, that Birds have come down to us through the Dinosaurs, and the close affinity of the latter with recent Struthious Birds will hardly be questioned. The case amounts almost to a demonstration, if we compare, with Dinosaurs, their contemporaries, the Mesozoic Birds. The classes of Birds and Reptiles, as now living, are separated by a gulf so profound that a few years since it was cited by the opponents of evolution as the most important break in the animal series, and one which that doctrine could not bridge over. Since then, as Huxley has clearly shown, this gap has been virtually filled by the discovery of bird-like Reptiles and reptilian Birds. *Compsognathus* and *Archæopteryx* of the Old World, and *Ichthyornis* and *Hesperornis* of the New, are the stepping stones by which the evolutionist of to-day leads the doubting brother across the shallow remnant of the gulf, once thought impassable.

It remains now to consider the highest group of the Animal Kingdom, the class *Mammalia*, which includes Man. Of the existence of this class before the Trias we have no evidence, either in this country or in the Old World, and it is a significant fact that at essentially the same horizon in each hemisphere, similar low forms of Mammals make their appearance. Although only a few incomplete specimens have been discovered, they are characteristic and well preserved, and all are apparently Marsupials, the lowest Mammalian group which we know in this country, living or fossil. The American Triassic Mammals are known at present only from two small lower jaws, on which is based the genus *Dromotherium*, supposed to be related to the insect-eating *Myrmecobius*, now living in Australia.

Although the Jura of Europe has yielded other similar Mammals, we have as yet none of this class from that formation; while, from rocks of Cretaceous age, no Mammals are known in any part of the world. This is especially to be regretted, as it is evidently to the Cretaceous that we must look for the first representatives of many of our present groups of Mammals, as well as for indications of their more ancient lineage. That some discovery of this nature from the Cretaceous is near at hand, I cannot doubt, when I consider what the last few years have brought to light in the Eocene.

In the lowest Tertiary beds of this country, a rich Mammalian fauna suddenly makes its appearance, and from that time through the Age of Mammals to the present, America has been constantly occupied by this type of life in the greatest diversity of form. Fortunately, a nearly continuous record of this life, as preserved, is now accessible to us, and ensures great additions to our knowledge of the genealogy of Mammals, and perhaps the solution of more profound problems. Before proceeding to discuss in detail American fossil *Mammalia*, it is important to define the divisions of time indicated in our Tertiary and Post-Tertiary deposits, as these in many cases mark successive stages in the development of the mammals.

The boundary line between the Cretaceous and Tertiary in the region of the Rocky Mountains has been much in dispute during the last few years, mainly in consequence of the uncertain geological bearings of the fossil plants found near this horizon. The accompanying invertebrate fossils have thrown little light on the question, which is essentially, whether the great Lignite series of the West is uppermost Cretaceous, or lowest Eocene. The evidence of the numerous vertebrate remains is, in my judgment, decisive, and in favor of the former view.

This brings up an important point in Palæontology, one to which my attention was drawn several years since, namely: the comparative value of different groups of fossils in marking geological time. In examining the subject with some care, I found that, for this purpose, plants, as their nature indicates, are most unsatisfactory witnesses; that invertebrate animals are much better; and that vertebrates afford the most reliable evidence of climatic and other geological changes. The subdivisions of the latter group, moreover, and in fact all forms of animal life, are of value in this respect, mainly according to the perfection of their organization, or zoological rank. Fishes, for example, are but slightly affected by changes that would destroy Reptiles or Birds, and the higher Mammals succumb under influences that the lower forms pass through in safety. The more special applications of this general law, and its value in geology, will readily suggest themselves.

The evidence offered by fossil remains is, in the light of this law, conclusive, that the line, if line there be, separating our Cretaceous from the Tertiary, must at present be drawn where the Dinosaurs and other Mesozoic vertebrates disappear, and are replaced by the Mammals, henceforth the dominant type.

The Tertiary of Western America comprises the most extensive series of deposits of this age known to geologists, and important breaks in both the rocks and the fossils separate it into three well-marked divisions. These natural divisions are not the exact equivalents of the Eocene, Miocene, and Pliocene of Europe, although usually so considered, and known by the same names; but, in general, the fauna of each appears to be older than that of its corresponding representative in the other hemisphere; an important fact, not hitherto recognized. This partial resemblance of our extinct faunas to others in regions widely separated, where the formations are doubtless somewhat different in geological age, is precisely what we might expect, if, as was probable, the main migrations took place from this Continent. It is better at once to recognize this principle, rather than attempt to bring into exact parallelism, formations that were not strictly contemporaneous.

The freshwater Eocene deposits of our Western Territories, which are in the same region at least two miles in vertical thickness, may be separated into three distinct subdivisions. The lowest of these, resting unconformably on the Cretaceous, has been termed the Vermilion Creek, or Wahsatch, Group. It contains a well-marked mammalian fauna, the largest and most characteristic genus of which is the ungulate *Coryphodon*, and hence I have called these deposits the Coryphodon Beds. The middle Eocene strata, which have been termed the Green River and Bridger Series, may be designated as the Dinoceras Beds, as the gigantic animals of this order are only found here. The uppermost Eocene, or the Uintah Group, is especially well characterized by large mammals of the genus *Diplacodon*, and hence may be termed the Diplacodon Beds. The fauna of each of these three subdivisions was essentially distinct, and the fossil remains of each were entombed in different and successive ancient lakes. It is important to remember that these Eocene lake-basins all lie between the Rocky Mountains on the east and the Wahsatch Range on the west, or along the high central plateau of the Continent. As these mountain chains were elevated, the enclosed Cretaceous sea, cut off from the ocean, gradually freshened, and formed these extensive lakes, while the surrounding land was covered with a luxuriant tropical vegetation, and with many strange forms of animal life. As the upward movement of this region continued, these lake-basins, which for ages had been filling up, preserving in their sediments a faithful record of Eocene life-history, were slowly drained by the constant deepening of the outflowing rivers, and they have since remained essentially dry land.

The Miocene lake-basins are on the flanks of this region, where only land had been since the close of the Cretaceous. These basins contain three faunas, nearly or quite distinct. The lowest Miocene, which is only found east of the Rocky Mountains, alone contains the peculiar mammals known as the *Brontotheridæ*, and these deposits may be called the Brontotherium Beds. The strata next above, which represent the middle Miocene, have as their most characteristic fossil the genus *Oreodon*, and are known as the Oreodon Beds. The upper Miocene, which occurs in Oregon, is of great thickness, and from one of its most important fossils, *Miohippus*, may be designated as the Miohippus Series. The climate here during this period was warm temperate.

Above the Miocene, east of the Rocky Mountains and on the Pacific Coast, the Pliocene is well developed, and is rich in vertebrate remains. The strata rest unconformably on the Miocene, and there is a well marked faunal change at this point, modern types now first making their appearance. For these reasons, we are justified in separating the Miocene from the Pliocene at this break; although in Europe where no marked break exists, the line seems to have been drawn at a somewhat higher horizon. Our Pliocene forms essentially a continuous series, although the upper beds may be distinguished from the lower by the presence of a true *Equus*, and some other existing genera. The Pliocene climate was similar to that of the Miocene. The Post-Pliocene beds contain many extinct mammals, and may thus be separated from recent deposits.

Returning now to our subject from this geological digression,—which will hardly be deemed unprofitable, since I have given you in few words the results of a great deal of hard mountain work,—let us consider the Tertiary mammals, as we know them from the remains already discovered, and attempt to trace the history of each order down to the present time. We have seen that a single small Marsupial, from the Trias, is the only mammal found in all the American rocks below the Eocene; and yet in beds of this age, immediately over the Chalk, fossil mammals of many different kinds abound.

The Marsupials, strange to say, are here few in number, and diminutive in size; and have as yet been identified only by fragmentary specimens, and most of them too imperfect for accurate description. In the higher Eocene deposits, this group is more abundant, but still represented by small animals, most of them insectivorous, or carnivorous in habit, like the existing Opossum. From the Miocene and Pliocene, no remains of Marsupials have been described. From the Post-Tertiary, only specimens nearly allied to those now living are known, and most of these were found in the caves of South America.

The Edentate Mammals are evidently an American type, and on this Continent attained a great development in numbers and size. No Eocene Edentates have been found here, and although their discovery in this formation has been announced, the identification proves to have been erroneous. In the Miocene of the Pacific Coast, a few fossils have been discovered which belong to animals of this group, and to the genus *Moropus*.

There are two species, one about as large as a Tapir, and the other nearly twice that size. This genus is the type of a distinct family, the *Moropodidæ.* In the lower Pliocene above, well preserved remains of Edentates of very large size have been found at several widely separated localities in Idaho and California. These belong to the genus *Morotherium*, of which two species are known. East of the Rocky Mountains, in the lower Pliocene of Nebraska, a large species apparently of the genus *Moropus* has been discovered. The horizon of these later fossils corresponds nearly with beds in Europe that have been called Miocene. In the Post-Pliocene of North America, gigantic Edentates were very numerous and widely distributed, but all disappeared with the close of that period. These forms were essentially huge Sloths, and the more important genera were *Megatherium*, *Mylodon* and *Megalonyx.* The genera *Megalocnus* and *Myomorphus* have been found only in Cuba.

In South America during the Pliocene or Post-Pliocene, enormous Edentates were still more abundant, and their remains are usually in such perfect preservation as to suggest a very recent period for their extinction. The Sloth tribe is represented by the huge *Mylodon*, *Megatherium*, *Megalonyx*, *Cœlodon*, *Ochotherium*, *Gnathopis*, *Lestodon*, *Scelidotherium*, and *Sphænodon;* and among the Armadilloes were *Chlamydotherium*, *Eurydon*, *Glyptodon*, *Heterodon*, *Pachytherium* and *Schistopleurum.* *Glossotherium*, another extinct genus, is supposed to be allied to the Ant-eaters.

It is frequently asserted, and very generally believed, that the large number of huge *Edentata* which lived in North America during the Post-Pliocene, were the results of an extensive migration from South America soon after the elevation of the Isthmus of Panama, near the close of the Tertiary. No conclusive proof of such migration has been offered, and the evidence, it seems to me, so far as we now have it, is directly opposed to this view. No undoubted Tertiary Edentates have yet been discovered in South America, while we have at least two species in our Miocene, and during the deposition of our lower Pliocene, large individuals of this group were not uncommon as far north as the forty-third parallel of latitude, on both sides of the Rocky Mountains. In view of these facts, and others which I shall lay before you, it seems more natural to conclude from our present knowledge, that the migration, which no doubt took place, was from north to south. The Edentates finding thus in South America a congenial home flourished greatly for a time, and although the larger forms are now all extinct, diminutive representatives of the group still inhabit the same region.

The *Cetacea* first appear in the Eocene, as in Europe, and are comparatively abundant in deposits of this age on the Atlantic Coast. The most interesting remains of this order, yet found, belong to the *Zeuglodontidæ*, which are carnivorous whales, and the only animals of the order with teeth implanted by two roots. The principal genera of this family are *Zeuglodon* and *Squalodon*, the former genus being represented by gigantic forms, some of which were seventy feet in length. The genus *Saurocetes*, which includes some small animals of this group, has been found in South America. The Dolphin family (*Delphinidæ*) are well represented in the Miocene, both on the Atlantic and Pacific Coast. The best known genus is *Priscodelphinus*, of which several species have been described. Several other generic names which have been applied to fragments need not here be enumerated. In none of the Tertiary species of this family were the cervical vertebræ ankylosed. The Sperm Whales (*Catodontidæ*) were also abundant throughout the Tertiary, and with them in the earlier beds, various Ziphioid forms have been found. The toothless *Balænidæ* are only known with certainty as fossils from the later Tertiary and more recent deposits.

The Sirenians, which appear first in the Eocene of the Old World, occur in the Miocene of our Eastern Coast, and throughout the later Tertiary. The specimens described have all been referred to the genus *Manatus*, and seem closely related to our living species. In the Tertiary of Jamaica, a skull has been found which indicates a new genus, *Prorastomus*, also allied to the existing Manatee. The genus *Rhytina*, once abundant on our Northwest Coast, has recently become extinct.

The Ungulates are the most abundant Mammals in the Tertiary, and the most important; since they include a great variety of types, some of which we can trace through their various changes down to the modified forms that represent them to-day. Of the various divisions in this comprehensive group, the Perissodactyle, or odd-toed Ungulates, are evidently the oldest, and throughout the Eocene are the prevailing forms. Although all of the Perissodactyles of the earlier Tertiary are more or less generalized, they are still quite distinct from the Artiodactyles, even at the base of the Eocene. One family, however, the *Coryphodontidæ*, which is well represented at this horizon, both in America and Europe, although essentially *Perissodactyle*, possesses some characters which point to a primitive Ungulate type from which the present orders have been evolved. Among these characters are the diminutive brain, which in size and form approaches that of the Reptiles, and also the five-toed feet from which all the various forms of the mammalian foot have been derived. Of this family, only a single genus, *Coryphodon* (*Bathmodon*), is known, but there were several distinct species. They were the largest mammals of the lower Eocene, some exceeding in size the existing Tapirs.

In the middle Eocene, West of the Rocky Mountains, a remarkable group of ungulates makes its appearance. These animals nearly equaled the Elephant in size, but had shorter limbs. The skull was armed with two or three pairs of horn-cores, and with enormous canine tusks. The brain was proportionally smaller than in any other land mammal. The feet had five toes, and resembled in their general structure those of *Coryphodon*, thus indicating some affinity with that genus. These mammals resemble in some respects the Perissodactyles, and in others the Proboscidians, yet differ so widely from any known Ungulates, recent or fossil, that they must be regarded as forming a distinct order, the *Dinocerata*. Only three genera are known, *Dinoceras*, *Tinoceras* and *Uintatherium*, but quite a number of species have been described. During the later part of the middle Eocene, these animals were very abundant for a short time, and then became extinct, leaving apparently no successors, unless possibly we have in the Proboscidians their much modified descendants. Their genetic connection with the Coryphodonts is much more probable, in view of what we now know of the two groups.

Besides these peculiar Mammals, which are extinct, and mainly of interest to the Biologist, there were others in the early Tertiary which remind us of those at present living around us. When a student in Germany some twelve years ago, I heard a world-renowned Professor of Zoology gravely inform his pupils that the Horse was a gift of the Old World to the New, and was entirely unknown in America until introduced by the Spaniards. After the lecture, I asked him whether no earlier remains of horses had been found on this Continent, and was told in reply that the reports to that effect were too unsatisfactory to be presented as facts in science. This remark led me, on my return, to examine the subject myself, and I have since unearthed, with my own hands, not less than thirty distinct species of the horse tribe, in the Tertiary deposits of the West alone; and it is now, I think generally admitted that America is, after all, the true home of the Horse.

I can offer you no better illustration than this of the advance vertebrate palæontology has made during the last decade, or of the important contributions to this progress which our Rocky Mountain region has supplied.

The oldest representative of the horse, at present known, is the diminutive *Eohippus* from the lower Eocene. Several species have been found, all about the size of a fox. Like most of the early mammals, these Ungulates had forty-four teeth, the molars with short crowns, and quite distinct in form from the premolars. The ulna and the fibula were entire and distinct, and there were four well developed toes and a rudiment of another on the fore feet, and three toes behind. In the structure of the feet, and in the teeth, the *Eohippus* indicates unmistakably that the direct ancestral line to the modern horse has already separated from the other Perissodactyles. In the next higher division of the Eocene, another genus (*Orohippus*) makes its appearance, replacing *Eohippus*, and showing a greater, although still distant, resemblance to the Equine type. The rudimentary first digit of the fore foot has disappeared, and the last premolar has gone over to the molar series. *Orohippus* was but little larger than *Eohippus*, and in most other respects very similar. Several species have been found in the same horizon with *Dinoceras*, and others lived during the upper Eocene with *Diplacodon*, but none later.

Near the base of the Miocene, in the Brontotherium beds, we find a third closely allied genus, *Mesohippus*, which is about as large as a sheep, and one stage nearer the horse. There are only three toes and a rudimentary splint bone on the fore feet, and three toes behind. Two of the premolar teeth are quite like the molars. The ulna is no longer distinct, or the fibula entire, and other characters show clearly that the transition is advancing. In the upper Miocene, *Mesohippus* is not found, but in its place a fourth form, *Miohippus*, continues the line. This genus is near the *Anchitherium* of Europe, but presents several important differences. The three toes in each foot are more nearly of a size, and a rudiment of the fifth metacarpal bone is retained. All the known species of this genus are larger than those of *Mesohippus*, and none pass above the Miocene.

The genus *Protohippus* of the lower Pliocene, is yet more equine, and some of its species equaled the ass in size. There are still three toes on each foot, but only the middle one, corresponding to the single toe of the horse, comes to the ground. This genus resembles most nearly the *Hipparion* of Europe. In the Pliocene, we have the last stage of the series before reaching the horse, in the genus *Pliohippus*, which has lost the small hooflets, and in other respects is very equine. Only in the upper Pliocene, does the true *Equus* appear, and complete the genealogy of the Horse, which in the Post-Tertiary roamed over the whole of North and South America, and soon after became extinct. This occurred long before the discovery of the Continent by Europeans, and no satisfactory reason for the extinction has yet been given. Besides the characters I have mentioned, there are many others, in the skeleton, skull, teeth, and brain of the forty or more intermediate species, which show that the transition from the Eocene *Eohippus* to the modern *Equus*, has taken place in the order indicated, and I believe the specimens now at New Haven will demonstrate the fact to any anatomist. They certainly carried prompt conviction to the first of anatomists, who was the honored guest of the Association a year ago, whose genius had already indicated the later genealogy of the horse in Europe, and whose own researches so well qualified him to appreciate the evidence here laid before him. Did time permit, I might give you at least a probable explanation of this marvellous change, but justice to the comrades of the horse in his long struggle for existence demands that some notice of their efforts should be placed on record.

Beside the Horse and his congeners, the only existing Perissodactyles are the Rhinoceros and the Tapir. The last is the oldest type, but the Rhinoceros had near allies throughout the Tertiary; and, in view of the continuity of the equine line, it is well worth while to attempt to trace his pedigree. At the bottom of the Eocene, in our Western lake-basins, the tapiroid genus *Helaletes* is found, represented by numerous small mammals hardly larger than the diminutive horses of that day. In the following epoch of the Eocene, the closely allied *Hyrachyus* was one of the most abundant animals. This genus was nearly related to the *Lophiodon* of Europe, and in its teeth and skeleton strongly resembled the living Tapir; whose ancestry, to this point, seems to coincide with that of the Rhinoceros we are considering. Strangely enough, the Rhinoceros line, before it becomes distinct, separates into two branches. In the upper part of the Dinoceras Beds, we have the genus *Colonoceras*, which is really a *Hyrachyus* with a transverse pair of very rudimentary horn-cores on the nasal bones. In the lower Miocene west of the Rocky Mountains, this line seems to pass on through the genus *Diceratherium*, and in the higher Miocene this genus is well represented. Some of the species nearly equaled in size the existing Rhinoceros, which *Diceratherium* strongly resembled. The main difference between them is a most interesting one. The rudimentary horn-cores on the nasals, seen in *Colonoceras*, are in *Diceratherium* developed into strong bony supports for horns, which were placed transversely, as in the Ruminants, and not on the median line, as in all existing forms of Rhinoceros. In the Pliocene of the Pacific Coast, a large Rhinoceros has been discovered, which may be a descendant of *Diceratherium*, but as the nasal bones have not been found, we must wait for further evidence on this point. Returning now to the other branch of the Rhinoceros group, which left their remains mainly East of the Rocky Mountains, we find that all the known forms are hornless. The upper Eocene genus *Amynodon* is the oldest known Rhinoceros, and by far the most generalized of the family.

The premolars are all unlike the molars, the four canines are of large size, but the inner incisor in each jaw is lost in the fully adult animal. The nasals were without horns. There were four toes in front, and three behind. The genus *Hyracodon*, of the Miocene, which is essentially a Rhinoceros, has a full set of incisor and canine teeth; and the molars are so nearly like those of its predecessor *Hyrachyus*, that no one will question the transformation of the older into the newer type. *Hyracodon*, however, appears to be off the true line, for it has but three toes in front. In the higher Miocene beds, and possibly with *Hyracodon*, occurs a larger Rhinoceros, which has been referred to the genus *Aceratherium*. This form has lost the canine and one incisor above, and two incisors below. In the Pliocene are several species closely related, and of large size. Above the Pliocene in America, no vestiges of the Rhinoceros have been found, and our American forms doubtless became extinct at the close of this period.

The Tapir is clearly an old American type, and we have seen that, in the Eocene, the genera *Helaletes* and *Hyrachyus* were so strongly tapiroid in their principal characters, that the main line of descent probably passed through them. It is remarkable that the Miocene of the West, so greatly developed as it is on both sides of the Rocky Mountains, should have yielded but a few fragments of tapiroid mammals, and the same is true of the Pliocene of that region. In the Miocene of the Atlantic Coast, too, only a few imperfect specimens have been found. These forms all apparently belong to the genus *Tapiravus*, although most of them have been referred to *Lophiodon*, a lower Eocene type. In the Post-Tertiary, a true *Tapirus* was abundant, and its remains have been found in various parts of North America. The line of descent, although indistinct through the middle and upper Tertiary, was doubtless continuous in America, and several species exist at present, from Mexico southward. It is worthy of notice that the species North of the Isthmus of Panama appear all to be generically distinct from those of South America.

In addition to these three Perissodactyle types which, as the fittest, have alone survived, and whose lineage I have endeavored to trace, there were many others in early Tertiary times. Some of these disappeared with the close of the Eocene, while others continued, and assumed strange specialized shapes in the Miocene, before their decline and extinction. One series of the latter deserves especial mention, as it includes one of the most interesting families of our extinct animals. Among the large mammals in the lower Eocene is *Limnohyus*, a true Perissodactyle, but only known here from fragments of the skeleton. In the next higher beds, this genus is well represented, and with it is found a nearly allied form, *Palæosyops*. In the upper Eocene, both have left the field, and the genus *Diplacodon*, a very near relative, holds the supremacy. The line seems clear through these three genera, but on crossing the break into the Miocene, we have, apparently as next of kin, the huge *Brontotheridæ*. These strange beasts show in their dentition and some other characters the same transition steps beyond *Diplacodon*, which that genus had made beyond *Palæosyops*. The *Brontotheridæ* were nearly as large as the Elephant, but had much shorter limbs. The skull was elongated, and had a transverse pair of large horn-cores on the maxillaries, in front of the orbits, like the middle pair in *Dinoceras*. There were four toes in front, and three behind, and the feet were similar to those of the Rhinoceros. There are four genera in this group, *Brontotherium*; *Diconodon*; *Menodus* (*Titanotherium*); and *Megacerops*, which have been found only in the lowest Miocene, east of the Rocky Mountains.

In the higher Miocene beds of Oregon, an allied genus, *Chalicotherium*, makes its appearance. It is one stage further on in the transition, and perhaps a descendant of the *Brontotheridæ*; but here, so far as now known, the line disappears. It is a suggestive fact, that this genus has now been found in Western America, China, India, Greece, Germany and France, indicating thus, as I believe, the path by which many of our ancient mammals helped to people the so-called Old World.

The Artiodactyles, or even-toed Ungulates, are the most abundant of the larger mammals now living; and the group dates back at least to the lowest Eocene. Of the two well marked divisions of this order, the Bunodonts and the Selenodonts, as happily defined by Kowalevsky, the former is the older type, which must have separated from the Perissodactyle line after the latter had become differentiated from the primitive Ungulate. In the Coryphodon Beds of New Mexico, occurs the oldest Artiodactyle yet found, but it is at present known only from fragmentary specimens. These remains are clearly Suilline in character, and belong to the genus *Eohyus*. In the beds above, and possibly even in the same horizon, the genus *Helohyus* is not uncommon, and several species are known. The molar teeth of this genus are very similar to those of the Eocene *Hyracotherium*, of Europe, which is supposed to be a Perissodactyle, while *Helohyus* certainly is not, but apparently a true lineal ancestor of the existing pigs. In every vigorous primitive type which was destined to survive many geological changes, there seems to have been a tendency to throw off lateral branches, which became highly specialized and soon died out, because they are unable to adapt themselves to new conditions. The narrow path of the persistent Suilline type, throughout the whole Tertiary, is strown with the remains of such ambitious offshoots, while the typical pig, with an obstinacy never lost, has held on in spite of Catastrophes and Evolution, and still lives in America to-day. In the lower Eocene, we have in the genus *Parahyus* apparently one of these short-lived, specialized branches. It attained a much larger size than the true lineal forms, and the number of its teeth was reduced. In the Dinoceras Beds, or middle Eocene, we have still, on or near the true line, *Helohyus*, which is the last of the series known from the American Eocene. All these early Suillines, with the possible exception of *Parahyus*, appear to have had at least four toes, all of usable size.

In the lower Miocene, we find the genus *Perchœrus*, seemingly a true Suilline, and with it remains of a larger form, *Elotherium*, are abundant. The latter genus occurs in Europe in nearly the same horizon, and the specimens known from each Continent agree closely in general characters. The name *Pelonax* has been applied erroneously to some of the American forms; but the specimens on which it was based clearly belong to *Elotherium*. This genus affords another example of the aberrant Suilline offshoots, already mentioned. Some of the species were nearly as large as a Rhinoceros, and in all there were but two serviceable toes; the outer digits, seen in living animals of this group, being represented only by small rudiments concealed beneath the skin. In the upper Miocene of Oregon, Suillines are abundant, and almost all belong to the genus *Thinohyus*, a near ally of the modern Peccary (*Dicotyles*), but having a greater number of teeth, and a few other distinguishing features. In the Pliocene, Suillines are still numerous, and all the American forms yet discovered are closely related to *Dicotyles*. The genus *Platygonus* is represented by several species, one of which was very abundant in the Post-Tertiary of North America, and is apparently the last example of a side branch, before the American Suillines culminate in existing Peccaries. The feet in this species are more specialized than in the living forms, and approach some of the peculiar features of the ruminants; as for example a strong tendency to coalescence in the metapodial bones. The genus *Platygonus* became extinct in the Post-Tertiary, and the later and existing species are all true Peccaries. No authenticated remains of the genera *Sus*, *Porcus*, *Phacochœrus*, or the allied *Hippopotamus*, the Old World Suillines, have been found in America, although several announcements to that effect have been made.

In the series of generic forms between the lower Eocene *Eohyus* and the existing *Dicotyles*, which I have very briefly discussed, we have apparently the ancestral line ending in the typical American Suillines. Although the demonstration is not yet as complete as in the lineage of the Horse, this is not owing to want of material, but rather to the fact that the actual changes which transformed the early Tertiary pig into the modern Peccary were comparatively slight, so far as they are indicated in the skeletons preserved, while the lateral branches were so numerous as to confuse the line. It is clear, however, that from the close of the Cretaceous to the Post-Tertiary, the Bunodont Artiodactyles were especially abundant on this Continent, and only recently have approached extinction.

The Selenodont division of the Artiodactyles is a more interesting group and, so far as we now know, makes its first appearance in the upper Eocene of the West, although forms, apparently transitional, between it and the Bunodonts occur in the Dinoceras Beds, or middle Eocene. These belong to the genus *Homacodon*, which is very nearly allied to *Helohyus* and but a single step away from this genus toward the Selenodonts. By a fortunate discovery, a nearly complete skeleton of this rare intermediate form has been brought to light, and we are thus enabled to define its characters. Several species of *Homacodon* are known, all of small size. This primitive Selenodont had forty-four teeth, which formed a nearly continuous series.

The molar teeth are very similar to those of *Helohyus*, but the cones on the crowns have become partially triangular in outline, so that when worn, the Selenodont pattern is clearly recognizable. The first and second upper molars, moreover, have three distinct posterior cusps, and two in front: a peculiar feature, which is seen also in the European genera *Dichobune* and *Cainotherium*. There were four toes on each foot, and the metapodial bones were distinct. The type species of this genus was about as large as a cat. With *Helohyus*, this genus forms a well marked family, the *Helohyidæ*.

In the *Diplacodon* horizon of the upper Eocene, the Selenodont dentition is no longer doubtful, as it is seen in most of the *Artiodactyla* yet found in these beds. These animals are all small, and belong to at least three distinct genera. One of these, *Eomeryx*, closely resembles *Homacodon* in most of its skeleton, and has four toes, but its teeth show well marked crescents, and a partial transition to the teeth of *Hyopotamus*, from the Eocene of Europe. With this genus, is another (*Parameryx*), also closely allied to *Homacodon*, but apparently a straggler from the true line, as it has but three toes behind. The most pronounced Selenodont in the upper Eocene is the *Oromeryx*, which genus appears to be allied to the existing Deer family, or *Cervidæ*, and if so is the oldest known representative of the group. These facts are important, as it has been supposed, until very recently, that our Eocene contained no even-hoofed mammals.

In the lowest Miocene of the West, no true crescent-toothed *Artiodactyla* have as yet been identified, with the exception of a single species of *Hyopotamus;* but in the overlying beds of the middle Miocene, remains of the *Oreodontidæ* occur in such vast numbers as to indicate that these animals must have lived in large herds around the borders of the lake-basins in which their remains have been entombed. These basins are now the denuded deserts so well termed *Mauvaises Terres* by the early French trappers. The least specialized, and apparently the oldest, genus of this group is *Agriochœrus*, which so nearly resembles the older *Hyopotamus*, and the still more ancient *Eomeryx*, that we can hardly doubt that they all belonged to the same ancestral line. The typical Oreodonts are the genera *Oreodon* and *Eporeodon*, which have been aptly termed by Leidy, ruminating hogs. They had forty-four teeth, and four well developed toes on each foot. The true Oreodons, which were most numerous east of the Rocky Mountains, were about as large as the existing Peccary, while *Eporeodon*, which was nearly twice this size, was very abundant in the Miocene of the Pacific slope.

In the succeeding Pliocene formation, on each side of the Rocky Mountains, the genus *Merychyus* is one of the prevailing forms, and continues the line on from the Miocene, where the true Oreodons became extinct. Beyond this, we have the genus *Merycochœrus*, which is so nearly allied to the last, that they would be united by many naturalists. With the close of the Pliocene, this series of peculiar ruminants abruptly terminates, no member surviving until the Post-Tertiary, so far as known.

A most interesting line, that leading to the Camels and Llamas, separates from the primitive Selenodont branch in the Eocene, probably through the genus *Parameryx*. In the Miocene, we find in *Pœbrotherium* and some nearly allied forms unmistakable indications that the Cameloid type of ruminant had already become partially specialized, although there is a complete series of incisor teeth, and the metapodial bones are distinct. In the Pliocene, the Camel tribe was, next to the Horses, the most abundant of the larger mammals. The line is continued through the genus *Procamelus*, and perhaps others, and in this formation the incisors first begin to diminish, and the metapodials to unite. In the Post-Tertiary we have a true *Auchenia*, represented by several species, and others in South America, where the Alpacas and Llamas still survive. From the Eocene almost to the present time, North America has been the home of vast numbers of the *Camelidæ*, and there can be little doubt that they originated here, and migrated to the Old World.

Returning once more to the upper Eocene, we find another line of descent starting from *Oromeryx*, which, as we have seen, had apparently then just become differentiated from the older Bunodont type. Throughout the middle and upper Miocene, this line is carried forward by the genus *Leptomeryx* and its near allies, which resemble so strongly the Pliocene *Cervidæ* that they may fairly be regarded as their probable progenitors. Possibly some of these forms may be related to the *Tragulidæ*, but at present the evidence is against it.

The Deer family has representatives in the upper Miocene of Europe, which contains fossils strongly resembling the fauna of our lower Pliocene, a fact always to be borne in mind in comparing the horizon of any group in the two continents. Several species of *Cervidæ*, belonging to the genus *Cosoryx*, are known from the lower Pliocene of the West, and all have very small antlers, divided into a single pair of tynes. The statement recently published, that most of these antlers had been broken during the life of the animals, is unsupported by any evidence, and is erroneous. These primitive Deer do not have the orbit closed behind, and they have all the four metapodial bones entire, although the second and fifth are very slender. In the upper Pliocene, a true *Cervus* of large size has been discovered. In the Post-Tertiary, *Cervus*, *Alces*, and *Tarandus* have been met with, the latter far south of its present range. In the caves of South America, remains of *Cervus* have been found, and also two species of Antelopes, one referred to a new genus, *Leptotherium*.

The Hollow-horned Ruminants, in this country, appear to date back no further than to the lower Pliocene, and here only two species of *Bison* have as yet been discovered. In the Post-Tertiary this genus was represented by numerous individuals and several species, some of large size. The Musk Ox (*Ovibos*) was not uncommon during some parts of this epoch, and its remains are widely distributed.

No authentic fossil remains of true Sheep, Goats, or Giraffes have as yet been found on this continent.

The Proboscideans, which are now separated from the typical Ungulates as a distinct order, make their first appearance in North America in the lower Pliocene, where several species of *Mastodon* have been found. This genus occurs, also, in the upper Pliocene, and in the Post-Tertiary; although some of the remains attributed to the latter are undoubtedly older. The Pliocene species all have a band of enamel on the tusks, and some other peculiarities observed in the oldest Mastodons of Europe, which are from essentially the same horizon. Two species of this genus have been found in South America, in connection with the remains of extinct Llamas and Horses. The genus *Elephas* is a later form, and has not yet been identified in this country below the upper Pliocene, where one gigantic species was abundant. In the Post-Pliocene, remains of this genus are numerous. The hairy Mammoth of the Old World (*Elephas primigenius*) was once abundant in Alaska, and great numbers of its bones are now preserved in the frozen cliffs of that region. This species does not appear to have extended east of the Rocky Mountains, or south of the Columbia River, but was replaced there by the American Elephant, which preferred a milder climate. Remains of the latter have been met with in Canada, throughout the United States, and in Mexico. The last of the American Mastodons and Elephants became extinct in the Post-Tertiary.

The order *Toxodontia* includes two very peculiar genera, *Toxodon* and *Nesodon*, which have been found in the Post-Tertiary deposits of South America. These animals were of huge size, and possessed such mixed characters that their affinities are a matter of considerable doubt. They are thought to be related to the Ungulates, Rodents, and Edentates, but as the feet are unknown, this cannot at present be decided.

Macrauchenia and *Homalodontotherium* are two other peculiar genera from South America, now extinct, the exact affinities of which are uncertain. *Anoplotherium* and *Palæotherium*, so abundant in Europe, have not been found in our North American Tertiary deposits, although reported from South America.

Perhaps the most remarkable mammals yet found in America are the *Tillodontia*, which are comparatively abundant in the lower and middle Eocene. These animals seem to combine the characters of several different groups, viz: the Carnivores, Ungulates, and Rodents. In the genus *Tillotherium*, the type of the order, and of the family *Tillotheridæ*, the skull resembles that of the Bears; the molar teeth are of the ungulate type; while the large incisors are very similar to those of Rodents. The skeleton resembles that of the Carnivores, but the scaphoid and lunar bones are distinct, and there is a third trochanter on the femur. The feet are plantigrade, and each had five digits, all with long pointed claws. In the allied genus *Stylinodon*, which belongs to a distinct family, the *Stylinodontidæ*, all the teeth were rootless. Some of these animals were as large as a Tapir. The genus *Dryptodon* has been found only in the *Coryphodon* beds of New Mexico, while *Tillotherium* and *Stylinodon* occur in the middle Eocene of Wyoming. *Anchippodus* probably belongs to this group, which may perhaps include some other forms that have been named from fragmentary specimens.

The Rodents are an ancient type, and their remains are not unfrequently disinterred in the strata of our lowest fresh-water

Eocene. The earliest known forms are apparently all related to the Squirrels, and the most common genus is *Sciuravus*, which continued throughout the Eocene. A nearly allied form, which may prove to be the same, is *Paramys*, the species of which are larger than those of the older type. In the Dinoceras beds, the genus *Colonomys* is found, and the specimens preserved point to the *Muridæ*, as the nearest living allies. A peculiar genus, *Apatemys*, which also occurs in the middle Eocene, has gliriform incisors, but the molars resemble those of Insectivores. All the Eocene Rodents are of small size, the largest being about as large as a rabbit.

In the middle and upper Miocene lake-basins of the West, Rodents abound, but all are of moderate size. The Hares first appear in the Oreodon beds, and continue in considerable numbers through the rest of the Tertiary and Post-Tertiary to the present day. In these beds, the most common forms belong to the *Leporidæ*, and mainly to the genus *Palæolagus*. The Squirrel family is represented by *Ischyromys*, the *Muridæ* by the genus *Eumys*, and the Beavers by *Palæocastor*. In the upper Miocene of Oregon, most of the same genera are found, and with them some peculiar forms, very unlike anything now living. One of these is the genus *Allomys*, possibly related to the flying Squirrels, but having molar teeth somewhat like those of the Ungulates. In the Pliocene, east and west of the Rocky Mountains, Rodents continue abundant, but most of them belong to existing genera. Among these are *Castor*, *Hystrix*, *Cynomys*, *Geomys*, *Lepus* and *Hesperomys*. In the Post-Tertiary, the gigantic beaver, *Castoroides*, was abundant throughout most of North America. *Hydrochœrus* has been found in South Carolina. In the caves of the island of Anguilla, in the West Indies, remains of large extinct Rodents belonging to the *Chinchillidæ* have been discovered.

The early Tertiary Rodents known from South America are the genera *Megamys*, *Theridromys*, and a large species referred to *Arvicola*. In Brazil, the Pliocene Rodents found are referred to the existing genera *Cavia*, *Kerodon*, *Lagostomus*, *Ctenomys*, *Hesperomys*, *Oxymycterus*, *Arvicola* and *Lepus*. A new genus, *Cardiodus*, described from this horizon, is a true Rodent, but the peculiar *Typotherium*, which has been referred to this order by some authorities, has perhaps other affinities. In the Post-Tertiary, the Rodents were very abundant in South America, as they are at present. The species are in most instances distinct from those now living, but the genera are nearly the same. The *Caviidæ* were especially numerous. *Cercolabes*, *Myopotamus*, and *Lagostomus* are also found, and two extinct genera, *Phyllomys* and *Lonchophorus*.

The *Cheiroptera*, or Bats, have not been found in this country below the middle Eocene, where two extinct genera, *Nyctilestes* and *Nyctitherium*, are each represented by numerous remains. These fossils all belong to small animals, and, so far as they have been investigated, show no characters of more than generic importance to distinguish them from the Bats of to-day. No other members of this group are known from our Tertiary. In the Post-Tertiary, no extinct species of Bats have been found in North America, but from the caves of Brazil quite a number have been reported. These all belong to genera still living in South America, and most of them to the family *Phyllostomidæ*.

The Insectivores date back, in this country, at least to the middle Eocene. Here numerous remains occur, which have been described as belonging to this order, although it is possible that some of them were insect-eating Marsupials. The best known genera are, *Hemiacodon*, *Centetodon*, *Talpavus*, and *Entomacodon;* all represented by animals of small size. In the Miocene, the bones of Insectivores are comparatively abundant, and the genera best determined are *Ictops* and *Leptictis*. A few specimens only have been found in the Pliocene and Post-Pliocene, most of them related to the Moles. No extinct Insectivores are known from South America, and no member of the group exists there at present.

The *Carnivora*, or true flesh-eating animals, are an old type, well represented in the Eocene, and, as might be expected, these early forms are much less specialized than the living species. In the Coryphodon beds, the genus *Limnocyon*, allied to the *Pterodon* of the European Eocene, is abundant. Another genus, apparently distinct, is *Prototomus*, and several others have been named from fragmentary fossils. In the middle Eocene, Carnivores were still more numerous, and many genera have been discovered. One of these, *Limnofelis*, was nearly as large as a lion, and apparently allied to the cats, although the typical *Felidæ* seem not yet to have been differentiated. Another Carnivore of nearly equal size was *Orocyon*, which had short massive jaws and broad teeth. *Dromocyon* and *Mesonyx* were large animals, allied to *Hyænodon*. The teeth were narrow, and the jaws long and slender. Among the smaller Carnivores were, *Vulpavus*, *Viverravus*, *Sinopa*, *Thinocyon*, and *Ziphacodon*.

In our Western Miocene, Carnivores are abundant, and make an approach to modern types. The *Felidæ* are well represented, the most interesting genus being *Machairodus*, which is not uncommon in the Oreodon beds on both sides of the Rocky Mountains. An allied genus is *Dinictis*, and several smaller Cats are known from about the same horizon. The *Canidæ* are represented by *Amphicyon*, a European genus, and by several species of *Canis*, or a very nearly allied form. The peculiar genus *Hyænodon*, found also in Europe, and the type of a distinct family, is abundant in the Miocene east of the Rocky Mountains, but has not yet been found on the Pacific Coast. In the Pliocene of both regions, the *Canidæ* are numerous, and all apparently belong to the existing genus *Canis*. The genus *Machairodus* is still the dominant form of the Cats, which are abundant, and for the most part belong to the genus *Felis*. The extinct *Leptarctus* is supposed to belong to the *Ursidæ*, and if so, is the oldest American representative of this family. In the Post-Pliocene, the extinct *Felidæ* include species nearly as large as a lion, and smaller forms very similar to those still living. Bears, Raccoons and Weasels have also been found.

In the Pliocene of South America, *Machairodus* represents the *Felidæ*, while the genera *Arctotherium* and *Hyænarctus* belong to the Bear family. Species of *Mustela* and *Canis* have also been found. In the caves of Brazil, the fauna of which is regarded as Post-Pliocene, one species of *Machairodus* is known, and one of *Synælurus*. *Canis* and *Icticyon*, still living in Brazil, and the extinct genus *Speothos*, represent the *Canidæ*. *Mephitis* and *Galictis*, among the Weasels, were also present, and with them species of *Nasua* and *Arctotherium*.

We come now to the highest group of Mammals, the Primates, which includes the Lemurs, the Apes, and Man. This order has a great antiquity, and even at the base of the Eocene we find it represented by several genera belonging to the lower forms of the group. In considering these interesting fossils, it is important to have in mind that the Lemurs, which are usually regarded as Primates, although at the bottom of the scale, are only found at the present day in Madagascar and the adjacent regions of the globe. All the American Monkeys, moreover, belong to one group, much above the Lemurs, while the Old World Apes are higher still, and most nearly approach Man.

In the lower Eocene of New Mexico, we find a few representatives of the earliest known Primates, and among them are the genera *Lemuravus* and *Limnotherium*, each the type of a distinct family. These genera became very abundant in the middle Eocene of the West, and with them are found many others, all however, included in the two families, *Lemuravidæ* and *Limnotheridæ*. *Lemuravus* appears to have been most nearly allied to the Lemurs, and is the most generalized form of the Primates yet discovered. It had forty-four teeth, forming a continuous series above and below. The brain was nearly smooth, and of moderate size. The skeleton most resembles that of the Lemurs. A nearly allied genus, belonging to the same family, is *Hyopsodus*. *Limnotherium* (*Tomitherium*) also is nearly related to the Lemurs, but shows some affinities with the South American Marmosets. This genus had forty teeth. 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. Other genera belonging to the *Limnotheridæ* are, *Notharctos*, *Hipposyus*, *Microsyops*, *Palæacodon*, *Thinolestes* and *Telmatolestes*. Besides these, *Antiacodon* (*Anaptomorphus*), *Bathrodon* and *Mesacodon* should probably be placed in the same group. In the Diplacodon Beds, or Upper Eocene, no remains of Primates have yet been detected, although they will doubtless be found there. All the Eocene Primates known from American strata are low generalized forms, with characters in the teeth, skeleton and feet that suggest relationships with the Carnivores, and even with the Ungulates. These resemblances have led palæontologists to refer some imperfect specimens to both these orders.

In the Miocene lake basins of the West, only a single species of the *Primates* has been identified with certainty. This was found in the Oreodon Beds of Nebraska, and belongs to the genus *Laopithecus*, apparently related both to the *Limnotheridæ* and to some existing South American Monkeys. In the Pliocene and Post-Pliocene of North America, no remains of Primates have yet been found.

In the Post-Pliocene deposits of the Brazilian caves, remains of Monkeys are numerous, and mainly belong to extinct species of *Callithrix*, *Cebus* and *Jacchus*, all living South American genera. Only one extinct genus, *Protopithecus*, which embraced animals of large size, has been found in this peculiar fauna.

It is a noteworthy fact, that no traces of any Anthropoid Apes, or indeed of any Old World Monkeys have yet been detected in America. Man, however, the highest of the Primates, has left his bones and his works from the Arctic Circle to Patagonia. Most of these specimens are clearly Post-Tertiary, although there is considerable evidence pointing to the existence of Man in our Pliocene. All the remains yet discovered belong to the well-marked genus *Homo*, and apparently to a single species, at present represented by the American Indian.

In this rapid review of Mammalian life in America, from its first known appearance in the Trias down to the present time, I have endeavored to state briefly the introduction and succession of the principal forms in each natural group. If time permitted, I might attempt the more difficult task of trying to indicate what relations these various groups may possibly bear to each other; what connection the ancient Mammals of this continent have with the corresponding forms of the Old World; and, most important of all, what real progress Mammalian life has here made since the beginning of the Eocene. As it is, I can only say in summing up, that the Marsupials are clearly the remnants of a very ancient fauna, which occupied this continent millions of years ago, and from which the other Mammals were doubtless all derived, although the direct evidence of the transformation is wanting.

Although the Marsupials are nearly related to the still lower Monotremes, now living in the Australian Region, we have as yet no hint of the path by which these two groups became separated from the inferior vertebrates. Neither have we to-day much light as to the genetic connection existing between Marsupials and the placental Mammalia, although it is possible that the different orders of the latter had their origin each from a separate group of the Marsupials.

The presence, however, of undoubted Marsupials in our lower and middle Eocene, some of them related to the genus *Didelphys*, although remotely, is important evidence as to the introduction of these animals into America. Against this, their supposed absence in our Miocene and Pliocene can have but limited weight, when taken in connection with the fact that they flourished in the Post-Tertiary, and are still abundant. The evidence we now have is quite as strongly in favor of a migration of Marsupials from America to the Old World, as the reverse, which has been supposed by some naturalists. Possibly, as Huxley has suggested, both countries were peopled with these low mammals from a continent now submerged.

The Edentate mammals have long been a puzzle to zoologists, and up to the present time no clew to their affinities with other groups seems to have been detected. A comparison of the peculiar Eocene Mammals which I have called the *Tillodontia*, with the least specialized Edentates, brings to light many curious resemblances in the skull, teeth, skeleton and feet. These suggest relationship, at least, and possibly we may yet find here the key to the Edentate genealogy. At present, the Tillodonts are all from the lower and middle Eocene, while *Moropus*, the oldest Edentate genus, is found in the middle Miocene, and one species in the lower Pliocene.

The Edentates have been usually regarded as an American type, but the few living forms in Africa, and the Tertiary species in Europe, the oldest known, have made the land of their nativity uncertain. I have already given you some reasons for believing that the Edentates had their first home in North America, and migrated thence to the southern portion of the continent. This movement could not have taken place in the Miocene period, as the Isthmus of Darien was then submerged; but near the close of the Tertiary, the elevation of this region left a much broader strip of land than now exists there, and over this, the Edentates and other mammals made their way, perhaps urged on by the increasing cold of the glacial winters. The evidence to-day is strongly in favor of such a southern migration. This, however, leaves the Old World Edentates, fossil and recent, unaccounted for; but I believe the solution of this problem is essentially the same, namely: a migration from North America. The Miocene representatives of this group, which I have recently obtained in Oregon, are older than any known in Europe, and, strangely enough, are more like the latter and the existing African types than like any of our living species. If, now, we bear in mind that an elevation of only 180 feet would, as has been said, close Behring's Straits, and give a road thirty miles wide from America to Asia, we can easily see how this migration might have taken place. That such a Tertiary bridge did exist, we have much independent testimony, and the known facts all point to extensive migrations of animals over it.

The *Cetacea* are connected with the marine Carnivores through the genus *Zeuglodon*, as Huxley has shown, and the points of resemblance are so marked that the affinity cannot be doubted. That the connection was a direct one, however, is hardly probable, since the diminutive brain, large number of simple teeth, and reduced limbs in the Whales, all indicate them to be an old type, which doubtless branched off from the more primitive stock leading to the Carnivores. Our American extinct Cetaceans, when carefully investigated, promise to throw much light upon the pedigree of these strange mammals. As most of the known forms were probably marine, their distribution is of little service in determining their origin.

That the Sirenians are allied to the Ungulates is now generally admitted by anatomists, and the separation of the existing species in distant localities suggests that they are the remnants of an extensive group, once widely distributed. The large number of teeth in some forms, the reduced limbs and other characters, point back to an ancestry near that of the earliest ungulates. The gradual loss of teeth in the specialized members of this group, and in the Cetaceans, is quite parallel with the same change in Edentates, as well as in Pterodactyls and Birds.

The Ungulates are so distinct from other groups that they must be one of the oldest natural divisions of mammals, and they probably originated from some herbivorous marsupial. Their large size, and great numbers during Tertiary and Post-tertiary time, render them most valuable in tracing migrations induced by climate, as well as in showing the changes of structure which such a contest for existence may produce.

In the review of the extinct Ungulates, I have endeavored to show that quite a number of genera usually supposed to belong originally to the Old World are in reality true American types. Among these were the Horse, Rhinoceros, and Tapir, all the existing odd-toed Ungulates, and besides these the Camel, Pig, and Deer. All these I believe, and many others, went to Asia from our North West Coast. It must, for the present, remain an open question whether we may not fairly claim the *Bovidæ*, and even the *Proboscidea*, since both occur in our strata at about the same horizon as on the other continent. On this point there is some confusion, at least in names. The Himalayan deposits called Upper Miocene, and so rich in Proboscideans, indicate in their entire fauna that they are more recent than our Niobrara River beds, which, for apparently good reasons, we regard as Lower Pliocene. The latter appear to be about the same horizon as the Pikermi deposits in Greece, also regarded as Miocene. Believing, however, that we have here a more complete Tertiary series, and a better standard for comparison of faunas, I have preferred to retain the names already applied to our divisions, until the strata of the two continents are more satisfactorily coördinated.

The extinct Rodents, Bats, and Insectivores of America, although offering many suggestive hints as to their relationship with other groups, and their various migrations, cannot now be fully discussed. There is little doubt, however, that the Rodents are a New World type, and, according to present evidence, they probably had their origin in North America. The resemblance in so many respects of this order to the Proboscideans is a striking fact, not yet explained by the imperfectly known genealogy of either group.

The Carnivores, too, I must pass by, except to call attention to a few special forms which accompanied the migrations of other groups. One of these is *Machairodus*, the saber-toothed Tiger, which flourished in our Miocene and Pliocene, and followed the huge Edentates to South America, and the Ungulates across Asia to Europe. With this genus went *Hyænodon*, and some typical Wolves and Cats, but the Bears came the other way with the Antelopes. That the Gazelle, Giraffe, Hippopotamus, Hyaena and other African types, once abundant in Asia, did not come, is doubtless because the Miocene bridge was submerged before they reached it.

The Edentates, in their southern migration, were probably accompanied by the Horse, Tapir and Rhinoceros, although no remains of the last have yet been found south of Mexico. The Mastodon, Elephant, Llama, Deer, Peccary, and other mammals, followed the same path. Why the Mastodon, Elephant, Rhinoceros, and especially the Horse, should have been selected with the huge Edentates for extinction, and the other Ungulates left, is at present a mystery, which their somewhat larger size hardly explains.

The relations of the American Primates, extinct and recent, to those of the other hemisphere, offer an inviting topic, but it is not in my present province to discuss them in their most suggestive phases. As we have here the oldest and most generalized members of the group, so far as now known, we may justly claim America for the birth-place of the order. That the development did not continue here until it culminated in Man, was due to causes which at present we can only surmise, although the genealogy of other surviving groups gives some data toward a solution. Why the old world Apes, when differentiated, did not come to the land of their earlier ancestry, is readily explained by the then intervening oceans, which likewise were a barrier to the return of the Horse and Rhinoceros.

Man, however, came; doubtless first across Behring's Straits; and at his advent became part of our fauna, as a mammal and primate. In these relations alone, it is my purpose here to treat him. The evidence, as it stands to-day, although not conclusive, seems to place the first appearance of Man in this country in the Pliocene, and the best proof of this has been found on the Pacific coast. During several visits to that region, many facts were brought to my knowledge which render this more than probable. Man at this time was a savage, and was doubtless forced by the great volcanic outbreaks to continue his migration. This was at first to the south, since mountain chains were barriers on the east. As the native Horses of America were now all extinct, and as the early man did not bring the old world animal with him, his migrations were slow. I believe, moreover, that his slow progress towards civilization was in no small degree due to this same cause, the absence of the Horse

It is far from my intention to add to the many theories extant in regard to the early civilizations in this country, and their connections with the primitive inhabitants, or the later Indians, but two or three facts have recently come to my knowledge which I think worth mentioning in this connection. On the Columbia River, I have found evidence of the former existence of inhabitants much superior to the Indians at present there, and of which no tradition remains. Among many stone carvings which I saw there, were a number of heads which so strongly resemble those of Apes, that the likeness at once suggests itself. Whence came these sculptures, and by whom were they made? Another fact that has interested me very much is the strong resemblance between the skulls of the typical Mound-builders of the Mississippi Valley and those of the Pueblo Indians. I had long been familiar with the former, and when I recently saw the latter, it required the positive assurance of a friend who had himself collected them in New Mexico, to convince me that they were not from the mounds. A third fact, and I leave Man to the Archæologists, on whose province I am even now trenching. In a large collection of Mound-builders' pottery, over a thousand specimens, which I have recently examined with some care, I found many pieces of elaborate workmanship so nearly like the ancient water-jars from Peru, that no one could fairly doubt that some intercourse had taken place between the widely separated people that made them.

The oldest known remains of Man on this continent differ in no important characters from the bones of the typical Indian, although in some minor details they indicate a much more primitive race. These early remains, some of which are true fossils, resemble much more closely the corresponding parts of the highest Old World Apes, than do the latter our Tertiary Primates, or even the recent American Monkeys. Various living and fossil forms of old world Primates fill up essentially the latter gap. The lesser gap between the primitive Man of America and the Anthropoid Apes is partially closed by still lower forms of men, and doubtless also by higher Apes, now extinct. Analogy, and many facts as well, indicate that this gap was smaller in the past. It certainly is becoming wider now with every generation, for the lowest races of men will soon become extinct, like the Tasmanians, and the highest Apes cannot long survive. Hence the intermediate forms of the past, if any there were, become of still greater importance. For such missing links, we must look to the caves and later Tertiary of Africa, which I regard as now the most promising field for exploration in the Old World. America, even in the Tropics, can promise no such inducements to ambitious explorers. We have, however, an equally important field, if less attractive, in the Cretaceous Mammals, which must have left their remains somewhere on this continent. In these two directions, as I believe, lie the most important future discoveries in Palæontology.

As a cause for many changes of structure in mammals during the Tertiary and Post-Tertiary, I regard, as the most potent, *Natural Selection*, in the broad sense in which that term is now used by American evolutionists. Under this head, I include not merely a Malthusian struggle for life among the animals themselves, but the equally important contest with the elements, and all surrounding nature. By changes in the environment, migrations are enforced, slowly in some cases, rapidly in others, and with change of locality must come adaptation to new conditions, or extinction. The life-history of Tertiary mammals illustrates this principle at every stage, and no other explanation meets the facts.

The real progress of mammalian life in America, from the beginning of the Tertiary to the present, is well illustrated by the Brain-growth, in which we have the key to many other changes. The earliest known Tertiary mammals all had very small brains, and in some forms this organ was proportionally less than in certain Reptiles. There was a gradual increase in the size of the brain during this period, and it is interesting to find that this growth was mainly confined to the cerebral hemispheres, or higher portion of the brain. In most groups of mammals, the brain has gradually become more convoluted, and thus increased in quality, as well as quantity. In some, also, the cerebellum, and olfactory lobes, the lower parts of the brain, have even diminished in size. In the long struggle for existence during Tertiary time, the big brains won, then as now; and the increasing power thus gained rendered useless many structures inherited from primitive ancestors, but no longer adapted to new conditions.

Another of the interesting changes in mammals during Tertiary time was in the teeth, which were gradually modified with other parts of the structure. The primitive form of tooth was clearly a cone, and all others are derived from this. All classes of vertebrates below mammals, namely, Fishes, Amphibians, Reptiles, and Birds, have conical teeth, if any, or some simple modification of this form. The Edentates and Cetaceans with teeth retain this type, except the Zeuglodonts, which approach the dentition of aquatic Carnivores. In the higher mammals, the incisors and canines retain the conical shape, and the premolars have only in part been transformed. The latter gradually change to the more complicated molar pattern, and hence are not reduced molars, but transition forms from the cone to more complex types. Most of the early Tertiary mammals had forty-four teeth, and in the oldest forms the premolars were all unlike the molars; while the crowns were short, covered with enamel, and without cement. Each stage of progress in the differentiation of the animal was, as a rule, marked by a change in the teeth; one of the most common being the transfer, in form at least, of a premolar to the molar series, and a gradual lengthening of the crown. Hence, it is often easy to decide from a fragment of a jaw, to what horizon of the Tertiary it belongs. The fossil Horses of this period, for example, gained a grinding tooth, for each toe they lost, one in each epoch. In the single-toed existing horses, all the premolars are like the molars, and the process is at an end. Other dental transformations are of equal interest, but this illustration must suffice.

The changes in the limbs and feet of mammals during the same period were quite as marked. The foot of the primitive mammal was doubtless plantigrade, and certainly five-toed.

Many of the early Tertiary forms show this feature, which is still seen in some existing forms. This generalized foot became modified by a gradual loss of the outer toes, and increase in size of the central ones; the reduction proceeding according to systematic methods, differing in each group. Corresponding changes took place in the limb bones. One result was a great increase in speed, as the power was applied so as to act only in the plane of motion. The best effect of this specialization is seen to-day in the Horse and Antelope, each representing a distinct group of Ungulates, with five-toed ancestors.

If the history of American Mammals as I have briefly sketched it, seems as a whole incomplete, and unsatisfactory, we must remember that the genealogical tree of this class has its trunk and larger limbs concealed beneath the *débris* of Mesozoic time, while its roots doubtless strike so deeply into the Paleozoic that for the present they are lost. A decade or two hence, we shall probably know something of the mammalian fauna of the Cretaceous, and the earlier lineage of our existing mammals can then be traced with more certainty.

The results I have presented to you are mainly derived from personal observation; and since a large part of the higher vertebrate remains found in this country have passed through my hands, I am willing to assume full responsibility for my presentation of the subject.

For our present knowledge of the extinct Mammals, Birds and Reptiles of North America, science is especially indebted to Leidy, whose careful, conscientious work has laid a secure foundation for our vertebrate palæontology. The energy of Cope has brought to notice many strange forms, and greatly enlarged our literature. Agassiz, Owen, Wyman, Baird, Hitchcock, Deane, Emmons, Lea, Allen, Gibbes, Jefferson, DeKay, and Harlan, deserve honorable mention in the history of this branch of science. The South American extinct vertebrates have been described by Lund, Owen, Burmeister, Gervais, Huxley, Flower, Desmarest, Aymard, Pictet, and Nodot. Darwin and Wallace have likewise contributed valuable information on this subject, as they have on nearly all forms of life.

In this long history of ancient life I have said nothing of what Life itself really is. And for the best of reasons, because I know nothing. Here at present our ignorance is dense, and yet we need not despair. Light, Heat, Electricity, and Magnetism, Chemical Affinity and Motion, are now considered different forms of the same force; and the opinion is rapidly gaining ground that Life, or vital force, is only another phase of the same power. Possibly the great mystery of Life may thus be solved, but whether it be or not, a true faith in Science knows no limit to its search for Truth.

ART. XLIII.—*Note on the Helderberg Formation of Bernardston, Massachusetts, and Vernon, Vermont;* by JAMES D. DANA.

IN examinations of the Bernardston Helderberg formation which were the basis of my former paper "On the Rocks of the Helderberg era in the Valley of the Connecticut"* my main purpose was lithological—that is, to ascertain and point out the kinds of crystalline rocks that were comprised within terranes of Helderberg (later Upper Silurian) age. The conformable position of the Bernardston limestone beneath strata of quartzyte and slate, first made known by Professor Edward Hitchcock,† I found to be, as I thought, a fact; and from there I traced the quartzyte at intervals, along with the slate—a peculiar mica slate easily distinguished by the minute garnets which gave its layers a pimpled surface, and the small crystals of mica set transversely to the lamination—over the country, to South Vernon in Vermont; and announced in my paper that the Helderberg formation included, besides the quartzyte and mica slate, beds of compact green hornblende rock, a rock of the composition of syenyte, staurolitic mica slate, coarse mica schist, whitish and grayish quartzose gneiss, and all stages of passage between quartzyte and gneiss.

Recently, Professor C. H. Hitchcock, in the Second Volume of his Report on the Geology of New Hampshire,‡ and more briefly in a note in this Journal,§ has suggested that the order of stratification at the limestone locality is not the true order; that the rocks may be "in an inverted position:" that the limestone stratum may have *overlaid* both the other formations, that is, the quartzyte and mica slate;‖ that "the limestone occupies a small valley in the quartzyte."¶ Having, through this supposition, made the limestone the newest of the formations, he concludes, further, that the mica slate, now lying over it, is not necessarily Helderberg; that the hornblende rocks and gneiss of Vernon are not necessarily of the Helderberg series,** and neither the staurolitic slate; that a long period

* This Journal, III, vi, 339.

† Report on the Geology, etc. of Massachusetts, by E. Hitchcock, 8vo, 1833, p. 295; Report of Amer. Assoc. for 1851, p. 299; Report Geol. of Vermont, 2 vols. 4to, 1861, p. 447. This last notice was prepared in conjunction with Mr. C. H. Hitchcock. It gives a section representing the limestone dipping beneath quartzyte and slate.

‡ Page 428 and beyond, 1877.

§ Vol. xiii, page 313, April, 1877.

‖ Ibid.

¶ Report New Hampshire, vol. ii, p. 455.

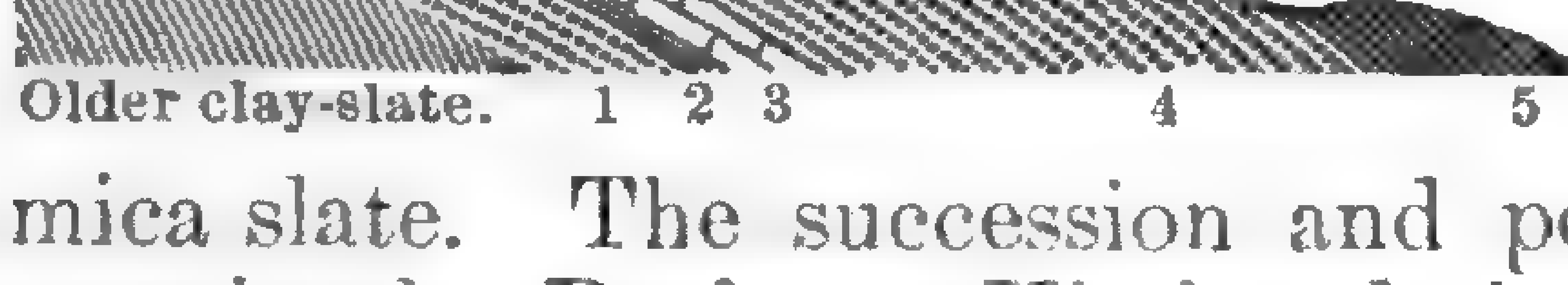
** It should be added here that the volume of the N. Hampshire Geological Report referred to conveys on an earlier page (p. 18), a different opinion as to the limits of the Helderberg, where it is stated that the Connecticut Valley Helderberg series consists of several thousand feet in thickness of quartzytes, limestones, slates, conglomerates, sandstones, flags, and probably hornblende schists.

intervened between the deposition of the hornblendic stratum and quartzyte.

While thus dissenting from my conclusions, Professor Hitchcock adopts my suggestion that the garnetiferous mica slate which overlies the quartzyte and limestone at the Bernardston limestone locality is identical with the Coös slate of the Connecticut Valley in all its characters and age, and hence that *if* the former should turn out after all to be Helderberg, the Coös formation (which extends up the valley to Canada, according to Professor Hitchcock) is also Helderberg or later Upper Silurian.

These differences of opinion, and the wide bearing of the facts on New England geology have led me to revisit the place and examine it anew. In my former paper I closed by stating my intention, another season, to study the stratigraphical details of the region, and trace out the limits or range of the formations southward along the Connecticut Valley. But other geological work in Western and Southern New England, and on the islands off its southern coast, have since occupied such leisure time as I could command. In my recent visit to Bernardston I was accompanied by Professor B. K. Emerson, of Amherst College; and it is a great satisfaction to know that he will give the whole subject a careful and thorough study, and connect it with a general geological survey of Central and Western Massachusetts—work for which he is eminently fitted.

To facilitate explanations I repeat the section of the strata at the Bernardston locality before published, with one correction. No. 3, the blocked area, represents the stratum of Crinoidal limestone; Nos. 1 and 4, dotted areas, an underlying and an overlying stratum of quartzyte; and Nos. 2 and 5, finely lined areas, an underlying and an overlying stratum of



garnetiferous mica slate. The succession and position are the same as in the section by Professor Hitchcock in the Vermont Geological Report, excepting the omission here of a layer of slate immediately *over* the limestone.

The conclusions which the facts appear to me to sustain, in opposition to those set forth by Professor C. H. Hitchcock in the New Hampshire Report of 1877, but mostly in agreement with Mr. C. H. Hitchcock of the Vermont Report* (p. 598) of 1861—are the following:

* The Vermont Report makes no mention, in the chapter on the Bernardston limestone (p. 447), of the hornblende rocks, gneiss, etc., of the adjoining region on the east. But on page 598, in an account of "Section I," extending across the

1. That the quartzyte is Helderberg as much as the limestone.

2. That the garnetiferous mica slate is equally Helderberg.

3. That the limestone is a local deposit between the other members of the Helderberg formation.

4. That hornblende rocks, staurolitic slate, mica schist and gneiss of the adjoining region on the east and northeast are of one and the same geological formation.

1. *The Quartzyte is of the Helderberg formation.* The overlying quartzyte (No. 4) besides occurring in large outcrops over the hill-side, *constitutes the upper two to four feet* of the vertical section exposed in a portion of the limestone quarry. This alone proves its conformable position and close relation to the limestone. But further, while this overlying quartzyte is in part very compact and solid, some portions are very cellular from the removal of calcareous matter and pyrite, and also from the removal of fossils. The first of the fossils was found by Professor Emerson, while we were together, and was a cast of a *Pentamerus;* and both of us afterward obtained other specimens. The casts were too imperfect for a decision as to the species; but they appear to show that it was nearly equal in height and breadth, and without costæ, which are characteristics of the *P. pseudo-galeatus*, a Lower Helderberg species. Besides these brachiopods, there were in the same layers of the quartzyte numerous fragments of *crinoidal stems*, mostly of small species. Some of the laminæ of this quartzyte have between them mica in scales, so as to look in a surface view like mica schist.

The fact that there is conformability between the limestone and quartzyte is hence beyond question. And it is equally certain that, overturned or not, the quartzyte belongs to the same

south extremity of the State near the Massachusetts boundary, Mr. C. H. Hitchcock describes the hornblende rocks of Vernon and Bernardston as associated with gneiss and mica schists; states that the mica schist west of South Vernon contains chiastolite [staurolite?]; speaks of the gneiss as graduating insensibly into the quartz rock, as in some places difficult to be distinguished from granite, as also "invariably resting upon the quartz rock" and hence "newer" than it; as, therefore, probably of the Upper Helderberg age, like the Bernardston limestone (Hall's first determination), which rests on the same quartz rock; thus making the whole series Upper Helderberg. The unconformability of the quartz rock series on the clay slate is also recognized.

If these were still his views, excepting the change of Upper Helderberg to Lower Helderberg, we should be in close agreement. In my arguments above, I am in fact sustaining Mr. C. H. Hitchcock of 1861, against Professor C. H. Hitchcock of 1877) whose later conclusions have been influenced by his faith in the lithological test of geological age, and his unbelief in the existence of gneiss-like metamorphic rocks of later date than Cambrian.

The suspicion that C. H. Hitchcock may not have been the author of the notes on Section I is apparently set aside by the heading of the Chapter, "Notes on the Sections, by C. H. Hitchcock," and the absence of any statement that the notes on Section I were prepared by any other person.

era with the crinoidal limestone; for the former really graduates into the latter as its calcareous matter and fossils show.

2. *The garnetiferous mica slate is of the Helderberg formation.*—This is demonstrated by the existence of a stratum of garnetiferous mica slate (No. 2, in the section, p. 380,) *beneath* the limestone as well as one (No. 5) above. This inferior mica slate wants the little disseminated crystals of mica common in the other; but it is pimpled with garnets like that. The line of outcrops extends for several rods, and runs along within a few yards of the limestone, at the nearest point hardly a yard of earth intervening; and the strike and dip throughout correspond with that of the limestone adjoining. Having garnetiferous mica slate below the limestone as well as above, and the three strata conformable in dip, there can be no reasonable doubt that all are of one formation. The limestone stratum is so placed with reference to those above and below that it could not have been originally at the top, and the newest of the series. Whatever faulting or inversion be supposed, it must have had originally, as it has now, an overlying and an underlying mica slate.

3. *The limestone a local deposit in the Helderberg formation.*—The fact that the limestone has not been observed elsewhere in the region is no evidence of independent and later formation. It is plainly an isolated bed, of limited lateral extent, *like those that are so common in the widely spread "Calciferous mica schist" of the Connecticut Valley.* The fact that it is a wedge-shaped mass thus isolated is evident; for just north of the main quarry it soon thins out, (together with the thin underlying stratum of mica slate) through the approach and junction of the overlying and underlying quartzyte. Fossils, if found in any of the many isolated calcareous deposits in the "Calciferous mica schist," would be regarded as showing the age of the schist; and so it should be here.

Professor Hitchcock says that if the Coös slate is Helderberg, the Calciferous mica schist is unquestionably so too. Admitting this to be true, the parallelism between the Bernardston limestone and the isolated calcareous deposits in the schist becomes complete.*

4. *The hornblende rocks, staurolitic slate, mica schist and associated gneiss are of the Helderberg formation.*—As limestone has been found in the region only at the one locality in Bernardston, the evidence of equivalence has to be derived from the distribution of its associated rocks. This evidence, east and northeast of the Bernardston village-plain, is as follows:

(1.) The same garnetiferous mica slate with disseminated brown mica crystals set transversely that occurs associated

*** My knowledge of the rock formations of Western Vermont is not sufficient to warrant an independent opinion with regard to the "Calciferous mica schist."**

with quartzyte at the Bernardston locality on the west side of the Bernardston plain occurs associated with quartzyte at different points between Bernardston and Vernon. It sometimes dips beneath quartzyte and sometimes overlies it.

(2.) Outcrops of the quartzyte and the peculiar Bernardston mica slate together appear east and northeast of Bernardston within one to one and a half miles of the Crinoidal limestone locality (the intervening flat valley being under drift and alluvium), and at intervals beyond, to Vernon, with the same aspect and conformable superposition as at the limestone locality.

(3.) In the same region, hornblende rocks, staurolitic slate, gneiss and mica schist occur in alternating beds with the Bernardston mica slate and quartzyte.

A mile and a half east of Bernardston,* the Bernardston mica slate occurs in alternating beds with the hornblende rock,—a gray-green compact rock, not schistose—with so obvious junctions that the alternation cannot be questioned. The hornblende rock (1) dips beneath (2) mica slate; this beneath (3) hornblende rock; and the last beneath (4) mica slate again. Whether there is a fault between 2 and 3 is not certain; but it is unquestionable that 1 and 2, and 3 and 4 are strictly conformable. Part of the hornblende rock is speckled white with quartzyte and feldspar and is like a quartzytic syenite in constitution, though unlike true syenyte in aspect.

Again: a mile to the north of the last mentioned locality and less than a mile and a half northeast of the Bernardston limestone locality, the same peculiar mica slate may be seen, dipping at a small angle beneath a stratum of quartzyte, the conformability, as in other cases in the region, unquestionable. Now this quartzyte stratum, while in part quartzyte, is partly a tough micaceous rock consisting chiefly of aggregated scales of brown mica, but with some hornblende and quartz.

Again: the Bernardston slate of the locality just mentioned extends eastward and is the same stratum, as well as the same kind of slate, with that of Purple's quarry, described in my former paper; which slate contains occasional crystals of *staurolite.* Hence the Bernardston slate which alternates with quartzyte is in some places a *staurolitic slate.* Another place, farther east, is mentioned in my former paper where the slate is abundantly staurolitic.

Again: in Vernon, four to five miles northwest of South Vernon, where the quartzyte is largely exposed to view, one of the quartzyte knolls consists partly of mica rock like that above described, made up mainly of aggregated scales of brown mica but containing distributed through it some quartz and

* For the position of this locality see my former paper.

hornblende. In other outcrops in the field adjoining, the rock is mostly true quartzyte, but partly a green compact hornblende rock, with insensible gradations between it and the quartzyte.

Again: at South Vernon, over the slopes nearly west of the hotel, there occur—first quartzyte, but with it, and graduating into it, the compact green hornblende rock; then, high up the slope, a coarse garnetiferous mica schist consisting mainly of brown mica, which is nothing but a coarse form of the Bernardston slate; and in this mica schist there are hornblendic layers; and some beds which consist of a quartzytic syenyte, though with the hornblende grains in slender crystals.

Again: between Vernon Center and South Vernon, there are outcrops showing the transition between the quartzyte and a quartzytic gneiss. The gneiss has the aspect of any ordinary light-colored thick-bedded gneiss. But it is all quartzytic, and in part very largely so.

Besides this light-colored quartzytic gneiss, there is also, north of South Vernon, quartzytic syenite, a whitish rock containing small grains of greenish hornblende, rather sparsely disseminated, without mica, and making a handsome rock which might at first be taken for a white granite.

5. *Conclusion.*—Thus, the region affords examples (1) of the *interstratification* of the quartzyte and Bernardston mica slate, with a green massive hornblende rock; with a syenytic rock; with gneiss; and with coarse mica schist; (2) of *transitions* of the Bernardston mica slate into staurolitic slate and mica schist; and (3) of *transitions* of the quartzyte into (*a*) micaceous quartzyte; (*b*) a tough quartzytic mica rock, more or less hornblendic; (*c*) quartzytic gneiss often granitoid: (4) green hornblende rock; and (5) syenyte, besides various intermediate forms. For some other examples of these transitions I refer to my former paper.

The demonstration is certainly complete that whatever the age of the quartzyte and the associated Bernardston mica slate, the same is the age of the rocks above mentioned; and that the fossils of the Bernardston locality decide the age approximately for the series; and finally, that all are of the Helderberg formation or later Upper Silurian, if that is true of the Crinoidal limestone.

6. *Lithological characteristics.*—In using the lithological test of geological age it must hence be noted that the following may be rocks of metamorphic Upper Silurian formations: mica slate and schist; staurolitic mica slate; hornblendic rocks, varying from a kind consisting mainly of green hornblende to a quartzytic syenyte, and hornblendic quartzyte; quartzytic gneiss; true gneiss; micaceous quartzyte; quartzyte.

The minerals included among the abundant metamorphic species are: brown and white mica, the former much the most common; staurolite; green and black hornblende; orthoclase; garnet; along with pyrite, magnetite, and granular limestone.

The mica slate and schist and the staurolitic mica slate are not distinguishable from kinds that are of earlier age.

The hornblende rocks are peculiar. Those which are made mainly of hornblende have a dark green color, and are massive, often indistinct in bedding instead of schistose and much jointed. The larger part consist of minute interlaced fibers; with sometimes whitish spots giving the rock a porphyritic aspect, which spots consist of quartzyte combined usually with grains of orthclase. Thin slices in polarized light under the microscope are beautiful objects. A cleavable granular variety occurs but is less common. Coarser kinds have the hornblende in oblong pointed crystals imbedded in fine grained quartzyte or quartzyte and orthoclase.

The whitish quartzytic syenite mentioned on the preceding page is peculiar in having a very fine grain; the hornblende dark green in color, and generally in oblong grains; and the whiter portions of the rock of an opaque white color and made up mostly of grains of orthoclase. In a thin slice, these whiter portions lie between others that are pellucid and consist of quartz grains with few of feldspar.

The gneiss also is peculiar. It generally consists very largely of grains of quartz, even where looking to the eye like a true gneiss. The mica is almost solely the brown kind and is like that of the mica slate, though often seeming to have as little elasticity as chlorite; and the regular disposition of the spots of mica, give to the most quartzytic varieties a strikingly gneiss-like look. Professor Hitchcock refers the rock to the Bethlehem gneiss. But "the most characteristic of the rocks comprising this formation," he says, speaking of the Bethlehem gneiss, "is a reddish granitic gneiss, the flesh-colored orthoclase predominating, with chloritic or some hydro-micaceous mineral in place of ordinary mica, and quartz in variable proportions" (Report, p. 105); and to such a rock it has little resemblance. Yet, it is to be admitted that there is nothing in the amount of orthoclase in characteristic "Bethlehem gneiss" which renders connection with a Helderberg formation improbable.

The quartzyte in some places—as two miles west of South Vernon,—contains much pearly mica (hydrous mica?); a weathered surface of such a specimen shows that the rock consists mainly of quartz. In other places the quartzyte is marked with dark-gray and blackish lines where the mica is not distinguishable without a glass. All of it indicates by its fineness of texture, and sometimes even flinty aspect, that the quartz sand of which it was made was very finely comminuted, and not coarse like that from which the Green Mountain quartzyte was made; and hence that the region, when the deposition took place, was not the border of the open sea.

7. *Origin of the Rocks.*—To understand the rocks of this Helderberg region, it must be borne in mind: that quartzyte beds in their original state, that is, beds of quartz sand, may have been formed at different times in the course of the era, owing to changes of level or of currents; that the sand beds—like those of any other era and of the present time—would, in many places, have had more or less earthy material (ground-up crystalline rock) with the quartz sand, so that metamorphism could not make pure quartzyte out of it, but might make a micaceous or gneissoid quartzyte, or a quartzytic gneiss, according to the nature of the earthy material present; that while sand-beds were formed where the currents were rapid enough for the purpose, mud-beds would have formed where the waters were more quiet, as now on all coasts (for sand-beds never exist along shores without cotemporaneous mud-beds within a distance that is not great); and that from these mud-beds, or beds of finely triturated rocks, the mica slate, mica schist, or mica rock, and the hornblende rocks would have been produced. The existence of some potash and alumina in the triturated rock or mud (both ingredients of orthoclase) would have favored the formation of brown mica (biotite) by metamorphism, while the presence of lime or rather a calcium compound, that of hornblende: magnesia and iron being in about the same proportion in the hornblende as in the mica. Analyses of average biotite and dark green hornblende afford:

	Biotite.	Hornblende.
Silica	40	45
Alumina	18	10–12
Iron protoxide } Iron sesquioxide }	10	10
Magnesia	22	20
Lime	--	14
Potash	10	--

The magnesia would have come from the trituration of such older rocks as are made partly or wholly of minerals containing it; of which minerals, hornblende and biotite are the most common.

Admitting the Coös formation of Professor Hitchcock, and the Calciferous mica schist adjoining it, to be of the same formation with the mica slate, quartzyte, and hornblende rocks of the Bernardston and Vernon region, which Professor H. states to be a fact, this Helderberg formation stretches northward beyond the boundary of New England, with a breadth along the Connecticut Valley of fifteen to thirty miles or more:

breadth enough where narrowest—as at Bernardstón—for a clear sea good for growing corals and crinoids. Whether Professor Hitchcock's Lisbon and Lyman groups, which he refers to the Huronian, are not to be included, remains to be ascertained, as indicated on page 317 of this volume. Adding them, it would follow that the Connecticut bay or channel of the Helderberg era covered a large part of Northern New Hampshire, and was connected with a great area in Maine marked off by the occurrence of Helderberg and Devonian fossils.

ART. XLIV.—*History of Cavern Exploration in Devonshire, England;* by W. PENGELLY, F.R.S., F.G.S., President of the Geological Section of the British Association at Plymouth.

[Continued from page 308.]

Brixham Cavern.—Early in 1858 an unsuspected cavern was broken into by quarrymen at the northwestern angle of Windmill Hill at Brixham, at a point seventy-five feet above the surface of the street, almost vertically below, and 100 feet above mean tide. On being found to contain bones, a lease in it was secured for the Geological Society of London, who appointed a committee of their members to undertake its exploration; funds were voted by the Royal Society, and supplemented by private subscriptions; the conduct of the investigation was intrusted to Mr. Prestwich and myself; and the work, under my superintendance, as the only resident member of the committee, was begun in July, 1858, and completed at midsummer, 1859.

The cavern, comprised within a space of 135 feet from north to south, and 100 from east to west, consisted of a series of tunnel galleries from six to eight feet in greatest width, and ten to fourteen feet in height, with two small chambers and five external entrances.

The deposits, in descending order, were:—

1st, or uppermost; a floor of stalagmite, from a few inches to a foot thick, and continuous over very considerable areas, but not throughout the entire cavern.

2d. A mass of small angular fragments of limestone, cemented into a firm concrete with carbonate of lime, commenced at the principal entrance, which it completely filled, and whence it extended thirty-four feet only. It was termed the *first bed.*

3d. A layer of blackish matter, about twelve feet long, and nowhere more than a foot thick, occurred immediately beneath the first bed, and was designated the *second bed.*

4th. A red, tenacious, clayey loam, containing a large number of angular and subangular fragments of limestone, varying from very small bits to blocks a ton in weight, made up the *third bed.* Pebbles of trap, quartz and limestone were somewhat prevalent, whilst nodules of brown hematite and blocks of stalagmite were occasionally met with in it. The usual depth of the bed was from two to four feet, but this was exceeded by four or five feet in two localities.

5th. The third bed lay immediately on an accumulation of pebbles of quartz, greenstone, grit and limestone, mixed with small fragments of shale. The depth of this, known as the *fourth* or *gravel bed*, was undetermined; for, excepting a few feet only, the limestone bottom was nowhere reached. There is abundant evidence that this bed, as well as a stalagmitic floor which had covered it, had been partially broken up and dislodged before the introduction of the third bed.

Organic remains were found in the stalagmitic floor and in each of the beds beneath it, with the exception of the second only; but as ninety-five per cent of the whole series occurred in the third, this was not unfrequently termed the *bone bed.*

The mammals represented in the stalagmite were bear, reindeer, *Rhinoceros tichorhinus*, mammoth, and cave lion.

The first bed yielded bear and fox only.

In the third bed were found relics of mammoth, *Rhinoceros tichorhinus*, horse, *Bos primigenius*, *B. longifrons*, red deer, reindeer, roebuck, cave lion, cave hyæna, cave bear, grizzly bear, brown bear, fox, hare, rabbit, *Lagomys spelæus*, water-vole, shrew, polecat and weasel.

The only remains met with in the fourth bed were those of bear, horse, ox and mammoth.

The human industrial remains exhumed in the cavern were flint implements and a hammer-stone, and occurred in the third and fourth beds only. The pieces of flint met with were thirty-six in number. Of these, fifteen are held to show evidence of having been artificially worked, in nine the workmanship is rude or doubtful, four have been mislaid, and the remainder are believed not to have been worked at all (see Phil. Trans., vol. clxiii, 1873, pp. 561, 562). Of the undoubted tools, eleven were found in the third and four in the fourth bed. Two of those yielded by the third bed, found forty feet apart, in two distinct but adjacent galleries, and one a month before the other, proved to be parts of one and the same *nodule*-tool; and I have little or no doubt that it had been washed out of the fourth bed and re-deposited in the third.

The hammer-stone was a quartzite pebble, found in the upper portion of the fourth bed, and bore distinct marks of the use to which it had been applied.

Speaking of the discovery of the tools just mentioned, Mr. Prestwich said in 1859:—"It was not until I had myself witnessed the conditions under which flint implements had been found at Brixham, that I became fully impressed with the validity of the doubts thrown upon the previously prevailing opinions with respect to such remains in caves" (Phil. Trans., 1860, p. 280); and according to Sir C. Lyell, writing in 1863:—"A sudden change of opinion was brought about in England respecting the probable coëxistence, at a former period, of man and many extinct mammalia, in consequence of the results obtained from the careful exploration of a cave at Brixham. . . . The new views very generally adopted by English geologists had no small influence on the subsequent progress of opinion in France" ("Antiquity of Man," pp. 96, 97).

Bench Cavern.—Early in 1861 information was brought me that an ossiferous cave had just been discovered at Brixham, and, on visiting the spot, I found that, of the limestone quarries worked from time to time in the northern slope of Furzeham Hill, one known as Bench Quarry, about half a mile due north of Windmill Hill Cavern, and almost overhanging Torbay, had been abandoned in 1839, and that work had been recently resumed in it. It appeared that in 1839 the workmen had laid bare the greater part of a vertical dike, composed of red clayey loam, and angular pieces of limestone, forming a coherent wall-like mass, twenty-seven feet high, twelve feet long, two feet in greatest thickness, and at its base 123 feet above sea-level. In the face of it lay several fine relics of the ordinary cave mammals, including an entire left lower jaw of *Hyæna spelæa* replete with teeth, but which had nevertheless failed to arrest the attention of the incurious workmen who exposed it, or of any one else.

Soon after the resumption of the work in 1861, the remnant of the outer wall of the fissure was removed, and caused the fall of an incoherent part of the dike, which it had previously supported. Amongst the *débris* the workmen collected some hundreds of specimens of skulls, jaws, teeth, vertebræ, portions of antlers, and bones, but no indications of man. Mr. Wolston, the proprietor, sent some of the choicest specimens to the British Museum, and submitted the remainder to Mr. Ayshford Sanford, F.G.S., from whom I learn that the principal portion of them are relics of the cave hyæna, from the unborn whelp to very aged animals. With them, however, were remains of bear, reindeer, ox, hare, *Arvicola ratticeps*, *A. agrestis*, wolf, fox, and part of a single maxillary with teeth not distinguishable from those of *Canis isatis.* To this list I may add rhinoceros, of which Mr. Wolston showed me at least one bone.

From the foregoing undesirably, but unavoidably, brief descriptions, it will be seen that the Devonshire caverns, to which attention has been now directed, belong to two classes, —those of Oreston, the Ash-Hole, and Bench being *Fissure Caves;* whilst those of Yealm Bridge, Windmill Hill at Brixham, Kent's Hole, and Ansty's Cove are *Tunnel Caves.*

Windmill Hill and Kent's Hole Caverns have alone been satisfactorily explored; and besides them none have yielded evidence of the contemporaneity of man with the extinct cave mammals.

Oreston is distinguished as the only known British cavern which has yielded remains of *Rhinoceros leptorhinus* (Quart. Journ. Geol. Soc., xxxvi, p. 456).

Yealm Bridge Cavern, if we may accept Mr. Bellamy's identification in 1835, was the first in this country in which relics of glutton were found (South Devon Monthly Museum, vi, pp. 218–223; see also "Nat. Hist. S. Devon," 1839, p. 89). The same species was found in the caves of Somerset and Glamorgan in 1865 (Pleist. Mam., Pal. Soc., pp. xxi, xxii), in Kent's Hole in 1869 (Rep. Brit. Assoc., 1869, p. 207), and near Plas Heaton, in North Wales, in 1870 (Quart. Jour. Geol. Soc.), xxvii, p. 407).

Kent's Hole is the only known British cave which has afforded remains of beaver (Rep. Brit. Assoc., 1869, p. 208), and up to the present year the only one in which the remains of *Machærodus latidens* had been met with. Indeed Mr. MacEnery's statement, that he found in 1826 five canines and one incisor of this species in the famous Torquay Cavern was held by many paleontologists to be so very remarkable as, at least, to approach the incredible, until the Committee now engaged in the exploration exhumed, in 1872, an incisor of the same species, and thereby confirmed the announcement made by their distinguished predecessor nearly half a century before (Rep. Brit. Assoc., 1872, p. 46). In April last (1877) the Rev. J. M. Mello was able to inform the Geological Society of London that Derbyshire had shared with Devon the honor of having been a home of *Machærodus latidens,* he having found its canine tooth in Robin Hood Cave in that county, and that there, as in Kent's Hole, it was commingled with remains of the cave hyæna and his contemporaries (Abs. Proc. Geol. Soc., No. 334, pp. 3, 4).

The Ash-Hole, as we have already seen, afforded the first good evidence of a British reindeer.

In looking at the published reports on the two famous Torbay caverns it will be found that they have certain points of resemblance as well as some of dissimilarity:

1st. The lowest known bed in each is composed of materials which, while they differ in the two cases, agree in being such as may have been furnished by the districts adjacent to the cavern-hills respectively, but not by the hills themselves, and must have been deposited prior to the existing local geographical conditions. In each, this bed contained flint implements and relics of bear, but in neither of them those of hyæna. In short, the *fourth bed* of Windmill Hill Cavern, Brixham, and the *breccia* of Kent's Hole, Torquay, are coëval, and belong to what I have called the *Ursine* period of the latter.

2d. The beds just mentioned were in each cavern sealed with a sheet of stalagmite, which was partially broken up, and considerable portions of the subjacent beds were dislodged before the introduction of the beds next deposited.

3d. The great bone bed, both at Brixham and Torquay, consisted of red clayey loam, with a large percentage of angular fragments of limestone; and contained *flake* implements of flint and chert, inosculating with remains of mammoth, the tichorhine rhinoceros, and hyæna. In fine, the *cave-earth* of Kent's Hole and the *third bed* of Brixham Cavern correspond in their materials, in their osseous contents, and in their flint tools. They both belong to what I have named the *Hyænine* period of the Torquay Cave.

But, as already stated, there are points in which the two caverns differ:

1st. While Kent's Hole was the home of man, as well as of the contemporary hyæna during the absences of the human occupant, there is no reason to suppose that either man or any of the lower animals ever did more than make occasional visits to Brixham cave. The latter contained no flint chips, no bone tools, no utilized *Pecten*-shells, no bits of charcoal, and no coprolites of hyæna, all of which occurred in the cave-earth of Kent's Hole.

2d. In the Torquay Cave, relics of hyæna were much more abundant in the cave-earth than those of any other species. Taking the teeth alone, of which vast numbers were found, those of the hyæna amounted to about 30 per cent of the entire series, notwithstanding the fact that, compared with most of the cave-mammals, his jaws, when furnished completely, possess but few teeth. At Brixham, on the other hand, his relics of all kinds amounted to no more than 8·5 per cent of all the osseous remains, while those of the bear rose to 53 per cent.

3d. The entrances of Brixham Cavern were completely filled up and its history suspended not later than the end of the Paleolithic era. Nothing occurred within it from the days when Devonshire was occupied by the cave-and grizzly bears, reindeer, rhinoceros, cave lion, mammoth, and man, whose best tools were unpolished flints, until the quarrymen broke into it early in A. D. 1858. Kent's Cavern, on the contrary, seems to have never been closed, never unvisited by man, from the earliest Paleolithic times to our own, with the possible exception of the Neolithic era, of which it cannot be said to have yielded any certain evidence.

Though my "History of Cavern Exploration in Devonshire" is now completed, so far as the time at my disposal will allow, and so far as the materials are at present ripe for the historian, I venture to ask your further indulgence for a few brief moments while passing from the region of fact to that of inference.

That the Kent's Hole men of the Hyænine period—to say nothing at present of their predecessors of the Breccia—belonged to the Pleistocene times of the biologist, is seen in the fact that they were contemporary with mammals peculiar to and characteristic of those times. This contemporaneity proves them to have belonged to the *Paleolithic* era of Britain and Western Europe generally, as defined by the archeologist; and this is fully confirmed by their unpolished tools of flint and chert. That they were prior to the deposition of even the oldest part of the peat bogs of Denmark, with their successive layers of beech, pedunculated oak, sessile oak, and Scotch fir, we learn from the facts that even the lowest zone of the bogs has yielded no bones of mammals but those of recent species, and no tools but those of *Neolithic* type; whilst even the granular stalagmite, the uppermost of the Hyænine beds in Kent's Hole, has afforded relics of mammoth, *Rhinoceros tichorhinus*, cave bear, and cave hyæna.

That the men of the Cave Breccia, or Ursine period, to whom we now turn, were of still higher antiquity, is obvious from the geological position of their industrial remains. That the two races of Troglodytes were separated by a wide interval of time we learn from the sheet of crystalline stalagmite, sometimes twelve feet thick, laid down after the deposition of the breccia had ceased, and before the introduction of the cave-earth had begun, as well as from the entire change in the materials composing the two deposits. But, perhaps, the fact which most emphatically indicates the chronological value of this interval is the difference in the faunas. In the cave-earth, as already stated, the remains of the hyæna greatly exceed in number those of any other mammal; and it may be added that he is also disclosed by almost every relic of his contemporaries—their jaws have, through his agency, lost their condyles and lower borders; their bones are fractured after a fashion known by experiment to be his; and the splinters into which they are broken are deeply scored with his teeth-marks. His presence is also attested by the abundance of his droppings in every branch of the cavern. In short, Kent's Hole was one of his *homes;* he dragged thither, piecemeal, such animals as he found dead near it; and the well-known habits of his representatives of our day have led us to expect all this from him. When, however, we turn to the breccia, a very different spectacle awaits us. We meet with no trace whatever of his presence, not a single relic of his skeleton, not a bone on which he has operated, not a coprolite to mark as much as a visit. Can it be doubted that had he then occupied our country he would have taken up his abode in our cavern? Need we hesitate to regard this entire absence of all traces of so decided a cave-dweller as a proof that he had not yet made his advent in Britain? Are we not compelled to believe that man formed part of the Devonshire fauna long before the hyæna did? Is there any method of escaping the conclusion that between the era of the Breccia and that of the Cave-earth it was possible for the hyæna to reach Britain?—in other words, that the last continental state of our country occurred during that interval? I confess that, in the present state of the evidence, I see no escape; and that the conclusion thus forced on me compels me to believe also that the earliest men of Kent's Hole were *interglacial*, if not *preglacial*.

The following table will serve to show at one view the co-ordinations and theoretical conclusions to which the facts of Kent's Cavern have led me, as stated briefly in the foregoing remarks. The table, it will be seen, consists of two divisions, separated with double vertical lines. The first, or left hand, division contains three columns, and relates exclusively to Kent's Cavern, as is indicated by the words heading it. The second, or right hand, division is of a more general character, and shows the recognized classification of well-known facts throughout western Europe. The horizontal lines are intended to convey the idea of more or less well-defined chronological horizons, and their occasional continuity through two or more columns denotes contemporaneity. Thus, to take an example from the two columns headed "Archæological" and "Danish-Bog," in the second division: the horizontal line passing continuously through both, under the words "Iron" and "Beech," is intended to suggest that the "Iron Age" of Western Europe and the "Beech" zone of the Danish Bogs take us back about equally far into antiquity; whilst the position of the line under the word "Bronze" indicates that the "Bronze age" (still of Western Europe) take us back from the ancient margin of the Beech era, through the whole of that of the Pedunculated Oak, and about half-way through the era of the Sessile Oak; and so on in all other cases.

KENT'S CAVERN.			PERIODS.				
Deposits.	Bones.	Implements.	Archeolog'al.	Danish-Bog.	Biological.	Geograph.	Climat
		Iron.	Iron.	Beech.			
Black Mould.	Ovine.	Bronze.	Bronze.	Pedunculated Oak.	Recent.	Insular.	Post-Glacial
		and (?)		Sessile Oak.			
		Neolithic.	Neolithic.	Scotch Fir.			
Granular Stalagmite.							
Black Band.	Hyænine.	Paleolithic Flakes.				Continental.	Glacial
Cave-earth.			Paleolithic.		Pleistocene.		and (?)
Crystalline Stalagmite.						Insular.	Inter-Glacial
	Ursine.	Paleolithic Nodules.					
Breccia.						Continental.	Pre-Glacial

ART. XLV.—*Is the Existence of Growth-rings in the Early Exogenous Plants proof of Alternating Seasons?* An extract from a paper read before the N. Y. Academy of Sciences, March 19, 1877; by CHARLES B. WARRING, PH.D.

WE are told that there must have been the same alternation of seasons before the Glacial Epoch as now, because the exogenous plants of those early times exhibit concentric growth-rings; and consequently the earth's axis must then have been inclined as at present.

But are seasons necessary to the formation of the rings? Until that is established their existence has no importance in this connection. Were it possible in some way to secure a temperature uniform through the year we might be able to determine the question experimentally. The nearest approach to such a condition in this latitude is to be found in green-houses.

The results thus far show that exogenous plants, e. g., the orange and lemon, so placed, form growth-rings as regularly as do the forest trees.

It would be interesting to know how generally exogenous plants in tropical regions exhibit these markings, and whether they are annual or whether they are made at longer or at shorter intervals. I have found it difficult to obtain any information on this point, either from books or from botanists. The latter tell me (I have applied to several botanists of distinction) that they know very little about it. Dr. Gray says, "I know of no exogenous tree that grows continuously. * * * Yet there are exogenous woody stems which do not make annual layers. There is a woody *Phytolacca* which makes more layers, at least twice as many, as it is years old—probably indicating two periods of growth and rest." To this I add that there now lies before me a section of *Chenopodium album* cut on the first of August, and consequently not more than four months old, in which are eight well defined rings. This section is as hard and compact and as well formed wood as if it were a section of ash or pine.

On the other hand there are exogens growing even in this climate, which, notwithstanding our cold winters and hot summers, show not the slightest trace of a ring. I have before me a section of *Akebia quinquefolia* cut by Dr. O. R. Willis on his own lawn from a plant five years old, which has no such markings. Then from a little further south I have a section of the Passion Vine in the same condition; also one of the Iron Wood (*Carpinus Americana*) which presents the faintest possible traces of them. For these also I am indebted to Dr. Willis.

Miss C. C. Haskell, of Vassar College, states the result of her examination of the tropical woods in their museum, as follows: In the *Moria atiara* of the Amazon, the circles are very apparent. In the *Aliso* or *Birch of the Indus*, the circles are evident. They are seen, too, in the *Brazilian Red-wood* (Upper Amazon), and in *Siphonia elastica* or Rubber tree, as well as in the *Moria peranya* of the Rio Negro. None are seen in the *Tortoise Shell Wood* or in the *Cow Tree*."

These suffice to show that, in the uniformly warm climate of the tropics, rings are formed as regularly as in the trees of our northern forests. But it may be said that although there is in these regions no alternation of hot and cold seasons, yet that they do undergo semi-annual changes from wet to dry, and from dry to wet, and that, these being dependent upon the earth's axial inclination, we are not at liberty to infer that the rings would have been formed had there been the absolutely seasonless condition which a perpendicular axis would produce. But there is evidence that exogenous trees would form these marks in a climate of absolutely no variation. I have before me a section of *Mangrove* also presented by Dr. Willis. This tree, as is well known, grows in the muddy margins of tropical rivers and all along the shores, forming dense forests even at the verge of the ocean and below high-water mark. In such a locality there can be no alternation of wet and dry seasons, and the changes of annual temperature must be less than the diurnal. It would seem impossible to conceive of greater uniformity of temperature and moisture, yet this tree presents the growth rings as broad and as well defined as those which are seen in any trees anywhere.

To dispel any vestige of belief that seasons and these markings are connected as cause and effect, I add that the *Cycads* require several years to form one ring.

The consideration of these facts leads to the conclusion that these circles have their origin in cycles of activity and repose, implanted in the constitution of the plant, which would continue to manifest themselves although there were no climatic variations—a conclusion strengthened by the experience of all who have attempted, by artificially equalizing the temperature, to make their plants bloom all the year. It is true that where seasonal variations exist, the successive stages of activity and rest are for obvious reasons synchronous with them, but they are not absolutely dependent upon them.

We may conclude, too, that the pre-glacial flora exhibited similar cycles of growth and rest, some of which may have been of short duration, measured perhaps by weeks, like those of the *Chenopodium*, while others like the *Cycads* may have required several years for their completion.

The following propositions appear to be established by the facts which have been presented.

1. Some exogens form rings at intervals much less than a year.
2. Others require intervals of several years.
3. Some form no rings.
4. The presence or absence of rings in exogens occurs in all climates.
5. Large and well defined rings are found under conditions in which there is absolutely no appreciable variation of temperature or moisture throughout the year.
6. An exogen naturally forming rings, will continue to form them although the climate become uniform through the year.

The existence, therefore, of these markings in the ancient flora gives no information as to the existence at that time of seasons, and so far as they are concerned we are left free to adopt any conclusion as to the inclination of the earth's axis which may appear to us most reasonable.

ART. XLVI.—*On Sipylite, a new Niobate, from Amherst County, Virginia;* by J. W. MALLET.

THE allanite found in Amherst County in this State, of which an analysis by Mr. J. A. Cabell, was published in the Chemical News, 1874, p. 141, occurs in large quantity, and furnishes an abundant source of supply of the cerium family of metals. In picking over a lot of three or four hundred pounds of it, I was struck with the appearance of a few fragments of an accompanying mineral, which on more careful examination turns out to be a new niobate.

The locality in question is on the northwest slope of Little Friar Mountain, about fifteen miles from the Virginia Midland Railway. The allanite is said to occur in a vein of more or less decomposed feldspar in a gneissoid rock, and is met with in large, but very imperfect crystals, and loose lumps of irregular shape, about four feet below the surface of the ground. Magnetite is found with it, the two minerals often forming parts of the same mass; and in going down the vein seems to become more compact, and tends to pass into solid magnetic iron ore. The vein is said to be about two feet wide, and runs about northeast and southwest, dipping at a large angle to the southeast.

Beside allanite, magnetite, and the new mineral now to be described, I have only noticed among the specimens which have reached me a few large crystals of hydrous zircon. One of these measured about 30×18×13 mm., was doubly terminated, of sp. gr.=4·217, and yielded on ignition 1·89 per cent of water.

The new mineral is decidedly rare; all the specimens I have collected were picked out from three lots of the allanite, two of them of several hundred pounds each, and would probably not weigh half a kilogram; the largest single piece weighs about forty grams; most of the fragments are much smaller. It is found imbedded in, or more commonly adherent to, the outside of the masses of allanite and magnetite, from which it is easily detached.

A few imperfect crystalline faces have been met with, but none of these brilliant, and only two dihedral angles that could be, even in a very rough way, measured with the application of a goniometer; each of these was about 125°, which is not far from $I \wedge I$ of the prism of yttro-tantalite, samarskite, and euxenite. There were observed also a few very imperfect cleavage planes. For the most part the mineral appears in little, irregularly shaped masses, very brittle, and exhibiting small, but distinct, conchoidal, as well as uneven fracture.

The color of the mineral in mass is brownish black, in thin splinters a red brown, like that of dark pine-rosin ; one or two small specimens display a gradual passage to a brownish orange, and even a yellow, but whether in these cases the chemical composition remains quite the same, there is not sufficient material to determine. The streak is light cinnamon-brown to pale gray. The luster resinous and pseudo-metallic. In general appearance to the eye the mineral is much like fergusonite from Greenland, euxenite from the neighborhood of Arendal, and samarskite from North Carolina, save that the last named is more distinctly pitchy black. Translucent in thin splinters. Hardness = nearly 6. Specific gravity may be considered = 4·89; one specimen gave 4·887 at 12°·5 C.; another 4·892 at 17°·5.

Heated alone in the ordinary blowpipe flame the mineral cracks, decrepitates, *glows brilliantly* (more brightly, I think, and at a lower temperature than any specimen of gadolinite I have ever seen), becomes pale greenish-yellow and opaque, like many specimens of good blast-furnace slag, and remains quite infusible. In the flame of one of Fletcher's hot-blast blowpipes, before which a stout blowpipe wire of platinum readily melts to a bead, thin splinters are fused merely on the edges. Heated in a closed glass tube, the same decrepitation, glowing and change of color are observed, and water is given off, which condensing on the surface of the tube is found to have an acid reaction, and slightly etches the glass. Fused with borax in the oxidizing flame, the mineral is dissolved, producing a yellow glass, which becomes pale on cooling, and assumes a greener tint in the reducing flame. With microcosmic salt, a yellowish green glass is obtained. Strong boiling hydrochloric acid attacks to some extent the mineral in fine powder, and the partial solution, if boiled with metallic tin and diluted with water, gives the fine sapphire-blue color due to niobium. This partial hydrochloric acid solution, if diluted, contains zirconium enough to brown turmeric paper to an extent quite sensible if a comparative experiment be made with similarly diluted hydrochloric acid alone. Boiling concentrated sulphuric acid decomposes the mineral completely, though somewhat slowly; and the diluted solution gives a blue color on addition of metallic zinc.

The chemical analysis was made, with much care and patience, under my direction by Mr. W. G. Brown, a student in this laboratory during the last winter. The details of the method used are given in a notice of his work in the Chemical News. Tantalum was found to be present, but in such small quantity, certainly less than one-twelfth of the niobium, that a satisfactory separation could not be obtained by Marignac's method. The sp. gr. of the mixed niobic and tantalic oxides was 4·60. By determination of the yttrium and erbium first as oxides and then as sulphates it was found that the mixture contained almost exclusively the latter metal, of which the absorption spectrum is obtainable with great distinctness from the crude solution. Iron and uranium were proved to exist as ferrous and uranous compounds. The following results were obtained:

Nb_2O_5	48·66 (with Ta_2O_5)
Ta_2O_5*	
WO_3	·16
SnO_2	·08
ZrO_2	2·09
Eb_2O_3	27·94 (with Y_2O_3)
Y_2O_3†	
Ce_2O_3‡	1·37
La_2O_3§	3·92
Di_2O_3‖	4·06
UO	3·47
MnO	trace
FeO	2·04
BeO	·62
MgO	·05
CaO	2·61
Li_2O¶	trace
Na_2O	·16
K_2O	·06
F	trace
H_2O	3·19
	100·48

Throwing together, as Rammelsberg has done in his valuable paper** on the natural tantalates and niobates, the acid oxides of niobium, tantalum, tungsten, tin and zirconium, reducing all the basic oxides present to the equivalent amounts of dyad oxides, and leaving out the water, we have from the above figures the ratio,

$$R''O : M^{v}_2O_5 = 221 : 100$$

leading to the formula $R''_3M^{v}_2O_8 \cdot 4\,R''_2M^{v}_2O_7$, or, applying the common phosphate nomenclature, a single atomic group of ortho-niobates with four of pyro-niobates; while samarskite, according to the calculation of Professor O. D. Allen†† from his analysis, contains one to one, or is represented by the formula

* Ta_2O_5 may be assumed = about 2 per cent.

† Y_2O_3 may be assumed = about 1 per cent.

‡ Cerous oxide, but with Cléve's formulæ and atomic weights for this and the corresponding oxides of lanthanum and didymium.

§ Containing a trace of Di_2O_3. ‖ Containing a trace of Ce_2O_3.

¶ Spectroscopically detected.

** Jour. Chem. Soc., March, 1872, p. 189.

†† This Journal, August, 1877, p. 131.

$R''_3M^v_2O_8 . R''_2M^v_2O_7$, and Rammelsberg makes pyrochlore from Fredriksvärn solely the pyro-niobate, $R''_2M^v_2O_7$, and fergusonite, tyrite, etc., solely the ortho-salt, $R''_3M^v_2O_8$.

If, however, the water be included in the calculation, and considered basic, placing it on an equivalent footing with the dyad oxides we have the ratio,

$$R''O : M^v_2O_5 = 311 : 100, \text{ or nearly } 3 : 1,$$

which gives the simple formula of an ortho-salt, $R''_3M^v_2O_8$. This I confess I am inclined to think more probable, and, if so, it may be allowable to suppose that the very remarkable glow exhibited by the mineral when heated is connected with the loss of basic water and the change from ortho- to pyro-niobate, as in the well known incandescence of ammonio-magnesian ortho-phosphate at the moment of change by heat to the pyro-phosphate of the latter metal.*

Whichever formula be preferred, however, for the mineral now described, it differs essentially from that of any niobate hitherto on record, the one view making it the nearest approach to a simple pyro-*niobate* (since the Fredriksvärn pyrochlore contains largely of titanium) and the other making it an ortho-salt like fergusonite, etc., but one partially acid in character or containing basic hydrogen.

Not on chemical grounds alone, but in several respects as to physical properties, the mineral is new and distinct. Carrying out the fancy of Heinrich Rose, which led him to name niobium from the daughter of Tantalus, and remembering the number and complexity of the natural niobates which have been met with, I propose for this species the name Sipylite, from Sipylus, one of the numerous children of Niobe.

* It may be worth remarking that from the analysis of Professor Allen (loc. cit.) of Professor J. Lawrence Smith's new mineral, hatchettolite, which accompanies samarskite in North Carolina, water seems to be present in it in definite proportion; and, although Rammelsberg has considered the water found in his analyses of tantalates and niobates as non-essential, and the formula, $R''_3M^v_2O_8$, which he has assigned in common to fergusonite, yttro-tantalite, tyrite and bragite, requires that water be excluded, if it be also taken into account his analyses of these minerals lead pretty closely to simple relations as to the extent of hydration (without considering the water basic), making

Fergusonite, from Greenland (with very little water)—$R''_3M^v_2O_8$, or perhaps $2R''_3M^v_2O_8 . H_2O$.

Brown yttro-tantalite, from Ytterby	$2 R''_3M^v_2O_8 . 3H_2O$.
Yellow " " "	
Tyrite	
Bragite	
Gray yttro-tantalite, from Gamle Kararfvet	$2R''_3M^v_2O_8 . 5H_2O$.

University of Virginia, Sept. 3, 1877.

ART. XLVII.—*On the Mean Motion of the Moon*; by SIMON NEWCOMB.

FOR some time after the appearance of Hansen's Lunar Tables, it was very generally considered that the theory of the moon, after occupying the attention of the mathematicians and astronomers of every century for two thousand years, was at length complete, and that the motion of that body could now be predicted with entire confidence. That Hansen's computation of the inequalities of short period produced by the sun not only far exceeded in accuracy any before made, but fulfilled all the requirements of modern astronomy, I conceive can hardly be doubted. But in the number of this Journal for September, 1870, I showed that this improvement did not extend to the inequalities of long period in the mean motion. While it was true that Hansen by an empirical term had secured a very good agreement with observations from 1750 to 1860, it was there shown that this agreement had been obtained by sacrificing the agreement before 1750, and that the moon had then begun to deviate from the tables at such a rate that they could not continue satisfactorily to represent the observations. During the seven years which have since elapsed, this suspicion has been entirely confirmed. So far as can be judged by the most recent observations, the error of the tables now exceeds ten seconds, and is increasing at a rate of not less than half a second a year.

Shortly after the publication of the short paper to which I have alluded, it was made a part of my official duty to investigate this question. In accordance with this arrangement, I have aimed at the complete discussion of all recorded observations of any astronomical value before the year 1750. These researches now being brought substantially to a close, so far as the observations are concerned, the object of the present article is to give some account of them, and of their results. The material consists in brief, of every observation of an eclipse or an occultation previous to 1750, which appears to be worthy of confidence, and calculated to throw any light upon the question of changes in the moon's mean motion. The available data may be classified as follows:—

I. Accounts of ancient historians from which it has been inferred that the shadow of the moon passed over certain points of the earth's surface during certain total eclipses of the sun. The celebrated eclipses of Thales, of Larissa, and of Agathocles have been very carefully discussed by Professor Airy in two papers which have appeared, the one in the Philosophical Transactions, and the other in the Memoirs of the Royal Astronomical

Society. After a careful examination of the six or eight eclipses in question, I was led to the conclusion that none of them could be safely relied upon as furnishing data for the error of the Lunar Tables at the times when they were observed. It is impossible, within the limited space of the present article, to enter into any details of the considerations which led me to this conclusion. It may be remarked, however, that among the eclipses in which I can feel but little confidence is the celebrated one of Thales. To prevent misapprehension I may say that I do not deny either that Thales predicted eclipses or that the shadow of the moon passed over Asia Minor, B.C., 585 as indicated by the Lunar Tables, or that a battle was stopped by some real or fancied advent of darkness, as described by Herodotus a century afterward; but I fail to see any good reason for maintaining that the extremely obscure account of Herodotus really refers to the total eclipse in question, or, in fact, to any eclipse whatever. Consequently, while these eclipses may be useful in throwing more or less of evidence on the question of the moon's secular acceleration, I do not think they can be considered reliable enough to be used for determining that quantity.

II. The second class comprises the nineteen eclipses of the moon quoted by Ptolemy in the Almagest, on which he founded his theory of the moon's motion. These eclipses appear to be worthy of some confidence, making due allowance for the very considerable errors of observation with which they are necessarily affected. The mode of treatment was this: from a very careful study of the account of each eclipse as given by Ptolemy, and without any knowledge of how it compared with the tables, I sought to make an estimate, first, of the most probable time of the phase described, and second, of the probable error of that time. These estimates I shall publish without any alteration suggested by the subsequent comparison with the tables. When this comparison was made, it was found that the general deviations of the tabular from the recorded times did not indicate a probable error essentially greater than that estimated, except in two cases.

There are five eclipses in which Ptolemy does not say to what phase the time which he gives refers. It has very generally been considered that in these cases the phase was that of the middle of the eclipse; but in all other cases the time which he gives is that of commencement; and there would be a certain probability in favor of the times where no phase was given being also those of commencement. The errors in question were systematically different from those of the other eclipses, and seemed to indicate that in these eclipses also, the beginning was referred to. Owing, however, to the uncertainty of this entire hypothesis, I judged it best to reject these eclipses entirely, and confine the discussion to the fourteen remaining ones.

Among these fourteen, which, in some cases, include the end of the eclipse as well as the beginning, there was a single one, that of B.C., 382, December 22, which was in contradiction with all the others. The other thirteen all agree in the most remarkable manner in assigning a correction of more than half an hour to the tabular times; while this one indicated a negative correction. This discordance, however, is not the most perplexing circumstance. It happened that this eclipse commenced just before sunrise, and therefore just before the moon set; and if the other eclipses were accurate, this one could not have been seen at all. If this one really was seen, it would almost necessitate a negative correction to the tabular times. We have then this dilemma: either the whole thirteen eclipses recorded by Ptolemy are, with a single exception, half an hour or more in error, or there is some mistake about this eclipse having been actually observed. Deeming the latter the more probable of the two hypotheses, I threw out this eclipse entirely. Of the twelve remaining eclipses, sixteen phases were observed, which were divided into four groups, and the mean result, by weight, of each group was taken. The mean corrections to the tabular times given by the several groups, are as follows:—

Epoch,	-687	$\delta t = +20^{m}$	$\delta\varepsilon = -11' \pm 4'$	3 phases.
	-381	$\delta t = +50$	$\delta\varepsilon = -27 \pm 5$	3 phases.
	-189	$\delta t = +36$	$\delta\varepsilon = -20 \pm 3$	8 phases.
	$+134$	$\delta t = +30$	$\delta\varepsilon = -16 \pm 4$	3 phases.

III. The next observations in order are the eclipses observed by the Arabian astronomers between the years 829 and 1004, which are published in the work entitled Le Livre de la Grande Table Hakémite, traduit par le Cen. Caussin, Paris, 1804. This work is a translation of the Arabic manuscript belonging to the University of Leyden. A few of the observations were known to Tycho Brahe and were published by him in his Historia Cœlestis. As a slight indication of the value of these eclipses it may be remarked that the two or three given by Tycho Brahe furnished the first data from which the secular acceleration of the moon was deduced. It is therefore a singular fact that no comparison of them with modern tables has ever been seriously attempted.

There are, in all, in this book, observations of twenty-five eclipses including thirty-four phases of beginning or ending. They were all reduced and compared with the tables of Hansen. Three of them were so far discordant that they had to be rejected entirely. This ratio of three out of thirty-four will not appear great if we reflect that the manuscript from which the observations were translated, was frequently very difficult to decipher or to translate, owing not only to the fading of the writing, but to the uncertainty of some of the terms which the author used. Besides these three discordant observations, there were two which could not be used because the altitude assigned to the moon at the time of the observation actually exceeded its meridian altitude. Here it was evident that there was something wrong, in recording, transcribing or translating the observation. The general result was that each observation of a phase gave the mean longitude of the moon with a probable error ranging from three to five minutes of arc. The results were divided into three groups, each made by a separate observer or set of observers, and therefore worthy of being considered as entirely independent. The mean result of each of these groups was as follows:—

Epoch, 846	$\delta\varepsilon = -4'\cdot4$
926	$\delta\varepsilon = -1\cdot1$
986	$\delta\varepsilon = -4\cdot8$

IV. Observations made after the revival of science in Europe and before the invention of the telescope. These observations were made by various astronomers from Regiomontanus to Tycho Brahe. But after a careful and laborious examination of all their observations I could find, I was led to the conclusion that none of them would throw any light on the problem. Before Tycho Brahe the observations were no better than those of the Arabs, while the time elapsed was one half that which has elapsed since the Arabian observations. No doubt the observations of Tycho Brahe are more accurate; but the records are so confused that it is impossible to obtain any definite result from them. In fact they preceded the invention of the telescope by so short an interval that it can hardly be supposed that they would throw much light on the question under consideration, however carefully they had been made. I searched carefully to find whether Tycho Brahe had ever observed an occultation, especially of Aldebaran; but could find no trace of any such observation.

V. Observations of occultations and eclipses made with a telescope but without a clock, the time being determined by the altitude of the sun or of some star observed with a quadrant. This class comprises the observations of Bullialdus and Gassendus, as well as some of the earlier of Hevelius. Bullialdus seems to have been the first one who actually observed the occultation of a star by the moon, but he does not appear to have been a skillful observer. The observations of occultations have the great advantage that the only error to be feared is that of the determination of time, always supposing that the phenomenon was actually seen. The disappearance of the star behind the moon's limb is, in fact, a sudden phenomenon which does not require any measure of distance to be well observed.

VI. Observations of eclipses and occultations made by Hevelius with a very imperfect clock regulated by altitudes taken with a quadrant with pinnules. It is well known that Hevelius would never use a telescope with his quadrant; so that the results to be derived from the observations of this most indefatigable observer do not correspond to the labor which he spent in making them. His observations are much better than those of Gassendus, but far more inaccurate than those made with the telescopic sights.

VII. Observations of Flamsteed at Greenwich, and of the astronomers of the French school, from 1672 to 1750. Flamsteed's observations were published in the Historia Cœlestis. Those of the French astronomers are not only for the most part unpublished, but seem to have been totally forgotten from the time they were made until I was fortunate enough to find them in the archives of the Paris Observatory in 1871. Not only were they wholly unreduced, but in many cases not even the name of the occulted star was given. The reduction of these observations has been the most laborious part of my work. The observers have left no explanations whatever of their mass of observations, and it was necessary to learn this by induction from the observations themselves; and from the calculations scattered here and there through the books. The errors of the instruments and of the clocks had to be investigated from modern data; and the observations have proved to be well worthy of the pains which were taken with them. Thereby, the motion of the moon has been traced back to 1675, an epoch seventy-five years before observations upon it have heretofore been supposed to commence. In the same class with these Paris observations are to be included those of DeL'isle at St. Petersburgh, with which I was furnished by Struve.

The following are some independent mean corrections given by the observations of Bullialdus, Gassendus, Hevelius, Flamsteed, and the French astronomers. The list is incomplete, as the discussion of the solar eclipses has not been finished; but it will suffice for the purposes of the present discussion:—

1621	+ 77″	1661	+ 37″
1630	+ 30	1666	+ 24
1633	+ 53	1680	+ 30·4
1635	+ 55	1682	+ 2[illegible]·5
1639	+ 23	1715	+ 13·8
1645	+ 51	1725	+ 7·0
1652	+ 38		

The investigation is terminated at the epoch of 1750 so far as the reduction of observations is concerned, because there is reason to believe that Hansen's tables are not greatly in error from 1750 to 1865. We may, therefore, in this preliminary discussion consider the tabular errors zero between these epochs. For the epoch 1875 the correction given by some good observations of occultations is −8″0, a result 1″·7 less than that indicated by the observations at Greenwich and Washington. This discrepancy is quite surprising. It is, however, worthy of remark that Captain Tupman from a discussion of all the meridian observations made in Europe about the time in question obtained a mean result somewhat less than that given by Greenwich and Washington alone. It is well known that Hansen's term depending on eight times the mean motion of Venus minus thirteen times that of the earth is almost entirely empirical, being adjusted so as to satisfy the observations between 1750 and 1850. And since this term fails to satisfy the observations outside of these limits, in fact making the tables worse than they would be without it, it ought to be rejected from the comparison of theory with observation. Its effect upon the ancient results is, however, so small in comparison with the necessary error of the observations that its effect need not be taken into account.

From the individual corrections to the moon's mean longitude which have been given for the modern dates I have sought to obtain by a rough interpolation the actual corrections for every quarter of a century from 1625 to 1725. The general results are shown in the following table, of which I shall explain the several parts:

Table of residual corrections to the several theories of the mean motion of the moon.

	(1)	(2)	(3)	(4)	(5)
Epoch.	Hansen.	H′.	s=8″·8.	s=6″·18.	Δt.
−687	−11′	−11′	+16′	+39′	−70m
−381	−27	−27	− 7	+10	−18
−189	−20	−20	− 4	+10	−17
+134	−16	−16	− 6	+ 4	− 6
846	− 4·4	− 4·4	− 2·4	− 0·2	0
926	− 1·1	− 1·1	+ 0·3	+ 2·1	− 4
986	− 4·8	− 4·8	− 3·8	− 1·3	+ 2
1625	+50″	+33″	+ 6″.1	− 6″·6	+12s
1650	+39	+18	− 6 ·9	−19 ·0	+ 3
1675	+32	+15	− 7 ·4	−18 ·6	+34
1700	+21	+16	− 3 ·6	−13 ·5	+25
1725	+ 7	+16	− 0 ·3	− 8 ·6	+16
1750	0	+19	+ 6 ·4	0 ·0	0
1775	0	+21	+12 ·5	+ 8 ·4	−15
1800	0	+15	+11 ·1	+ 9 ·5	−17
1825	0	+ 2	+ 3 ·0	+ 4 ·4	− 8
1850	0	−11	− 4 ·6	0 ·0	0
1875	− 8	−28	−15 ·8	− 7 ·6	+14

In column (1) we have the mean correction indicated by observations to Hansen's tables of the moon without any modification whatever. In column (2) these corrections are modified by the effect of Hansen's empirical term, so as to show the corrections to the pure theory after this term is subtracted from the tables. If the theory is perfect, these numbers ought to be represented by corrections to the mean longitude and mean motion of the moon and the secular acceleration.

The following are the several corrections given by the method of least squares:

$$\left.\begin{aligned} \delta e &= +19''{\cdot}57 \\ \delta n &= -12\ {\cdot}31 \\ \delta s &= -\ 3\ {\cdot}36 \end{aligned}\right\} \text{Epoch, 1700.}$$

The value of the secular acceleration adopted by Hansen is $12''{\cdot}17$. Subtracting the correction it seems that the acceleration to which we are led by observation alone, is $8''{\cdot}8$.

Column (3) shows the outstanding corrections which remain after subtracting the result of the corrections we have just found. It is evident that the theory does not represent the observations, and that the most recent observations indicate a value of the secular acceleration much less than that indicated by the older ones. If we investigate the uniform variation of the acceleration which would best satisfy the whole of the observations, we shall find it to be $-0''{\cdot}9$ in a century. The hypothesis of such a uniform variation is, however, too improbable to be admitted; and moreover, it still fails to represent the modern observations, although the ancient ones are thus greatly improved.

In recent times it has been generally considered that the difference between the theoretical acceleration and that given by observations arises from a change in the length of the day. It is worthy of remark that by supposing this change itself subject to variations, all the apparent changes in the mean motion of the moon can be accounted for. This is a hypothesis which I have suggested in former numbers of this Journal, as one by which the changes in question may be explained. Let us now see what the actual variations in the rotation of the earth must be to account for the difference between observation and theory. In the first place, the secular acceleration must be supposed to be uniform and equal to $6''{\cdot}17$. Two epochs at which we may suppose the time given by the rotation of the earth to be correct, being entirely arbitrary, we shall take 1750 and 1850 for these epochs. Having thus formed a theory of the moon's mean motion founded on gravitation alone, column (4) shows the apparent corrections indicated by observation In column (5) these corrections are changed into time. The times here given are hypothetical errors of the earth's rotation which it is necessary to subtract from the times given by astronomical observations in order to reduce them to a perfectly uniform measure of time. The sign + indicates that the earth is ahead of its mean rotation, and the sign − that it is behind it. For some years past it has seemed to me that this was the most probable hypothesis on which to explain the deviations in question. It was evidently a most unwelcome one; for, granting its truth it would be no longer possible to predict the apparent motion of the moon, since the changes in the rotation of the earth could not be expected to follow any determinate law. It is therefore extremely gratifying to find that the comparisons we have just given lead to the hope that these deviations may, after all, be due to the action of some of the bodies of the solar system. A very cursory examination of the residuals given in column 3 shows that they have apparently a period not very far from 260 years. Now, it is remarkable that this differs very little from the period of Hansen's first inequality, which is 273 years. The question therefore arises whether the deviations in question may not be explained by a change in the constants of this inequality. The result is very surprising. By merely diminishing the argument of Hansen's first inequality by 60° 48′ without changing the co-efficients at all, the observations from 1625 to 1875 may all be represented within the limits of error. In fact, we see that the numbers in column (3) may be very nearly represented by the formula

$$-5''{\cdot}04 - 10''{\cdot}14\left(\frac{t-1800}{1800}\right) - 15''{\cdot}50 \cos A,$$

in which we have placed,

$$A = 18V - 16E - g,$$

V being the mean longitude of Venus counted from the equinox of 1800, E that of the earth counted in the same way, and g the mean anomaly of the moon. The comparison in question is shown in the following tables; the fourth column of which is taken from the corresponding column of the preceding table. The residuals still outstanding are shown in the last column.

Epoch.	A.	Computed terms.	Observ.	Diff.
1625	−47°·0	+2″·2	+6″·1	+3″·9
1650	−14 ·0	−4 ·7	−6 ·9	−2 ·2
1675	+19 ·0	−7 ·1	−7 ·4	−0 ·3
1700	52 ·0	−4 ·5	−3 ·6	+0 ·9
1725	85 ·0	+1 ·2	−0 ·3	−1 ·5
1750	118 ·0	+7 ·3	+6 ·4	−0 ·9
1775	151 ·0	+11 ·0	+12 ·5	+1 ·5
1800	184 ·0	+10 ·4	+11 ·1	+0 ·7
1825	217 ·0	+4 ·8	+3 ·0	−1 ·8
1850	250 ·0	−4 ·8	−4 ·6	+0 ·2
1875	283 ·0	−16 ·0	−15 ·8	+0 ·2

Correcting Hansen's term by this empirical addition, we find that instead of

$$15''\cdot 34 \sin (A+30^\circ\cdot 2),$$

the value given by Hansen, we shall have

$$15''\cdot 3 \sin (A-30^\circ\cdot 6),$$

as the result of observation.

As a test of this result, the sum of all the corrections here found to Hansen's tables has been taken and compared with the corrections given in column 1. It is to be remarked in the first place that the diminution of 10″ a century in the mean motion of the moon involves a further correction of $-0''\cdot 4$ to the value of the secular acceleration in order that the ancient observations may still, on the average, be best represented. Thus the secular acceleration reduces to

$$8''\cdot 4\,;$$

and the total correction to the acceleration of Hansen is

$$-3''\cdot 76.$$

We put V_2 for the empirical term of Hansen,

$$21''\cdot 47 \sin (8V-13E+274^\circ\ 14'),$$

the existence of which appears to have been entirely refuted by the researches of Delaunay; and T for the time counted in centuries after 1800. Then the total corrections to the tables of Hansen are as follows:—

$$-V_2-1''\cdot 14-29''\cdot 17\,T-3''\cdot 76\,T^2-15''\cdot 5 \cos A.$$

The following are the values of these corrections for the principal epochs from 1625 to 1900. The computation and comparison with observation is given so fully that any explanation of the table appears to be unnecessary.

Epoch.	$-V_2$	$-15''\cdot 5$ cos A.	$-1''\cdot 14$ $-29\cdot 17$ T $-3\cdot 77$ T².	Sum.	Observation.	Diff.
1625	+17″·1	−10″·6	+38″·4	+44″·9	+50″	+5″
1650	21 ·4	−15 ·0	34 ·1	40 ·5	39	−1·5
1675	16 ·9	−14 ·7	29 ·4	31 ·6	32	+0·4
1700	+ 5 ·2	− 9 ·5	24 ·3	20 ·0	21	+1·0
1725	− 8 ·6	− 1 ·4	18 ·6	8 ·6	7	−1·6
1750	−18 ·9	+ 7 ·3	12 ·5	+ 0 ·9	0	−0·9
1775	−21 ·2	13 ·6	+ 5 ·9	− 1 ·7	0	+1·7
1800	−14 ·7	15 ·4	− 1 ·1	− 0 ·4	0	+0·4
1825	− 2 ·1	12 ·4	− 8 ·7	+ 1 ·6	0	−1·6
1850	+11 ·4	5 ·3	−16 ·7	0 ·0	0	0·0
1860	15 ·7	+ 1 ·8	−20 ·0	− 2 ·5	+1·5	+4·0
1870	19 ·0	− 1 ·7	−23 ·4	− 6 ·1	−5·5	+0·6
1880	20 ·9	− 5 ·2	−26 ·9	−11 ·1	....	....
1890	21 ·4	− 8 ·4	−30 ·4	−17 ·4	....	....
1900	+20 ·6	−11 ·2	−34 ·1	−24 ·7	....	....

The only case in which the difference exceeds the possible error of the comparisons is at the epoch 1860. As an explanation of this I can only suggest that the term found by Mr. Neison as due to the action of Jupiter is at that time added to the result of a possible error in Hansen's value of the term which depends upon the ellipticity of the earth. The comparison may therefore be improved when the theory is suitably corrected.

The great question which now arises is this. Is it possible that this correction to the term produced by the action of Venus can really be a result of the attraction of that planet? We are struck by the fact that the proposed change can be expressed by a mere change of the algebraic sign of the constant term of the argument, leaving the value of the co-efficient unchanged. It may therefore be inquired whether it is possible that the sign of this quantity is erroneous in Hansen's formula. This question must be answered in the negative. I have found by an investigation still unpublished, substantially the same result as Hansen; while the researches of Delaunay published in the Connaissance des Temps for the year 1862 show that the approximate expression of the constant term in question, is

$$180°-2h'',$$

h'' being the longitude of the node of Venus, which does not differ much from 75°. It is, therefore, a mere chance that the change of Hansen's term can be expressed in this way.

Although Hansen, Delaunay, and myself have all arrived at the same result for the value of the term in question, I cannot confidently say that that result is complete. In all three computations the terms of the second order due to the mutual attraction of Venus and the earth are neglected. It is evident that in consequence of this mutual attraction, the direct action of Venus on the moon is different from what it would be if each planet moved in its elliptic orbit. It may be that this difference is sensible in terms of so high an order as those under consideration. I have actually computed the additional terms in $\frac{1}{\Delta^3}$ (Δ being the distance of Venus from the earth) which arise in this way and which depend upon the argument $18V-16E$. The result is that the values of the several parts which make up this term are quite comparable with those of the elliptic terms which depend on the same argument; but these co-efficients destroy each other in taking the sum. I have, however, always regarded my computations on this subject as incomplete, and have, in consequence, never published them.

As the case stands, the marked agreement between theory and observation which is produced by the introduction of this empirical term, seems to me such as to warrant its provisional use until a more careful investigation of the subject can be made.

Washington, Oct. 3, 1877.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Action of Saline solutions on Lead.*—Muir has examined the action exerted by various saline solutions upon lead, with and without access of air, with a view to explain the mechanism of the process. The lead used was sold as pure, and contained only traces of manganese, zinc and iron. Three parallel series of experiments were tried, one in corked flasks, another in beakers covered with paper, and a third in basins, similarly covered. Twenty-five square centimeters of lead were used in each experiment, being placed in a solution of 2·0 gram per liter, of one of the following salts: ammonium nitrate, potassium nitrate, calcium chloride, ammonium sulphate or potassium carbonate, for a time varying from 14 to 21 days. In the corked flask the maximum effect took place in the calcium chloride solution, 1·9 milligrams of lead being dissolved in 14, and 3 milligrams in 21 days; while in the open beaker, ammonium nitrate dissolved from 2 to 4 milligrams, and in the open basin, the nitrate and sulphate each dissolved from 8 to 16 milligrams. The order of solvent power is NH_4NO_3, $CaCl_2$, $(NH_4)_2SO_4$, KNO_3, K_2CO_3. In general, access of air increases the action. The lead deposit formed was a plumbic hydrocarbonate $(PbCO_3)_2$,

$$Pb(OH)_2 \text{ or } \begin{array}{l} Pb\begin{cases} OH \\ O \end{cases} \\ \qquad\quad CO \\ Pb\begin{cases} O \\ O \end{cases} \\ \qquad\quad CO \\ Pb\begin{cases} O \\ OH \end{cases} \end{array}$$

, in fine silky scales. It was found to be more soluble in ammonium nitrate when air was excluded (one part in 4,600), and in calcium chloride with access of air (one part in 26,000), though its solubility was very great in carbonic acid water (one part in 4,300). The author believes that in the action of saline solutions upon lead, a soluble salt is first produced; that carbon dioxide is slowly absorbed from the air, converting the lead into hydrocarbonate, which is mostly precipitated; that in certain liquids the formation of the soluble salt proceeds at first more rapidly than its precipitation, but that later the latter action preponderates; and that carbonates precipitate the lead salt as fast as it is formed, in the form of hydrocarbonate.—*J. Ch. Soc.*, xxxi, 660, June, 1877. G. F. B.

2. *New Method for the Synthesis of Hydrocarbons.*—Friedel and Crafts, in examining the action of finely divided aluminum upon organic chlorides, which is at first very slow, but becomes more rapid, found that the aluminum chloride formed in the reaction was the active agent in evolving the hydrogen chloride, remaining itself unaltered. If, for example, amyl chloride be treated with the anhydrous chloride, hydrochloric acid gas is

evolved in the cold, as well as a mixture of gases not absorbable by bromine. In the residue, beside the unaltered Al_2Cl_6, are contained various hydrocarbons, some of high boiling point. If, however, the amyl chloride be mixed with a hydrocarbon, such as benzene in excess, the evolution of gas is regular, and the liquid separates into two layers, the upper one of which is a solution of amyl-benzene in excess of benzene, the lower, one of Al_2Cl_6. Iodides and bromides act similarly, though not as uniformly. Ethyl iodide treated as above gave ethylbenzene, methyl chloride gave toluene (methyl-benzene), xylene (dimethylbenzene) mesitylene (trimethylbenzene) and durene (tetramethylbenzene), benzyl chloride gave diphenylmethane, chloroform gave triphenylmethane and carbon tetrachloride gave tetraphenylmethane. Acid chlorides act in the same way. Benzoyl chloride dissolved in benzene, gives, by the action of aluminum chloride, the ketone benzophenone, acetyl chloride gives acetophenone, phthalyl chloride gives phthalophenone and another product, probably anthraquinone. Further examination showed that zinc and ferric chlorides acted similarly in the cold, ferrous chloride on warming. Copper, cobalt, and magnesium chlorides appeared to be without action. The authors explain the reaction by supposing an aluminum organic compound to be first formed and then decomposed, regenerating the chloride, thus:

$$C_6H_6+Al_2Cl_6=HCl+Al_2Cl_5(C_6H_5)$$

$$Al_2Cl_5.(C_6H_5)+(CH_2C_6H_5)Cl=Al_2Cl_6+(CH_2.C_6H_5)C_6H_5.$$

—*J. pr. Ch.*, II, xvi, 233, Aug., 1877. (*C. R.*, lxxxiv, 1392, 1450).

G. F. B.

3. *The Terpenes of Swedish Wood Tar.*—Atterberg has examined a so-called "wood oil," which is the first product of distillation of the wood tar made in Sweden by the destructive distillation of resinous woods, principally that of *Pinus sylvestris.* The oil was freed from creasote-like bodies and gummy acids by repeated treatment with potassium hydrate, and then submitted to repeated fractioning. In this way there was isolated a terpene boiling at 156·5°–157·5°, and having the properties of australene, and another boiling at 173°–175° having the odor of fresh pine wood, and not identifiable with any other terpene. This the author calls sylvestrene. These two terpenes constitute 80 per cent of the oil. Sylvestrene has a specific gravity of 0·8612 at 16°, is dextrorotatory, rotating +19·5° in sodium light, and forms mono- and di-hydrochlorates, the latter of which recrystallized from alcohol yields broad flat brilliant needles fusing at 72°–73°. Heated in sealed tubes with potassium hydrate, sylvestrene yields an oil having a strong pelargonium odor.—*Ber. Berl. Chem. Ges.*, x, 1202, July, 1877.

G. F. B.

4. *On the Amylene from Amyl Iodide.*—Eltekoff has investigated the action of alcoholic potash upon the amylene dibromide obtained from amyl iodide, and concludes that this amylene is really a mixture of two isomeric bodies, isopropylethylene

$\overset{CH[CH(CH_3)_2]}{\underset{CH_2}{|}}$ whose bromine derivative gives isopropylacetylene by the action of alcoholic potash; and methylethylethylene $\overset{CH[CH_2(C_2H_5)]}{\underset{CH_2}{|}}$ which does not yield valerylene under these circumstances, but is transformed into valeric ether. Isopropylacetylene boils at 35°, forms a crystalline addition product with silver nitrate $AgC{\equiv}C-CH\left\{\begin{matrix}CH_3\\CH_3\end{matrix}\right.$, which is decomposed by iodine, yielding $IC{\equiv}C-CH\left\{\begin{matrix}CH_3\\CH_3\end{matrix}\right.$, moniodisopropylacetylene.—*Bull. Soc. Ch.*, II, xxviii, Aug., 1877. G. F. B.

5. *On the Constitution of unsaturated Dibasic Acids.*—At the close of a series of researches upon certain unsaturated dibasic acids made in his laboratory, FITTIG sums up the results and discusses their bearing upon the constitution of the acids in question; i. e., fumaric and maleic acids in one group, and itaconic, citraconic and mesaconic acids in another. The facts are (1) the two former unite directly with hydrogen to yield succinic acid $\begin{matrix}CH_2.COOH\\|\\CH_2.COOH\end{matrix}$, as the three latter by the same treatment yield the same pyrotartaric acid, $\begin{matrix}CH_3\\|\\CH.COOH\\|\\CH_2.COOH\end{matrix}$; (2) the former acids by union with bromine give two different dibromosuccinic acids (both of which, however, are substitution products of ethylene-succinic acid), as the latter give in the same way three different dibromopyrotartaric acids (which must equally be regarded as substitution products of common pyrotartaric acid); (3) the former acids by union with hydrogen bromide yield the same bromosuccinic acid, the latter the same bromopyrotartaric acid, except itaconic acid, which yields an isomer; (4) while mono- or di-brom-citraconic and mesaconic acids lose with great ease on boiling with water or bases a molecule of carbon dioxide, becoming methacrylic or bromomethacrylic acids, probably identical, and easily reduced to isobutyric acid, the corresponding derivatives of itaconic acid are more permanent and yield no carbon dioxide when thus treated; (5) while fumarates and maleates yield on electrolysis the same acetylene, and citraconic and mesaconic acids the same allylene, itaconic acid gives a hydrocarbon not precipitating silver solutions. There is no constitutional formula which will satisfy all these conditions if the position be maintained that in unsaturated compounds the carbon atoms are *always* united by several bonds. Hence the facts compel the adoption of the view advanced by Kekulé, that beside these, there are other bodies, such as carbonous oxide for example, in which there are single carbon atoms whose attractions are not completely balanced. Rejecting also as unproved the existence in a compound of carbon atoms three of whose units are

balanced while the fourth is free, the author gives for maleic acid the formula $\begin{array}{l} CH_2COOH \\ \vert \\ =C.COOH \end{array}$ and for fumaric acid $\begin{array}{l} CH.COOH \\ \Vert \\ CH.COOH \end{array}$. For itaconic acid he gives $\begin{array}{l} =CH \\ \vert \\ CH.COOH \\ \vert \\ CH_2.COOH \end{array}$, or $\begin{array}{l} CH_2 \\ \Vert \\ C.COOH \\ \vert \\ CH_2.COOH \end{array}$, for citraconic acid $\begin{array}{l} CH_3 \\ \vert \\ CH.COOH \\ \vert \\ =C.COOH \end{array}$ and for mesaconic acid $\begin{array}{l} CH_3 \\ \vert \\ C.COOH \\ \Vert \\ CH.COOH \end{array}$. Hence the isobrommaleic acid of Kekulé is properly bromfumaric acid, and the dibrommaleic acid of Bourgoin, dibromfumaric acid. Of the two itaconic acid formulas, Fittig prefers the first.—*Liebig Ann.*, clxxxviii, 95, July, 1877. G. F. B.

6. *On a Phenol of Phenanthrene, Phenanthrol.*—Rehs has examined, under Graebe's direction, the product obtained by fusing phenanthrenemonosulphonic acid with potassium hydrate. After solution in water, the phenanthrol was separated in oily drops by the addition of sulphuric acid, which solidified on cooling. After boiling with ammonium carbonate, and recrystallization from a mixture of petroleum naphtha and benzene, it was obtained in beautiful blue-fluorescing plates, fusing at 112°, and giving on analysis the formula $C_{14}H_9(OH)$. It forms well crystallized compounds with alkalies, and ethers with acid oxides.—*Ber. Berl. Chem. Ges.*, x, 1252, July, 1877. G. F. B.

7. *Formation of Rosolic acid from Cresol and Phenol.*—The discovery of Caro and Wanklyn that by de-nitrogenizing rosaniline rosolic acid could be formed, and of Dale and Schlorlemmer, that aurin (rosolic acid) could be converted into rosaniline, led Zulkowsky to attempt the production of rosolic acid from cresol and phenol as rosaniline is produced from toluidine and aniline. A mixture of two molecules cresol, one phenol and three of sulphuric acid heated with arsenic acid to 120° C. became dark brown and thick and yielded to water a gummy body with a greenish metallic luster, having all the properties of rosolic acid. It is not produced with phenol alone. The author represents rosaniline as

$$NH_2.C_6H_3\begin{array}{l} \diagup C_6H_2\left\{\begin{array}{l}CH_3\\NH\end{array}\right. \\ \quad\vert \qquad\qquad \vert \\ \diagdown C_6H_2\left\{\begin{array}{l}NH\\CH_3\end{array}\right. \end{array} \text{ and rosolic acid as } OH.C_6H_3\begin{array}{l} \diagup C_6H_2\left\{\begin{array}{l}CH_3\\O\end{array}\right. \\ \quad\vert \qquad\qquad \vert \\ \diagdown C_6H_2\left\{\begin{array}{l}O\\CH_3\end{array}\right. \end{array}.$$

Corallin he separated into five different bodies.—*Ber. Berl. Chem. Ges.*, x, 1201, July, 1877. G. F. B.

8. *A new Coloring matter.*—Hofmann has examined a new brilliant red coloring matter, obtained from Martius. He found it to be the sodium salt of an organic acid, which was separated by concentrated hydrochloric acid. Fine red needles were obtained, easily soluble in alcohol, less so in water, having the formula $C_{16}H_{12}N_2SO_4$, and being monobasic. No doubt, therefore, that

this body was analogous to chrysoidin, and that it could be formed by diazobenzol and naphtolsulphonic acid, by azosulphanilic acid with a naphtol, by azonaphtylaminsulphonic acid and phenol, and by diazonapthalene and a phenolsulphonic acid. Using the first method, and mixing sodium α naphtolsulphonate with aniline nitrate and potassium nitrite, the new color was obtained.—*Ber. Berl. Chem. Ges.*, x, 1378, July, 1877. G. F. B.

9. *Examination of a Nickel magnet.*—H. WILD. (Abstract from the original memoir). The author has submitted to examination a nickel magnet presented to Kotschubey, President of the Russian Technological Society, by Jos. Wharton of Philadelphia. It had the form of a flat bar, 2 mm. thick, 9.5 mm. broad, and 155 mm. long, pointed at the ends, and had at its center an agate cap for supporting it on a pivot. Its weight was 25 grams. Its magnetic moment was determined by comparison with a bar of steel of about the same dimensions, and found to be per gram 112,000 units, the steel giving 245,000. After remagnetizing, the nickel gave 188,000, the steel 368,000. With wolfram steel, the moment went up to 594,000 in one instance. The nickel was analyzed by Butlerow and found to contain only one-third of one per cent of iron, with traces of cobalt. The effect of temperature and of time upon the magnetism of nickel was also noted. The following are the conclusions of the memoir: 1st. Pure nickel, unlike pure soft iron, may acquire a considerable amount of permanent magnetism; but the amount of this magnetism, as a maximum, is only from one-half to one-third of that which hardened steel can receive. 2d. The magnetism remaining in the nickel after the magnetizing force ceases, is less permanent than in well hardened steel; the slow loss of magnetism in the course of time, as well as that occasioned by heating and cooling, is proportionally greater than in hardened steel, even when like the steel, it is brought by repeated warming and cooling into a certain condition of permanence. 3d. The temperature-coefficient of a nickel magnet in this condition, is a little greater than that of well hardened steel. 4th. The temporary magnetism which pure nickel assumes is about double that of its permanent magnetic moment, about half of the temporary magnetism which hardened steel can acquire and one-fourth of that capable of being developed in soft iron.—*Bull. Ac. St. Pet.*, xxiv, 1, May, 1877.

10. *Spectroscope with a Fluorescent Eye-piece.*—M. J. L. SORET has published a detailed description of improvements which he has made in the application of the well known properties of fluorescent substances to the observation of the ultra violet portions of the spectrum. He places a screen of the fluorescent material at the focus of the object-glass of the spectroscope, and views the spectrum projected on this screen with an eye-piece placed obliquely, so that the diaphragms and blackened walls of the tube may extinguish the direct rays. As a screen he uses either a small plate of uranium glass or a cell fitted with an aqueous solution of esculine; and the spectroscope is best con-

structed with lenses of quartz and prisms of Iceland spar. With lenses of glass and prisms of flint the spectrum lines could not be distinguished beyond N, but with the spectroscope whose construction he describes in detail the principal lines could be distinguished as far as T. With a more portable spectroscope of similar construction M. Soret has made observations in the Alps at an altitude of 3180 meters, and draws from them the conclusions, that although the ultra violet spectrum is more brilliant at high elevations than on the plains it has no greater extent. In the observations referred to, he could not distinguish rays more refrangible than T. Whence he infers that it is the atmosphere of the sun, and not that of the earth which absorbs the most refrangible rays of the spectrum. The diminution in brilliancy of the more refrangible portion of the spectrum caused by the atmosphere he refers not to the selective absorption of its aeriform constituents, but to the effect of the floating liquid or solid particles, which when more abundant produce a distinct haze or collect in clouds. The general absorption of light due to this last cause affects all the rays of the spectrum, but to a greater extent in proportion as the rays are the more refrangible.—*Ann. Chim. et de Phys.*, V, xi, 72. J. P. C., JR.

11. *Sun's Heat.*—M. A. CROVA has published a very extended paper on the calorific intensity of the solar radiation and its absorption by the atmosphere of the earth. In this paper the author discusses very exhaustively methods of observation and gives the results of a large number of measurements which are of great interest, but can not be described in a short abstract.—*Ann. Chim. et de Phys.*, V, xi, 433. J. P. C., JR.

12. *Changes in the Spectra of Gases caused by increasing tension.*—In the spectrum of a gas rendered luminous by an electric spark M. Wullner distinguishes two classes of effects as caused by an increasing tension. In the case of hydrogen only, the bands themselves broaden into a continuous spectrum. With other gases a continuous spectrum appears between the bands which remain meanwhile as definite as at first. In the case of compounds of carbon and markedly in the case of carbonic dioxide the brilliancy of the continuous spectrum soon becomes so great that the bands disappear, but with nitrogen and with air they can be distinguished until the pressure becomes much more considerable. This restatement of the results of previous observations is occasioned by a communication of M. Cazin who refers the continuous spectrum in such cases to the solid particles transported and rendered luminous during the electric discharge.—*Ann. Chim. et de Phys.*, V, xii, 143. J. P. C., JR.

13. "*The Influence of Light in Chemical Changes and chiefly in Oxidation*," is the subject of a recent paper by M. P. CHASTAING. The author distinguishes as a definite effect of the sun's rays the determining of the oxidation of inorganic metallic compounds, an influence which he locates in a different part of the solar spectrum from the well-known reducing action. He deduces this conclusion chiefly from the observation that the oxidation of

such substances as ferrous sulphate, alkaline solution of arsenious acid, and aqueous solutions of hydric sulphide or alkaline sulphides proceeds more rapidly in the light than in the dark, and he endeavors to estimate the action of the light by the difference in the rapidity of the process in the two cases under otherwise like conditions. He concludes that the chemical action of the solar spectrum on metallic compounds both binaries and salts while reducing at the more refrangible end is oxidizing at the less refrangible end. The general reducing action of white light he refers to the circumstance that in the rays as a whole the reducing action is the more powerful of the two. M. Chastaing finds that the green rays still exert a reducing action and he locates between the rays D and E a neutral point of the spectrum, at which chemical action takes place as in darkness. It appears however that the action exerted on organic compounds by the light is quite different from that just indicated. Its influence on such bodies is always oxidizing and this effect continually increases as we pass from the red to the violet end of the spectrum with some variation from this law in the green rays. For numerous details and subordinate conclusions we must refer to the original paper which is quite long but full of interest. We must add that results of our own do not accord, at least *apparently*, with those of M. Chastaing. We have recently discovered in the oxidation of a solution of antimonious iodide under the combined action of the air and light a direct effect of oxidation caused by the sun's rays, and this effect is produced chiefly, if not wholly, by the more refrangible rays.—*Ann. Chim. et de Phys.*, V, xi, 145. J. P. C., JR.

14. *Magnetic rotatory Polarization.*—M. HENRI BECQUEREL has very recently published the results of an important investigation on "Magnetic rotatory Polarization," which is especially interesting as supplementing the researches of his distinguished father on the same subject. His memoir is quite long and the results cannot be stated in a few words. The most important general conclusions are the following:—

(1.) That the positive rotation of the plane of polarization of a ray of light having a definite wave-length, in passing through the unit of thickness of a diamagnetic material under the influence of magnetism, is sensibly proportional to $n^2(n^2-1)$, a function of the index of refraction, and to a factor depending on the magnetism and on the diamagnetism of the body, this factor becoming the greater in proportion as the substances are more diamagnetic. (2.) That with substances chemically allied or containing the same radical the quotient of the magnetic rotation, and the corresponding value of $n^2(n^2-1)$, varies very slightly. (3.) That the chemical nature of the substance exerts an important influence on the phenomenon, and that the several constituents of a compound may produce an independent effect. (4.) That when in solution the specific effect of the molecules of diamagnetic bodies is not influenced by the concentration of the solution, while that of the molecules of magnetic bodies may be greatly affected by the closer proximity, which such a concentration would cause, (5.) That when the substances are very diamagnetic the dispersion of the rays caused by the magnetic rotation is sensibly proportional to $\frac{n^2(n^2-1)}{\lambda^2}$ in which expression λ is the wave length and n the index of refraction. For various qualifications and details we must refer to the original paper, and also for a discussion of the theory advanced by M. Becquerel père, which refers the differences between magnetic and diamagnetic effects to the relative strength of the magnetic energy of the bodies experimented on and that of the medium by which they are surrounded. —*Ann. Chim. et de Phys.*, V, xiii, 5. J. P. C., JR.

15. *Rose-colored Sulphide of Manganese.*—The conditions of the transformation of the rose-colored sulphide of manganese obtained by precipitation into the green semi-crystalline modification of the same compound has been studied by MM. Ph. de Clermont et H. Guiot who come to the conclusion that the two substances are different states of hydration of the same body.—*Ann. Chim. et de Phys.*, V, xii, 111.

16. *Analysis of Alkaline Sulphides and Sulpho-carbonates.*—M.M. Delachanal et Mermet have described a new method for the complete chemical analysis of alkaline sulphides and sulphocarbonates based on the application of hypobromite of potassium as an oxidizing agent. The method offers certain marked advantages and the values obtained indicate that it yields accurate results.—*Ann. Chim. et de Phys.*, V, xii, 88.

17. *Separation of Potassium from Sodium.*—Schloesing has improved and simplified the process proposed by Serullas for separating potassium from sodium based on the circumstance that potassic prochlorate is insoluble in alcohol and that of the radicals most frequently occurring in analytical processes potassium is the only one whose prochlorate does not dissolve in this solvent. He uses for the purpose pure perchloric acid, and gives simple methods for preparing this reagent in the required quantity. Perchloric acid in excess readily replaces both nitric and hydrochloric acid, forming perchlorates of the bases present. Potassic perchlorate is then easily separated and washed with alcohol of forty degrees Baumè. In this process the potassium is weighed as perchlorate after the salt has been heated to 250°, while the sodium is converted into sulphate and weighed as such.—*Ann. Chim. et de Phys.*, V, xi, 561. J. P. C., JR.

18. *A volumetric method of determining the amount of Manganese in iron ores*, is described by M. Garcia Parreño which will undoubtedly be found useful in many cases. The manganese in the ore is at the outset converted into Mn_3O_4 by roasting in a platinum crucible. About a gram is taken for each assay which is dissolved in thirty-five to forty cubic centimeters of hydrochloric acid. The process is conducted in a flask, and the chlorine gas conducted into a weak solution of potassic iodide, the last traces being driven over by boiling the acid. The amount of iodine

thus set free is then determined by a standard solution of hyposulphite of sodium which bleaches the solution colored by the iodine. The solution of the hyposulphite is standardized by a preliminary experiment with pure Mn_3O_4.—*Ann. Chim. et de Phys.*, V, xi, 571. J. P. C., JR.

19. *Light: A series of simple, entertaining and inexpensive experiments in the phenomena of light, for the use of students of every age*; by ALFRED M. MAYER and CHARLES BARNARD. 112 pp. 8vo. New York, 1877, (D. Appleton & Co.).—The purpose of this little volume is to present and illustrate the fundamental phenomena of light in a manner suited to the ready comprehension of the younger class of students, and to suggest means for verifying the laws of its action by actual experiment. The text, which was prepared by Mr. Barnard and revised by Professor Mayer, is written in vivacious and entertaining style, and with such clearness and accuracy of statement that the most inexperienced student cannot fail to understand it. The experiments, which were devised by Professor Mayer, are for the most part new, and have the merit of combining precision in the methods with extreme simplicity and elegance of design. Nearly all the apparatus figured can be made by the young experimenter himself, with the use of the most common and inexpensive materials, and at a very slight expense, the whole cost of the articles required being less than fifteen dollars. The aim of the authors has been to make their readers "experimenters, strict reasoners, and exact observers," and for the attainment of this end the book is admirably adapted. Its value is further enhanced by the numerous carefully drawn and well executed cuts, which add greatly to its beauty. It is to be hoped that many will avail themselves of this opportunity to become practically acquainted with the fundamental principles of Optics. A. W. W.

20. *A Manual of Inorganic Chemistry*; Vol. II. *The Metals*; by T. E. THORPE, Ph.D., F.R.S., Professor of Chemistry in the Yorkshire College of Science, Leeds. New edition, 406 pp. 8vo. New York, 1877, (G. P. Putnam & Sons).—The previous edition of this work, as well as the other volumes by the same author, are well known among chemists, and their value fully appreciated. A feature of this new edition is the collection of examination questions and exercises at the end of the volume.

21. *A System of Volumetric Analysis, by Dr. Emil Fleischer. Translated with notes and additions from the second German edition*; by M. M. PATTISON MUIR, F.R.S.E. 274 pp. 8vo. London, 1877, (Macmillan & Co).—The peculiar merit of this work lies in the fact that it gives not "a complete collection of receipts" for independent processes, but a system of general methods under which the individual cases may be brought. As remarked by the translator the work attempts to divide volumetric processes into a few great groups, to explain clearly the principles underlying each, and further to illustrate by examples the application of these principles. It will be readily seen how much greater benefit the

student will derive from studying this subject, when so systematically presented. We are indebted to the translator for the introduction of the chemical nomenclature and notation of modern chemistry, for some advantageous condensation, and for the addition of more or less new matter.

II. Geology and Mineralogy.

1. *Geological and Geographical Survey of the Territories;* by F. V. Hayden, U. S. Geologist in charge. Conducted under the authority of the Secretary of the Navy. Washington.—The following are notices of the recent publications of Dr. Hayden's survey, which has been so rich in results to science and the country.

(1.) *Ninth Annual Report, being a Report of Progress for the year* 1875. 810 pp. 8vo, with numerous plates.—This volume contains the following Reports: A letter to the Secretary of the Interior, by Dr. F. V. Hayden (30 pp.); Geology of the Grand River District, by Dr. A. C. Peale (70 pp.); Geology of the Southeastern District of Colorado, by F. M. Endlich (134 pp.); Geology of the San Juan Division, by W. H. Holmes (50 pp.); Notes on the Tertiary and Cretaceous of Kansas, by B. F. Mudge (18 pp.). Also Topographical and Geographical Reports by A. D. Wilson and F. B. Rhoda, H. Gannett, G. B. Chittenden and G. R. Bechler; and Zoological Reports on the History of the American Bison, by J. A. Allen; and on the Rocky Mountain Locust and other injurious insects of the West, by A. S. Packard, Jr. We cite a few facts from some of these reports.

Dr. Peale describes first the topography of his region and then the distribution and characters of the geological formations. These formations include the Archæan, (visible only where the other rocks have been removed), the Carboniferous or Permo-Carboniferous, the Triassic ?, Jurassic ?, and Cretaceous, and also volcanic rocks. Dr. Peale observes that the formations afford evidence of a gradual subsidence of the surface in this part of the Rocky Mountains (the Grand River District), from Pre-Silurian times to at least the end of the Cretaceous, and of no mountain-making era between. "The Archæan area along the northern edge of the San Juan Mountains and south of the Gunnison River probably formed a shore-line in Cretaceous times." "The area of the Archæan Continent was probably of some considerable extent, and the area of this district was probably an extension of that farther east, where the main chain of the Rocky Mountains is now." No Silurian or Devonian beds were observed; and over a great part of the district the red beds (Triassic) rest immediately on the Archæan. The thickness of the Carboniferous in Colorado is stated to be 4,000 to 5,000 feet; and of this only 500 to 1,000 feet consist of fragmental rocks. The accounts of the other formation contain interesting sections and many important details.

Dr. Endlich describes the Sangre de Cristo range and the San Luis and the Huerfano region. The highest mountains of this part of Colorado generally consist, he states, of metamorphic rocks, among which granites and gneisses are the prevailing kinds. Some of them, however, carry sedimentary beds to their summits, as is the case with the Trinchera group, 13,000 feet above the sea-level. The absence of Silurian beds among the unaltered strata in connection with their presence farther east, leads Dr. Endlich to suggest that the metamorphic rocks—granites, gneisses, etc.—may belong to the Silurian and perhaps also the lowest Carboniferous, and he adds, this point is at least "entitled to further investigation." The Carboniferous and Cretaceous rocks are described and various sections are given. The volcanic rocks are spoken of as either trachyte, dolerite or basalt. There are six volcanic areas situated—near the eastern entrance of the Sangre de Cristo Pass; on the Lower Huerfano, constituting small tables; the Spanish Peaks; and a trachytic area near the headwaters of Rio Culebra and Costella. Besides these areas there are numerous dikes. In the chapter on the Sawatch Range, several remarkable examples of erosion are finely represented on the plates, in which beds of trachytic conglomerate are reduced to clusters of slender columns or monuments from 50 to 400 feet in height. An account of the coal beds of the Trinidad region contains results of assays of the coal. Dr. Endlich also discusses the distribution of the Ancient Glaciers of Southern Colorado, and illustrates the subject with a map.

Dr. Holmes describes the geology of the La Plata mining region, giving several well-executed views and sections, and stating many facts of interest connected with the trachytic eruptions. Professor Mudge presents stratigraphical details respecting the Tertiary and Cretaceous beds of Kansas.

The Topographical and Geographical Reports treat of the Grand River District, (including the Uncompahgre valley and plateau,) the San Juan District, the Front Range of the Rocky Mountains, and the Middle and South Parks, giving details of the courses and heights of mountains, systems of drainage, soil and vegetation, and a large amount of information of practical as well as scientific value. Mr. Bechler's Report covers observations for the three years, 1873, 1874, 1875. It contains a general discussion of the mountain systems of the Middle and South Parks, and is illustrated by many outline sketches which are very effective.

The Zoological Report by Mr. Allen, which had previously appeared, has already been noticed in this Journal. Professor Packard's Report treats of a subject of the highest importance to the country—the injurious insects of the west—and occupies 220 pages of the volume. He remarks that in the United States the loss of agricultural products from this source is probably over two hundred millions of dollars each year, and that from one-quarter to one-half of this amount might be saved by preventive measures. Many figures are added to the text illustrating the species.

(2.) *Bulletin of the Survey*, vol. iii, No. 4, pp. 118, 8vo, (739-856 of vol. iii).—This number of the Bulletin contains the following articles: The first discovered traces of fossil insects in the American Tertiaries, by S. H. SCUDDER; description of two species of Carabidæ from Scarboro Heights, by S. H. SCUDDER; Report on insects collected in the explorations of 1875, by P. R. UHLER; on *Cambarus Couesi*, a new craw-fish from Dakota, by T. H. STREETS; on a Carnivorous Dinosaur (*Lælaps trihedrodon*) from the Dakota beds of Colorado, by E. D. COPE; contribution to the Ichthyological fauna of the Green River Shales, by E. D. COPE; on the genus *Erisichthe*, by E. D. COPE.

Mr. Cope states that the fish of the Green River Shales represent families partly of fresh water and partly of brackish or salt water species. Material is needed to decide whether the Green River lake had communication with the sea.

(3.) *Monographs of North American Rodentia*, by ELLIOTT COUES, Assistant Surgeon U. S. A., and J. A. ALLEN, Assistant in the Museum of Comparative Zoology, Cambridge.—This large volume consists of a series of elaborate monographs of the several families of Rodents by Dr. Coues and Professor Allen. Those of the *Muridæ*, *Zapodidæ*, *Saccomyidæ*, *Haplodontidæ*, *Geomyidæ*. by Dr. Coues, and those of the *Leporidæ*, *Hystricidæ*, *Lagomyidæ*, *Castoroididæ*, *Castoridæ and Sciuridæ*, by Professor Allen. Specific and family distinctions, structural relations, geographical distribution past and present, divergences of varieties, and causes or conditions of variation, are among the subjects which come under discussion in this volume, and all the topics are treated with thoroughness and precision. The monograph on the Muridæ is accompanied by four plates. The volume closes with a synoptical list of the fossil Rodents of North America, by Professor Allen, and a Bibliography, by Mr. T. Gill and Dr. Coues.

(4.) *Miscellaneous Publications*, No. 7. *Ethnography and Philology of the Hidatsa Indians;* by WASHINGTON MATTHEWS, Assistant Surgeon, U. S. A. 240 pp. 8vo. Washington, 1877.—This volume, by one who has spent much time with the tribe treated of, contains a full account of the condition, habits, arts, history, etc., of the people, and also a discussion of the relations of its language, together with a grammar and vocabulary.

(5.) *Miscellaneous Publications*, No. 8. *Fur-bearing Animals. A Monograph of North American Mustelidæ;* by ELLIOTT COUES. 348 pp. 8vo, with 20 plates. Washington, 1877.—A work that is thoroughly scientific, while also in part popular in its character.

2. *Fifth Annual Report of the Geological and Natural History Survey of Minnesota, for the year* 1876, N. H. WINCHELL, State Geologist. 248 pp. 8vo. Saint Paul, 1877.—This volume contains reports on the Geology of Houston and Hennepin Counties, with colored maps of each, notes on the Trenton forests of Minnesota; a chemical report by Prof. S. F. PECKHAM; a list of the Fungi of the State, by Dr. A. E. JOHNSON; an entomological

report, treating of the locusts and other insects, by Allen Whitman.

The report on Hennepin County contains many valuable facts about the drift of the county, and also on the changes from erosion of the Falls of St. Anthony. According to the observations at the Falls from 1680 (by Hennepin) to the present time, the amount of recession is made out to be 906 feet, or, on an average, 5·15 feet per year. At this rate, it would have taken 8,202 years for its recession from Fort Snelling.

3. *The Geological Record for* 1875 *; an account of works on Geology, Mineralogy and Palæontology,* published during the year. Edited by Wm. Whitaker, B.A., F.G.S., of the Geological Survey of England. 444 pp. 8vo. London, 1877.—This second volume of the Geological Record will be welcomed by all who are interested in the progress of geological or mineralogical science. The notices are brief, but yet they are so well prepared as to give a correct idea of the contents of publications. It thus enables the student to survey the year's progress at a glance, and to gather up references to the papers or works which he may need to consult in detail.

4. *Preliminary Notice of the Discovery of a new Mineral Species;* by Gideon E. Moore, Ph.D. (Communicated.)—The species here briefly described occurs associated with chalcophanite in ochreous limonite, at the Passaic Zinc Mine, Sterling Hill, New Jersey, and presents the following characters:

In botrioidal coatings of columnar radiate structure, usually coated with a thin layer of chalcophanite.

H.=5 (Mohs's scale); G.=4·933. Luster metallic to submetallic. Color black. Streak brownish black. Opaque. Brittle.

Before the blowpipe: in the forceps unchanged; in the closed tube yields a little water. With fluxes reactions for manganese and zinc.

The analyses lead to the formula $\dot{\mathrm{Zn}}$, $\dot{\mathrm{Mn}}$, $\dddot{\overline{\mathrm{Mn}}}$ or $\dot{\mathrm{Zn}}\,\dddot{\overline{\mathrm{Mn}}}$. Whence the species is a zinc haussmanite.

From its invariable association with and close genetic relation to chalcophanite, I propose for the species the name *Hetærolite,* from ἑταῖρος, a companion.

Jersey City, Sept. 25, 1877.

5. *On some Tellurium and Vanadium Minerals;* by F. A. Genth.—Dr. Genth's paper contains descriptions of three new species, whose characters are here given.

Coloradoite. Not crystallized, without cleavage; massive, somewhat granular; sometimes having an imperfectly columnar structure. (Smuggler Mine). Hardness about 3; specific gravity = 8·627 (calculated for the pure mineral). Color iron-black, inclining to gray with a very faint purplish hue; luster metallic; surface frequently tarnished. Fracture uneven to subconchoidal. Composition: HgTe = Tellurium 39·02, mercury 60·98 = 100; all the specimens analyzed were more or less impure, as it was impossible to separate entirely the associated minerals. Found in Colorado at the Keystone and Mountain Lion Mines, with native tellurium and quartz; also at the Smuggler Mine, where it is often mixed with native gold, tellurium and tellurite.

Magnolite. Occurs in exceedingly fine needles, grouped in bundles or tufts, sometimes radiating. Color white; luster silky. Composition: Hg_2TeO_4. Found at the Keystone Mine, Magrolia District, Colorado; it occurs in the upper decomposed portion of the mine, with quartz, limonite and psilomelane, having been produced by the oxidation of coloradoite.

Ferrotellurite. A crystalline coating on quartz, associated with native tellurium; under the microscope it appears in very delicate tufts, sometimes radiating, or in cavities in minute prismatic crystals of a color between straw and lemon-yellow inclining to greenish-yellow. Composition probably $FeTeO_4$; the small quantity in hand did not allow of a reliable analysis. Found at the Keystone Mine, Colorado.

Dr. Genth also mentions the occurrence of *Tellurite* (tellurium dioxide, TeO_2) at the Keystone, Smuggler, and especially at the John Jay Mine, Colorado. It is found in minute white, yellowish-white and yellow crystals, mostly prismatic, isolated or aggregated into bundles. Cleavage eminent in one direction, luster on this face adamantine, elsewhere vitreous inclining to resinous. The same compound was observed by Petz with native tellurium at Transylvania. Native tellurium has been found, according to Dr. Genth, at the Keystone, Mountain Lion and Dun Raven Mines in Magnolia District, Boulder Co., Colorado, also at the Smuggler Mine in Ballerat District, Boulder Co.; hessite, (containing only ·1 per cent gold) has been found at the Kearsarge Mine, Dry Cañon, Utah; calaverite occurs at the Keystone and Mountain Lion Mines, Colorado.

Roscoelite is shown to contain not V_2O_5 (as assumed by Prof. Roscoe), but probably V_2O_3; a related "green mineral" has been found in an impure state in the gangue rock of the mines in Magnolia District, Colorado; it contains, however, more aluminum and less vanadium. An analysis of the Siberian volborthite is given, and its relation shown to the species psittacinite. E. S. D.

6. *Mineralogische Mittheilungen* von G. VOM RATH.—The recent mineralogical memoirs of the eminent crystallographer, Prof. vom Rath of Bonn, contain descriptions of crystals of gold, of a remarkable twin of smaltite, of rutile in the form of hematite from Switzerland, and on compound rutile crystals from Arkansas; the explanation of the obscure crystallization of the plates, and thread-like forms of gold, is an especially valuable contribution, and is elucidated by a considerable number of figures. E. S. D.

7. *Elemente der Mineralogie* von CARL FRIEDRICH NAUMANN. *Zehnte gänzlich neubearbeitete Auflage* von DR. FERDINAND ZIRKEL. 714 pp. 8vo. Leipzig, 1877, (Wilhelm Engelmann).—The Mineralogy of Naumann has long been the standard work in Germany. The first edition was published in 1846; the ninth edition bears the date October 18, 1873, only a few weeks before the close of the author's long and active career. Fortunately this, his most

important work, did not end with his death, but its continuation has been undertaken by one well fitted to perform the task. The present edition, while including much new matter, retains the form and arrangement of those which have preceded except in one most important particular: the awkward and antiquated system of classification of mineral species employed by Naumann has been replaced by the now generally accepted method based upon their chemical composition. This will be seen to be a most important change for the better, increasing much the value of the work.

E. S. D.

III. Botany and Zoology.

1. *Occurrence of another gigantic Cephalopod on the coast of Newfoundland;* by A. E. Verrill.—A nearly perfect specimen of a large squid, was found cast ashore after a severe gale, at Catalina, Trinity Bay, Newfoundland, Sept. 24. It was living when found. It was exhibited for two or three days at St. Johns, and subsequently was carried in brine to New York, where it was purchased by Reiche & Bro. for the New York Aquarium, where I have had an opportunity to examine it.* Although somewhat mutilated, and not in a very good state of preservation when received, it is of great interest, being, without doubt, the largest and best specimen ever preserved. It proves to be *Architeuthis princeps*, formerly described by me, from the jaws alone, in this Journal.† The jaws agree well in form and color with the large pair there figured, and are fully equal to them in size, being apparently larger in proportion to the body than in *A. monachus*, so that my estimate of the probable size of the body of the former specimen was much too great. The Catalina specimen, when fresh,‡ was 9·5 feet from tip of tail to base of arms; circumference of body 7 feet, length of tentacular arms 30 feet; length of longest sessile arms (ventral ones) 11 feet; circumference at base 17 inches. Length of upper mandible 5·25 inches; diameter of large suckers 1 inch; diameter of eye-sockets 8 inches. The eyes were destroyed by the captors. It agrees in general appearance with *A. monachus*, but the caudal fin is broader and less acutely pointed; it was two feet and nine inches broad when fresh, and broadly sagittate in form. The rims of the large suckers are white, with very acutely serrate margins, and the small smooth-rimmed suckers, with their accompanying tubercles, are distantly scattered along most of the inner face of the tentacular arms, the last ones noticed being nineteen feet from the tips. The sessile arms present considerable disparity in length and size, the dorsal ones being somewhat shorter and smaller than the others; the serrations are smaller on the inner edge than on the outer of the

* When examined by me it was loose in a tank of alcohol. I learn that it has since been "prepared" for exhibition by a taxidermist, who has inserted two large, round, red eyes close together on the top of the head!

† Vol. ix, p. 181. Plate V, figs. 14, 15. March, 1875.

‡ Measurements of the freshly caught specimen were made by Rev. M. Harvey, at St. Johns, and communicated to me.

suckers. A more detailed description is deferred to a succeeding number, together with a description of another specimen.

2. *The Antelope and Deer of America;* by JOHN DEAN EATON. 8vo, 426 pp., numerous cuts. New York, (Hurd & Houghton.) 1877.—This is an excellent treatise on the prong-horn antelope and the various species of deer, moose and elk, of which eight species are recognized. The descriptions of the species are detailed, and a large part of the book is devoted to their habits, domestication, hybridity, aliment, diseases, the chase, comparisons with congeners, and other kindred subjects. The illustrations are well executed and characteristic. V.

3. *Life Histories of the Birds of Eastern Pennsylvania;* by THOMAS G. GENTRY. Vol. ii, 8vo, 399 pp. Philadelphia. Published by the author, 1877.—The second volume of this work, which has just reached us, is, like the first, replete with details in respect to the habits of birds, and more especially as to their migrations, the time occupied in building nests and incubating, and the nature of food at different seasons of the year. In this consists its chief scientific value. The author has evidently spent a great amount of time and labor in making and recording observations of this kind. The volumes include all the families above the waders, and the author proposes to complete the work in another volume. V.

4. *Zoologische Wandtafeln;* by Dr. R. LEUCKART and Dr. H. NITSCHE. Cassel: Theodor Fischer.—We have received three examples (Protozoa, Cœlenterata, Arthropoda) of these lithographic zoological diagrams. They are admirably executed. The figures are large and clearly drawn, and printed in strong colors, so that they are excellently adapted for class rooms of large size. They will thus supply a want that has long been felt by teachers of zoology. The figures have been well selected from the best works, including very recent memoirs. Each diagram is printed in sections, on four sheets, and can easily be mounted on cloth backs. We heartily commend this series to all teachers who are in want of illustrative zoological diagrams. V.

5. *Bulletin of the U. S. National Museum.* Department of the Interior.—Numbers 7, 8 and 9 of this Bulletin have recently been issued. No. 7 contains contributions to the Natural History of the Hawaiian and Fanning Islands and Lower California, by T. H. STREETS, M.D., 169 pp. 8vo, 1877; No. 8, Index to the Names which have been applied to the subdivisions of the Class Brachiopoda, by W. H. DALL, 88 pp. 8vo, 1877; No. 9, contributions to North American Ichthyology; No. 1, by DAVID S. JORDAN, 54 pp. 8vo, 1877.

6. *Notes on some Common Diseases [of plants] caused by Fungi;* by W. G. FARLOW. Bulletin of the Bussey Institution, vol. ii, part 2, 1877.—Leaving to another department of the Journal to notice the interesting papers on the composition of pumpkins and squashes, the analyses of certain seeds occasionally used for human food, and two or three other papers by Prof. Storer which this new number

of the Bussey Bulletin contains, we call attention here only to Prof. Farlow's short article, which refers to some of the various questions and problems he has had to deal with during the past year. They mainly relate to the Black Knot of Plum trees, which was the subject of a former paper; to the American Grape-vine mildew (*Peronospora viticola*), and a disease caused by *Uncinula spiralis* the conidial form of which is practically undistinguishable from the notorious *Oidium Tuckeri ;* to the *Fumago* of Orange and Lemon trees, in which it appears that the mischief produced is owing to a wooly plant-louse, upon the excretions of which, or the exudations of the leaf caused by the punctures, the fungus is thought to live; and, finally, there are some notes supplementary to Prof. Farlow's memoir on the Onion-smut. It seems that this *Urocystis Cepulæ* of Frost is not peculiar to the United States, but is to all appearance the same as *U. magica*, found on an Italian *Allium* in Italy. "A careful examination of the wild species of Onion growing in our own country should be made by fungologists, for it seems highly probable that the fungus which does so much injury to cultivated onions will also be found on the wild species." It is well that we have in this country an institution which furthers investigations of this sort, and intends to educate a generation of teachers capable of undertaking them. A. G.

7. *Flora Brasiliensis.*—The 70th fascicle, a large one, with 70 plates, is filled with Bentham's elaboration of the *Mimoseæ*, and concludes the sixteenth volume. The 71st contains the small orders, *Ochnaceæ*, *Anacardiaceæ*, *Sabiaceæ*, and *Rhizophoraceæ*, by Dr. Engler. As to *Ochnaceæ*, the author confirms Planchon's idea, announced in 1862 but not anywhere acted upon, that this order embraces *Sauvagesia;* and he insists that it is allied to *Dilleniaceæ* and not to *Rutaceæ*. For the large genus of the order, Engler, following Baillon, replaces Schreber's long received name of *Gomphia* by *Ouratea* of Aublet, and he appears to have seen and identified Aublet's original specimens. In *Anacardiaceæ* the genus *Lithrea* of Miers is reinstated. Brazil has but one species of the order *Sabiaceæ*, and only one Mangrove. Fascicle 72, which is rather large, continues the Grasses and includes the tribe *Paniceæ*. The editor, Dr. Dœll, describes 156 Brazilian species of *Panicum* (keeping *Helopus* distinct) and 105 of *Paspalum*. A. G.

8. *Botany of British Columbia and Northern Rocky Mountains.*—In the *Report of Progress* of the *Geological Survey of Canada for* 1875–76, issued in 1877, we find an interesting narrative, by Professor John Macoun, of a botanical exploration from Victoria to the Peace and Athabasca Rivers east of the Rocky Mountains, and thence to Canada, to which is appended a full Catalogue of the Plants collected, or known to Mr. Macoun to occur on this range, with a careful indication of their geographical distribution across the continent. A very useful and important paper. A. G.

9. *Sketch of the Vegetation of the Nicobar Islands ; Enumeration of Burmese Palms ; Contributions toward a knowledge of the*

Burmese Flora, etc.; by S. KURZ.—These are the titles of some of the principal papers recently contributed by Dr. Kurz to the Journal of the Asiatic Society of Bengal, which we have received, and which seem not to be as well known as they deserve to be. Besides critical systematic work, there are interesting observations upon the kinds and characteristics of tropical forests, etc. The subjoined note may be a caution to those who collect native names. "*Petal* occurs as a name for several different plants in Jelinck's journal. I fear it is meant for '*bétúl*' ('*just so*,' '*right so*'), a very usual reply of a Malay to a question regarding the pronunciation of a word." A. G.

10. *Arboretum Segrezianum* . . . . par ALPH. LAVALLÉE.—This handsome octavo volume, as its full title declares, is an enumeration of the trees and shrubs cultivated at Segrez (Seine and Oise), including their synonymy and their origin, with references to the works in which they are figured. It is published by Baillière, is edited with much care (yet not to the avoidance of sundry mistakes and misprints in other than French names, etc.), and is beautifully printed. It represents a great amount of conscientious work while the author was forming the Arboretum which now adorns his paternal estate, and which bids fair to be one of the very best in France, although as yet only twenty years old. The catalogue is prefaced by some notice of its formation, and of the origin and condition of several of the older French collections. Among the difficulties encountered, that of nomenclature was foremost and greatest, the same tree coming to him under various different names, and different trees under the same name, sometimes through traditional errors or oversights of the nurserymen, sometimes through less innocent practices of "*quelques horticulteurs*," which our author is constrained to denounce. In consequence he was obliged to study up the nomenclature and arrange the synonymy for himself throughout, with the best aid to be had from the *Jardin des Plantes* and elsewhere. Hence the *raison d'être* of this volume, and its value to all who have similar collections to make, or to care for. A. G.

11. *Systema Iridacearum*; by J. G. BAKER.—This begins in the 90th number of the Journal of the Linnean Society, and is continued in the following. When concluded, we may give an abstract of the portions which relate to North American botany. Mr. Baker's work upon the monocotyledonous orders has been useful and timely, and the *Iridaceæ* particularly need revision, having been almost untouched by all later systematists, except by Dr. Platt, whose synopsis in the Linnea is far from complete, being founded mainly upon the materials in the Berlin herbarium, and whose views are not always to be adopted. A. G.

12. *Native "Artichokes."*—Upon reading the article upon *Helianthus tuberosus*, contributed to this Journal (in May last) by Messrs. Trumbull and Gray, the well-known Canadian botanist and explorer, Mr. John Macom, wrote as follows:

"It is a fact that a species of *Helianthus* which I took to be *H.*

tuberosus, grows in abundance in the valley of the Kaministiknia, on the right bank of the river, above Point Memon. This river discharges into Thunder Bay, Lake Superior, and is quite easy of access from the United States. I saw the plant growing in abundance on the alluvial flats on the 12th July, 1869, and found the tubers of a large size at that time. Whether my plant is the true tuberosus or not, it is certainly the parent of the Indian tuber. Where I got it was on the old (high) road to the northwest. It would be worth while to have one of the American tourists get a few plants late in August. I have no doubt but I have hit upon the exact locality from which the French took the tubers, and it only remains to identify my plant with *H. doronicoides.*"

It is well to know of this station; but the Hurons of Sagard's narrative doubtless dwelt much farther east.

Dr. C. C. Parry has directed our attention to his list of plants of Wisconsin and Minnesota, published in Owen's Geographical Survey of Wisconsin, Iowa and Minnesota, in which, on page 614, is the entry: "*Helianthus tuberosus* L., Common Artichoke, river banks, St. Peter and St. Croix, certainly native, and a well-known article of diet among the Indians, called by the Chippewas Ush-ke-baug." An original specimen was kindly supplied by Dr. Parry, of which at this moment we can only say that it does not belong to *Helianthus tuberosus.* Thus there appears to be a second edible tuberiferous *Helianthus*, of which a further knowledge is a desideratum.

In regard to the other sort of root mentioned by Sagard as resembling parsnips, "which they call *Sondhratates*, and which are much better," Dr. Macom is confident that not *Sium lineare* but *Aralia racemosa* is meant: for the older inhabitants of that part of Canada affirm that the root of this *Aralia* was a favorite food of the Indians, and that they taught its use to the first settlers. In flavor this root (commonly called "spikenard" and "spignet") might well be said to resemble parsnips. A. G.

13. *Necrological.*—There have died during the past summer two European botanists of note, namely, Henry A. Weddell and Philip Parlatore; notices of whom will be given in the obituary record of the year. A. G.

IV. Astronomy.

1. *Discovery of a New Planet;* by C. H. F. Peters. (From a letter to the editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., Oct. 15, 1877.)—I take pleasure in forwarding an observation of a new planet found last night, showing the brightness of a star of 10·5 magnitude:

Oct. 14. 12h 39m 51s H. C. m. t. $\alpha(175) = 1h\ 6m\ 4.73s.$ $\delta(175) = +8° 6' 37''.4$,

from 18 comparisons with Schj. 397. The daily motion of the planet is about 36^s in right ascension, and between 13′ and 14′ in declination toward the south. You are perhaps already aware, that the planet, of which the last number of the Journal contains a valuable series of observations with the number (174), is identical with the planet (141) *Lumen;* so that what is called there (175), receives the former, and the present planet the latter number.

2. *Comets in* 1877.—The number of comets for the present year already amounts to six. 1. Discovered by Borrelly, Feb. 8th. 2. Discovered by Winnecke, April 5th. 3. Discovered by Swift, April 11th. 4. Discovered by Coggia, Sept. 13th. 5. Discovered by Tempel, Oct. 2. To these is to be added d'Arrest's comet of short period.

3. *Observations and Orbit of Tempel's Comet.*—Comet *b*, 1877, discovered by Tempel October 2d, was first seen at the Observatory of the Sheffield Scientific School October 5th. From measurements made on the 5th, 7th and 9th, the following provisional orbit has been computed. The comet is receding from both the earth and sun, and will soon disappear. From places computed for August 1st and September 1st it appears that the comet must have been in reach of the telescope for a time after evening twilight as early as July, and has been ever since that time both favorably situated for observation and at least as bright as when discovered. It cannot have approached us at any time nearer than about ·8 of the earth's radius vector. These elements show no marked resemblance to those of any previously calculated orbit. The observations were made and orbit computed by Mr. W. Beebe and Mr. H. A. Hazen.

New Haven m. t.	Comet's α (m. eq. 1877·0).	Comet's δ.
h m	h m s	
Oct. 5, 10 30·7	23 39 12·7	−13° 50′ 9″
7, 9 48·3	32 31·0	15 40 47
9, 9 25·2	26 29·1	17 20 58
11, 7 45.4	21 7·7	18 48 53

T=1877. June 26·800 Wash. m. t.

π = 80° 43′·2 } m. eq. 1877·0
☊ =184 17 ·9 }
i =115 54 ·0
log. q.=·031956

C.—O.

	$\Delta\alpha$	$\Delta\delta$
Oct. 7,	−·1s	+ 2″
11,	−·9	+38

V. Miscellaneous Scientific Intelligence.

1. *Proceedings of the Davenport Academy of Natural Sciences.* Vol. ii, Part 1. Jan., 1876 to June, 1877. 148 pp. 8vo.—The Davenport Academy publications are especially rich in papers on American Archæology. The number of the Proceedings before us contains several papers of this character by the following authors: W. H. Pratt, Rev. J. Gass, R. J. Farquharson, M.D., Rev. S. D. Peet, C. T. Lindley and Julia J. Wirt.

Mr. Gass announces the discovery of three engraved tablets in an Indian mound, which he calls "Mound No. 3 of the Cook's Farm Group;" and these are particularly described by Mr. Farquharson in a paper illustrated by excellent photographs of the tablets. One represents a calendar, another a sacrificial or cremation scene, and the third a hunting scene. In the last, thirty individuals are represented: of man, 8; bison, 4; deer, 4; birds, 3; hares, 3; big-horn or Rocky Mountain goat, 1; fishes, 1; prairie wolf, 1; non-descript animals, 3. One of the last three it is suggested may be the Mastodon, and hence, and in view of other published announcements, the cotemporaneity of Man and the Mastodon is deemed probable. The number contains also a few zoological papers by J. D. Putnam.

2. *U. S. Geographical and Geological Survey of the Rocky Mountain Region.* J. W. POWELL, Geologist in charge. Department of the Interior.—This survey, under the Interior Department, has recently issued volume I of *Contributions to North American Ethnology*, a quarto volume of 362 pages, with many illustrations. Part I contains a Report on the tribes of the extreme Northwest; by W. H. DALL; Part II, on the tribes of Western Washington and Northwestern Oregon, with a map, by GEORGE GIBBS, including, in an appendix of 122 pages, comparative vocabularies, and a Niskwalli-English and English-Niskwalli Dictionary.

3. *Burial Customs of North American Indians;* Mr. H. C. YARROW, of Washington, D. C., has issued a circular requesting information in aid of a memoir he is preparing, upon the "Burial Customs of the Indians of North America, both ancient and modern, and the disposal of their dead," and to this end invites attention to the following points in regard to which information is desired: Name of the tribe; locality; manner of burial, ancient and modern; funeral ceremonies; mourning observances, if any. The material obtained will be published under the auspices of Major J. W. Powell, in charge of the U. S. Geographical and Geological Survey of the Rocky Mountain Region. Communications may be addressed to Mr. Yarrow, 1747 F St., Washington, or at the Army Medical Museum, Washington, D. C. The circular contains more detailed statements.

4. *On the Science of Weighing and Measuring and Standards of Measure and Weight;* by H. W. CHISHOLM, Warden of the Standards. 192 pp. 8vo. London: 1877, (Macmillan & Co. Nature Series).—This little volume contains a very interesting account of the ancient standards of weight and measure, more particularly those of England; it also describes the methods employed in the restoration of the imperial pound and yard after their destruction by the burning of the Houses of Parliament in 1834. Another chapter is devoted to the Metric System, and one also to instruments for weighing and measuring. The numerous illustrations of the ancient standards add much to the interest of the description.

5. *How to draw a Straight Line; A Lecture on Linkages;* by A. B. KEMPE, B.A. 51 pp. 8vo. London, 1877, (Macmillan & Co. Nature Series).—A description of the ingenious systems of linkages with which it is possible to draw a straight line, to trisect an angle, and to solve other geometrical problems.

6. *The Elements of Descriptive Geometry, Shadows and Perspective, with a brief statement of trihedrals, transversals, and*

spherical axonometric and oblique projections. For colleges and Scientific Schools; by S. EDWARD WARREN, C.E. 282 pp. 8vo. New York, 1877, (John Wiley & Sons).—A valuable work for students in descriptive geometry. It is intended as a concise text-book, and is rendered more useful in this work by the addition of numerous examples in connection with the successive problems.

7. *Smithsonian Report for* 1876.—Many are the ways in which the Smithsonian Institution is promoting the progress of science in the land. One among these, of very wide influence, is the publication, in its Annual Report, of an appendix containing memoirs on scientific subjects. Among the memoirs in the Report for 1876 there are the following:

Eulogy of Guy Lussac, by M. Arago; a biographical sketch of Dom Pedro II, by A. Fialho; a paper reviewing the kinetic theories of Gravitation, by W. B. Taylor; on the Revolutions of the Crust of the Earth, by Prof. G. Pilar, of Brussels; on the Asteroids between Mars and Jupiter, by D. Kirkwood; and various Ethnological papers, relating mostly to American relics. One of the papers, that on the Latimer Collection of Antiquities (from Porto Rico), now in the Smithsonian Museum, by O. T. Mason, is illustrated by sixty figures; and another, on Mounds in Wisconsin, by M. Strong, by five figures or diagrams.

RECEIVED TOO LATE FOR FURTHER NOTICE HERE.

Palæontology of the Geological Survey of the State of New York: Illustrations of Devonian Fossils, Gasteropoda, Pteropoda, Cephalopoda, Crustacea, and Corals of the Upper Helderberg, Hamilton and Chemung Groups; by JAMES HALL. Published in advance of the Palæontology of New York, by authority of the Legislature of the State of New York, nearly 150 plates, 4to. Albany, 1877.

Twenty-eighth Annual Report of the New York State Museum of Natural History, by the Regents of the University of the State of New York (ex-officio Trustees of the Museum). Transmitted to the Legislature March 30, 1875; containing a paper by James Hall, consisting of 34 plates of fossils of the Niagara group of Central Indiana with explanations, and important papers on Trilobites, etc., by C. D. Walcott, with a Botanical Report, by C. H. Peck.

OBITUARY.

URBAN J. J. LEVERRIER, the French astronomer, died on Sunday, the 23d of September, at the age of sixty-six, having been born on the 11th of March, 1811.

JOHN G. ANTHONY, the conchologist, Professor in Harvard College, Cambridge, Mass., died on the 9th of October, aged seventy-three years. He was born in Providence, Rhode Island, May 17, 1804.

BENJAMIN HALLOWELL, author of a work on Geometrical Analysis, died at Nair Hill, Montgomery County, Maryland, in his seventy-eighth year.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XLVIII.—*On the Proper Motion of the Trifid Nebula:* M. 20 = H. v; 10, 11, 12 = h. 1991, 3718 = G. C. 4355.

[R. A. = 17^h 53^m $51^s{\cdot}8$, N. P. D. = 113° 1′ 39·″9; 1860·0];

by EDWARD S. HOLDEN.

[Read in Abstract to the American Association for the Advancement of Science.]

IN a paper in this Journal for May, 1876, on the supposed changes in the Nebula M. 17, I said (p. 360): "A remarkable instance of proper motion of this latter kind is that of the *Trifid Nebula* G. C. 4355, which has moved since 1833 so that the remarkable triple-star which was then quite clear from the nebulosity in a dark space formed by the junction of the three dark channels, is now by the evidence of Lassell (1863) Winlock and Trouvelot (1874) and myself (1875) well involved, the motion being confirmed by Herschel's drawing at the Cape of Good Hope (1837) and Mason's of about the same date."

It seems proper to collect the evidence now existing on this point in order to show the desirability of the study of this nebula, and because, in case the indications which we there find of a decided proper motion should be confirmed, such results would be of importance.

Following I give in chronological order such extracts from published and unpublished observations of this nebula as bear on the points now under consideration, italicizing such portions as deserve particular attention.

OBSERVATIONS OF THE NEBULA.

This nebula was discovered by MESSIER June 5, 1764, but he gives no details concerning it.—*Hist. de l'Acad. R. des Sciences*, 1771, p. 443.

Observations of Sir William Herschel.

1784. July 12: "Three nebulæ faintly joined form a triangle. *In the middle is a double star.* Very faint and of great extent." —*Phil. Trans.*, 1786, p. 494.

1786. May 26: "A double star with extensive nebulosity of different intensity. *About the double star is a black opening*, resembling the nebula of *Orion* in miniature."—*Phil. Trans.*, 1789, p. 247.

1811. . . . . : "Three nebulæ seem to join faintly together forming a kind of triangle; the middle of which is less nebulous, or perhaps free from nebulosity; *in the middle of the triangle is a double star*, etc."—*Phil. Trans.*, 1811, p. 289.

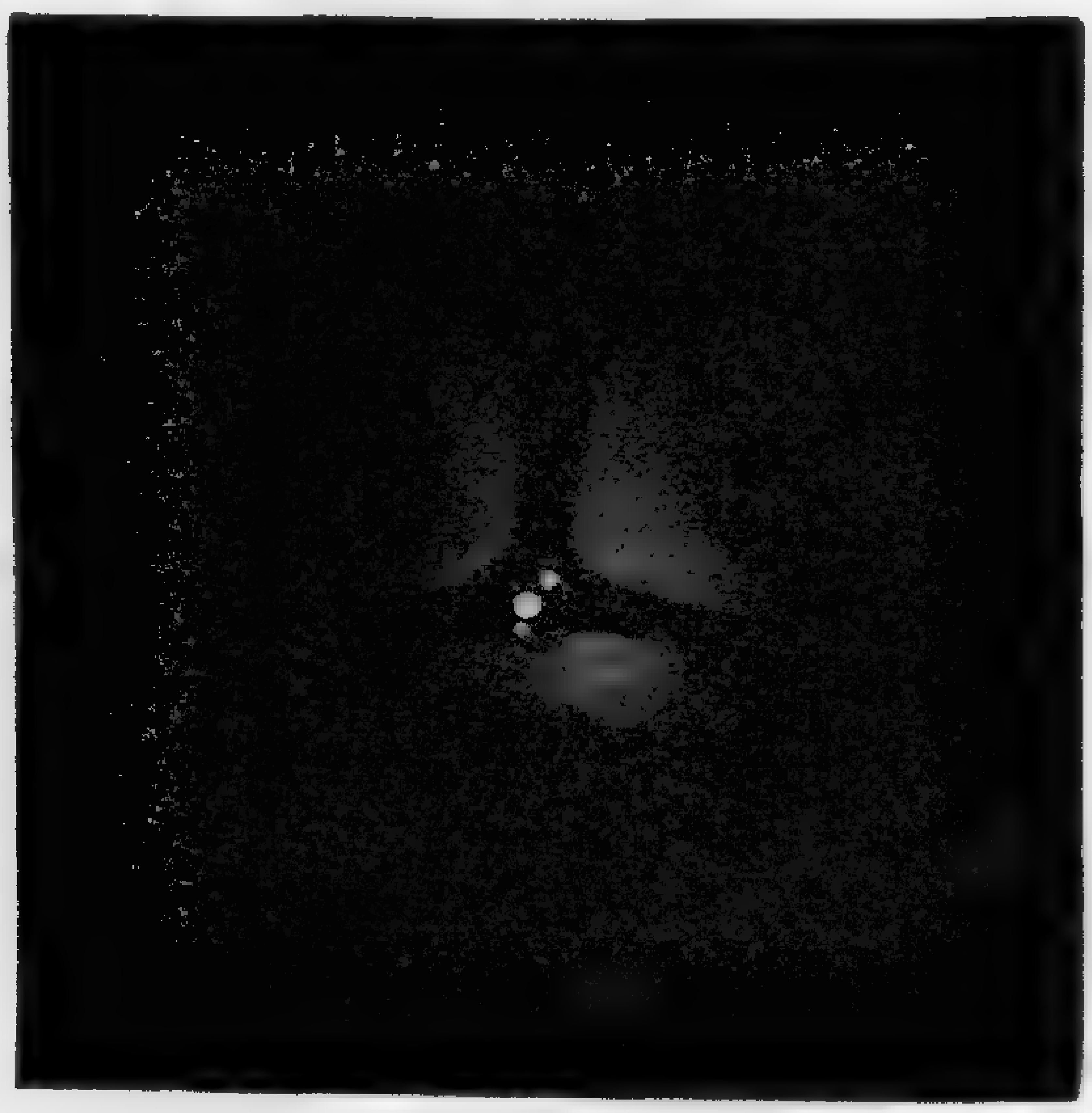
236 Sweep July 12, 1784: "Between 3 nebulæ (10, 11, 12, V class) is a double star."—*Mem. R. A. S.*, i, p. 167.

566 Sweep. May 26, 1786: "A double star within nebula IV, 41."—*Mem. R. A. S.*, i, p. 170.

Observations of Sir John Herschel.

1826 . . . . : "In the nebula R. A. 17^h 52^m, N. P. D. 113° 1′ in *Sagittarius* * * * * the idea of an absorption by the double star in its middle is very forcibly suggested. This nebula is broken into three parts, and the three lines of division meet in *a vacancy, in the midst of which is situated the double star. This curious object has perhaps a proper motion.*"—*Mem. R. A. S.*, ii, p. 490.

S.

F.  P.

N.

Fig. 1. Herschel, 1833.

1827 . . . . : "*A double star placed exactly in the central vacuity of a large irregular nebula*, which appears to have broken up into three portions by three rifts or cracks, extending from its center to its circumference, and *whose directions meet at the double star.*" —*Mem. R. A. S.*, iii, p. 63.

1833 . . . . : "*The double star* Sh. 379 *in the center of the trifid nebula*" . . . . [sweep 275].

"A careful drawing taken, but the nebula is not clear from twilight and clouds. (N. B. This drawing is unfortunately lost, and that engraved in fig. 80 is constructed from much less elaborate sketches, aided by memory.)" . . . . [Sweep 32.]

"Very large; trifid, three nebulæ with *a vacuity* in the midst, *in which is* centrally *situated the double star* Sh. 379."—*Phil. Trans.*, 1833, p. 460.

If we had nothing but the preceding evidence with regard to this nebula we should be justified in laying down the following proposition with regard to the situation of the triple star relative to the three nebulosities.

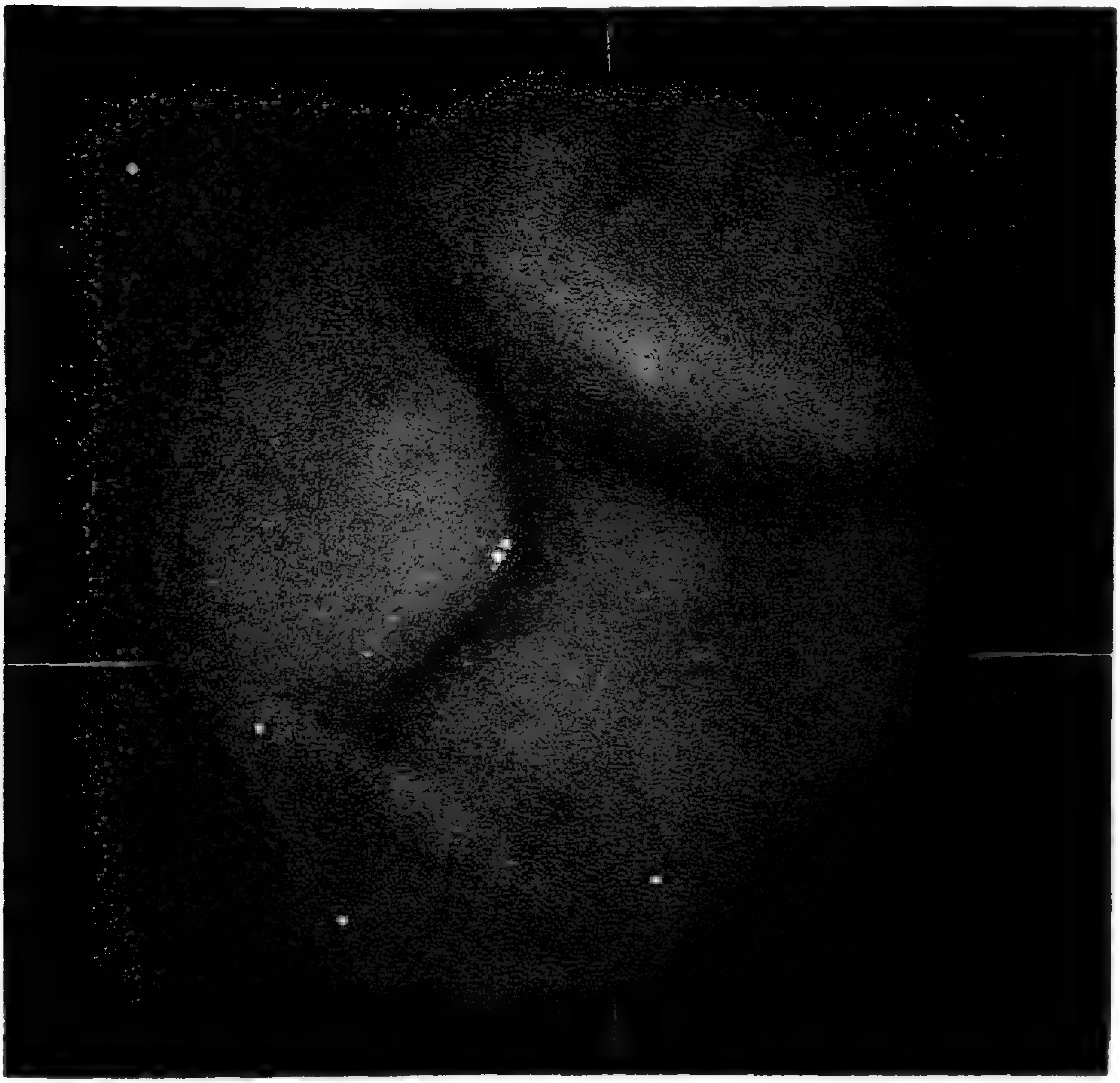


Fig 2. MASON and SMITH, 1839.

A. *From* 1784, *July* 12, *to* 1833, *this triple star was centrally situated between the three nebulosities.* The evidence is based upon two observations of Sir William Herschel and four observations of Sir John, and in the *Phil. Trans.* for 1811 Sir William again repeats his former statements.

Observations of MASON and SMITH.

1839. August 1: "*The double star is certainly not as figured in Phil. Trans.*, 1833, *but rather adhering to the* [*eastern*] *of the three divisions.*"

1839. August 9 . . : "*The triple star is certainly not central, but involved * * *.*"—*Trans. Amer. Phil. Soc'y*, vol. vii, pp. 175–176.

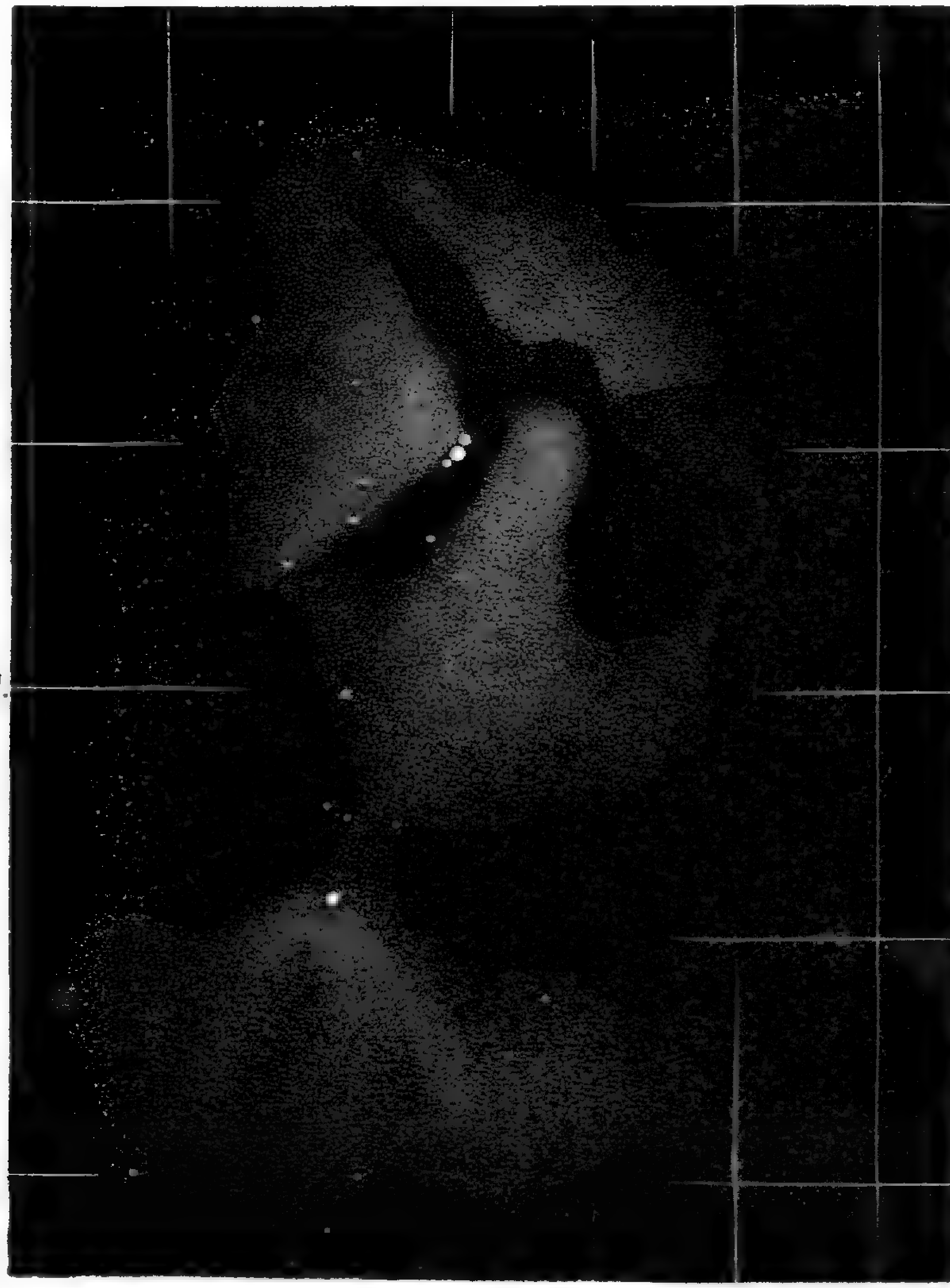


Fig. 3. HERSCHEL, 1834–8.

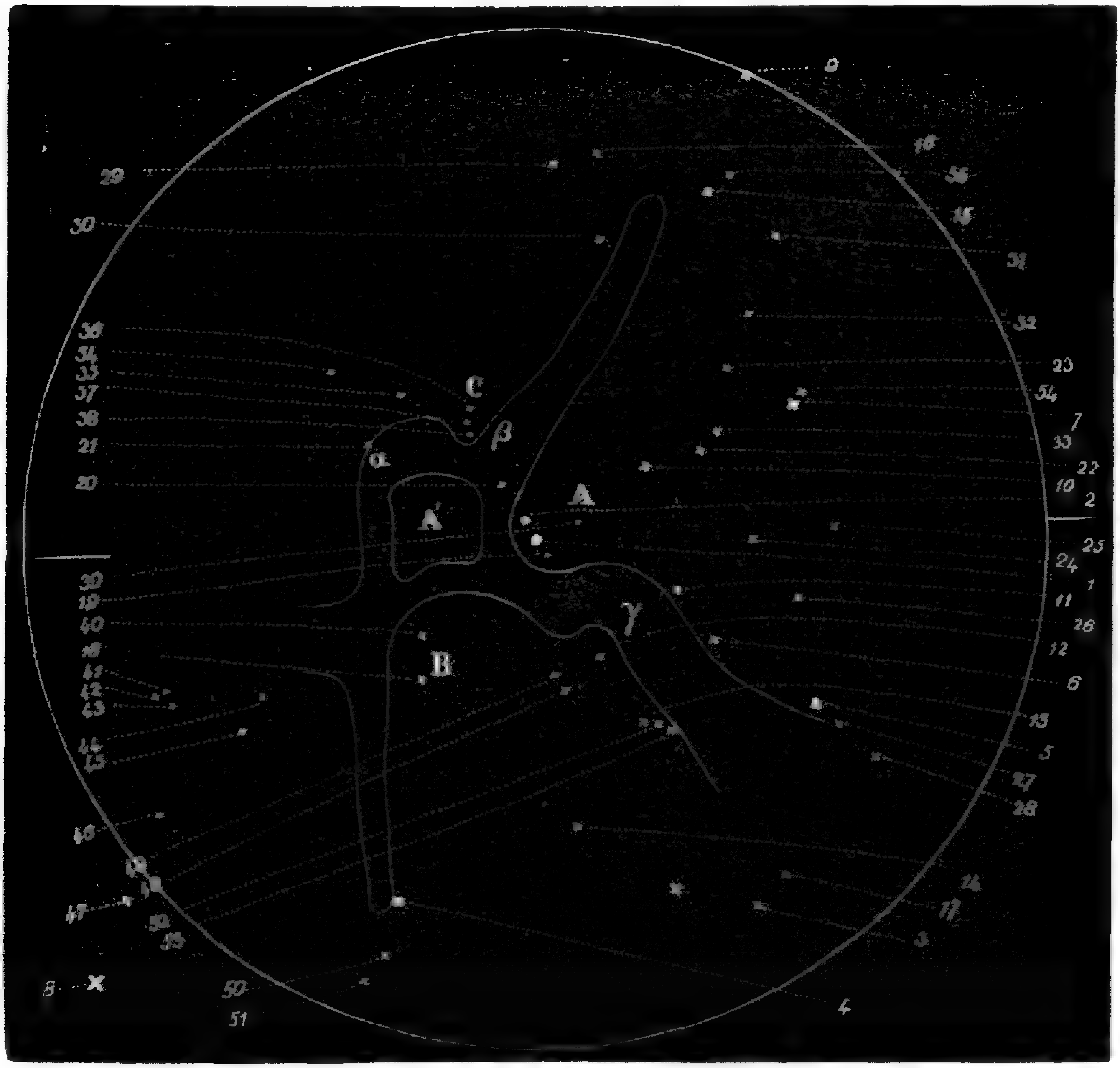
Observations of Sir JOHN HERSCHEL *at the Cape of Good Hope.*

1835. August . . . : "I have been rather unfortunate in my figures of this nebula. That given in my Northern Catalogue (our figure 1) is not to be taken as more than an attempt, and that a most rude and imperfect one, to show *the situation of the fine triple star in its center with respect to the nearer portions of the three principal surrounding nebulous masses.*

Herschel then speaks of the drawing of Mason (our figure 2) as follows:

"On comparing our figures they will be found to agree in every essential particular, allowing for the difference of light between reflectors of 12 and 18 inches aperture, with one rather remarkable exception, viz: in the form of the southern mass of the trifid nebula and the character of the three paths or avenues which lead up to the triple star. Mason represents these avenues as free from any abrupt change of direction, the northern and preceding of them branching out with and easy and graceful bifurcation from

S.

P  F.

N.

Fig. 4. Index-Map. (Lassell.)

the southern; whereas my figure, whose correctness in this respect I cannot doubt, gives the preceding avenue a remarkably sudden and uncouth flexure, like a gnarled branch of an oak, just at its divergence from the other two."*—*Astron. Obser. Cape of Good Hope*, p. 10.

* In Mason's Memoir, Art. 46, p. 199, this appearance is recorded among the things "slightly suspected." His figure represents only "things certain," and probably Sir John Herschel referred only to the drawings in his comparisons.

The observations of Secchi* (1852–5) and of D'Arrest† (1866, June 2) throw no light on the position of the triple star relative to the nebula.

Later observations of the nebula are those of Lassell, Langley, Trouvelot and myself. (It has also been observed at Melbourne, but the Melbourne results are yet unpublished.)

Lassell's two figures are of high importance, having been made under the most favorable conditions at Malta with his 4-foot reflector, an instrument well suited to the purpose. They are published in the Memoirs of the Royal Astronomical Society, volumes xxxiii and xxxvi.

No verbal description of the nebula is given by Lassell, but the drawings are complete in themselves, and the evidence to be derived from them will be considered hereafter. The following micrometric observations were made by Lassell. In order to present the nomenclature of the stars the Index-Map (Lassell's) is given.

Table I.—LASSELL'S STAR-POSITIONS.‡
[The positions are referred to Star 1.]

Star 1 and Star —.	Observed.		Computed.	
	p.	s.	$\Delta\alpha$.	$\Delta\delta$.
3	25° 46′	270″·15	+117″·44	+243″·30
4	333 4	243·20	−110·16	+216·82
5	54 31	215·37	+175·38	+125·02
7	116 49	181·21	+161·72	− 81·75
8	311 24	391·68	−293·81	+259·03
10	121 30	90·39	+ 77·07	− 47·23
14	3 43	177·17	+ 11·49	+176·80
15	167 52	249·25	+ 52·39	−243·69
21	235 40	129·17	−106·67	− 72·85

Observations at Harvard College Observatory in 1866 *by* Prof. LANGLEY.

Through the courtesy of Prof. E. C. Pickering, Director of the Observatory of Harvard College, I have been enabled to extract from the observing books portions of observations made by Prof. S. P. Langley in 1866 with the 15-inch refractor of that institution.* These are given immediately following, and in the proper place I have also given results derived from manuscript sketches by Prof. Langley. The measures of star coördinates are complete so far as they extend. I am informed by Prof. Langley that the sketches were, however, not regarded as completed, and therefore I shall only give those deductions from them which appear to have been regarded as certain at the time of observation. I desire especially to convey my thanks to Professors Langley and Pickering, who have allowed me to use these valuable materials.

* Mem. dell' Oss. Coll. Romano, 1852–55, p. 89.
† Abhand. d. k. Säch. Gesell. d. Wissenschaften, vol. v, p. 343.
‡ Memoirs Royal Astronomical Society, vol. xxxvi, p. 49.

Observations at the Harvard College Observatory.

1866. July 31.

Prof. Langley discovered the 4th star of Sh. 379 (D), which he estimated 13 mag., and which he described as "blue." It was independently seen by Prof. Winlock. Measures of coördinates made.

1866. August 2.

[The following remarks are copied *verbatim* from the original observing books, except that I have replaced the letters which are assigned to the stars by Prof. Langley, by Lassell's numbers, for the sake of uniformity. The explanations in square brackets are my own.]

"The nebula is brightest at 1. 6 and 11 are, if anything, outside of its confines. The prolongation [*north* of] 5 is very faint. It diminishes [in brightness] very slightly and uniformly toward 10 and 7? 1 is involved in faint nebulosity, which bridges the dark channel. The region about 1, 18, 12 is somewhat brighter than that in the triangle 7, 10, 11. 12 and 13 are a little within the nebulosity. The region [C] devoid of stars is perhaps the brightest part of the nebula, the dark channel [*south* of] 1 appearing relatively well defined. The whole heavens in the vicinity are (dubiously) nebulous."

1866. August 11.

Measures of coördinates of stars [omitted]. "Observed just *south* of 1, 10, 7, a faint, straight, narrow channel nearly filled up with nebulous matter. Was less confident to-night that the nebula surrounded the quadruple star, which seemed to be in the channel with blackness on each side, less in the *preceding* than in the *following* side."

1866. August 13.

Fifth component (E) of Sh. 379 discovered by Prof. Langley.

1866. September 10.

The entire region *south* of 1 [C] is judged, as before, to be the brightest part of the nebula, or nearly so. Cannot feel sure that there is *any* nebulosity about 1. The channel [*south* of] 1, 10, 7, is rather suspected than seen.

The drawing of M. Trouvelot was made with the aid of the Harvard College refractor (of 15 inches aperture) in 1874, and is published in the Annals of the Harvard College Observatory, vol. viii, plate 32. This plate is not here reproduced, as it has only recently been published, and is in the hands of astronomers. The evidence to be derived from it will be considered in its proper place. The following observations made by me with the 26-inch refractor of the U. S. Naval Observatory complete the materials at our disposal.

*Washington Observations in detail.**

I give the Washington observations almost literally from the

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observing books, in order that they may serve for future comparisons. Not infrequently a verbal statement can be made more definite and satisfactory than the presentation of the same evidence in a drawing.

Washington Observations.

1874. August 12. Observers, S. W. Burnham and E. S. Holden: the subsequent observations are by the latter observer.

Sketch of stars made. 37 and 38 faint. Within 35″ of Sh. 379 are 4 stars, I, II (=Lassell's 20), III and IV. [These have been subsequently measured, see *Wash. Ast. Obs.* for 1874–5–7; of these I and IV were discovered by Prof. Langley at Harvard College Observatory.]

34 equal in brightness to 36. [The principal work of this night was the making of the star-chart.]

6 is certainly inside the nebulosity, but is close to its *preceding* edge. 11 is inside the nebulosity by ⅓ of the distance from 6 to 11, but the nebulosity is faint there; 12 and 13 both inside; 12 is nearer to the *following* edge of the nebula than 13. 52 is inside the nebulosity ? ? Clouds prevent further work.

1875. August 5.

6 is on the edge of A. 11 is on the edge of a brighter streak, but follows the *extreme* edge by about ⅓ the distance 6–11. From 11 to the point near the triple star [this refers to the point of the edge of the nebula A *north* of 1–2–19 and about the prolongation of the line 1–2; August, 1877] the edge is *faint* and tremulous. 12–13–52 all inside the nebulosity. In the line 13–52 the distance to the *following* edge (which is not always sharp) is about equal to the distance from 13 to 52. [This distance is to be measured from 52 toward the *following* side. 1877.]

A figure was made, from which the following notes are derived. The nebula is condensed around star 4. If a line be drawn joining 12 and 40, and if through 18 a line be drawn parallel to the former, this last line cuts the *preceding* edge of B at a distance from 18 equal to the distance 18–40. [This is quite different from Lassell's second figure, where the line described cuts the edge at a distance from 18 equal to about ⅓ or ½ of the distance 18–40.]

[The nebulosity near 44, 45, 41, 43 agrees with Lassell 1864 in the arrangement of the two degrees of brightness of the nebula.]

41, and 36, 37, 38 are all involved. 41 is involved by about the distance from 36 to 37 ?

20 is about the middle of the dark channel β [see index-map]. The angle of position of this channel β is 160° (1 measure).

β extends ⅔ of the distance from 20 to 9. [16 ?]

32 is immersed in nebulosity. The line 20–9 [16 ?] is nearly the axis of β.

[A second sketch of the bounding lines of the nebula made, which agrees more nearly with Lassell 1864 than the first one of this night, in the position of the nebulosity relative to the stars 18 and 40.]

The triple star Sh. 379 is really sextuple.

1877. July 2.

The following stars were identified and placed on the chart: 1, 2, 3, 4, 5, 6, 7, —, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, —, —, 44, 45, —, —, 48, 49, 50, 51, 52, —, 54, 55; leaving stars 8, 42, 43, 46, 47, 53 to be subsequently charted.

1877. July 6.

Measures of p, $\Delta\delta$, etc. See Table II. *Notes.*—48 has a little less $\Delta\delta$ than 18. 44 has a little greater $\Delta\delta$ than 18. The p of 1 and 12, 19°·2, is nearly that of 1 and 19. If anything the p of 1 and 19 is greater than that of 1 and 12.

1877. July 12.

Measures of p, $\Delta\alpha$, etc. See Table II. *Notes.*—The line 12–13 passes *west* of 1, and the nebulosity near 1 is still *west* of this line. Star 3 is *east* of the line 12–13 by about 1″ (est.). The line 1–18 bisects A (roughly speaking). 7 *precedes* 5 a little.

Along the line 14–20 there is nebulosity to the edge of γ, then darkness to the edge of A, then nebulosity to the edge of A again, then darkness in β. That is, the *preceding* edge of A is cut off by the line 14–20.

The nebulosity of A just *following* the line 14-20 is fainter for 3″-6″ (est.); but beyond this limit it is uniformly bright up to 1, 2, 19.

1877. July 13.

The line 14–20 is situated in regard to the nebulosity as in figure [omitted]; that is, the line 14–20 really passes through the nebula near 1, 2, 19, but through a fainter part. It is, however, *about* tangent to nebulosity of the same brightness as that near 1–2 on the following side. Eye-piece 175. The figure omitted shows following 1, 2, 19 a fainter band or dark channel, so that these three stars seem to be symmetrically situated in a brighter part of the nebula with fainter nebulosity again surrounding that, as if the nebulosity had condensed about these stars since Mason's drawing.

1877. July 16.

Measures of p and $\Delta\alpha$. See Table II. I suspect D to be variable. 11 very faint.

1877. July 25.

Measures of $\Delta\alpha$, $\Delta\delta$. See Table II. D and E seen. D is far brighter than any other of the small components of Sh. 379, of which only D and E are visible to-night. E is quite faint. E $<$ 20.

1877. July 26.

Moonlight. Placing the micrometer wire through 12–13 the wire runs *west* of 1, 2, 19, but is involved in fainter nebulosity near them. Half way from this wire to star 1 the nebulosity becomes bright, and so continues up to and beyond [*following*] 1.

With eye-pieces 400 and 600 A, the three stars 1, 2, 19 appear to be about symmetrically surrounded by an oval mass of nebulosity, separated from the rest of A by a fainter band following 1, 2, 19.

Line 14–20 is involved in A near 2, but only in fainter nebulosity.

Line 1–10 is involved *west* of 1 in brighter nebulosity by some seconds.

1877. July 30.

V. The line 3–35 is almost exactly parallel to the line 12–13, and intersects the nebulosity A near 1, 2, 19. This line is tangent very exactly to the *preceding* edge of the brighter nebula about these three stars.

Angle of position of β, passing through 20 and 16 (not 9), 162°·7 (1).

New dark channel between 1 and 10, as in sketch. It extends no further *east* than 10, and 10 and 11 are on or near its *following* borders. Its *preceding* border is 20″–30″ *following* 1, 2, 19. The seeing is poor, and this point should be reëxamined.

(A) The brightest part of the nebula is about the triple star. It is an oval mass nearly symmetrically disposed about the triple star. The triple star is, if anything, toward its *western* side.

(B) The next brightest nebulosity is near 36, but this is not much brighter than (C) or the brightest parts of (B) near 18.

(D) Stars 12–13 are both inside the nebulosity. [See Observations of 1875, Aug. 4; 1877, July 12, July 26.]

(E) Star 11 is on the very edge of a brighter portion, but *follows* the *extreme* edge by $\frac{1}{3}$ the distance 6 to 11. [See Observations of 1875, Aug. 4.)

(F) Star 26 is within the brighter nebulosity, the boundary line of which runs (see sketch) [omitted] between 5 and 26, but much nearer 26 than 5; perhaps $\frac{1}{5}$ of the distance 26 to 5.

(G) [Star 6 is certainly inside the nebulosity, about half way from the *preceding* edge of the fainter nebulosity to the *preceding* edge of the brighter.] See Observations of 1875, Aug. 4, Aug 5.

(H) Stars 5, 27 and 28 are on the *preceding* edge of the fainter parts of A. [But *preceding* 5, 7, 28 it is not totally black.]

(J) The triangle 40, 44, 21 has no nebulosity which is at all bright within it except A′.

(K) 21 is involved in C a few seconds, but it is close to its *north* edge. 35 is well involved. 36, 37, 38 are correct on the map.

1877. July 31.

$\Delta\delta$, 21 and 1, $-65''\cdot73$ (3), $-0''\cdot09$ refraction, $\Delta\delta = -65''\cdot82$. This is about the mean of the $\Delta\delta$'s of 38 and 37. Sketch of stars, etc., near 5, 17, 28.

The atmosphere on this night was more favorable than previously during the year, and the principal work was devoted to the examination of the apparent differences between Lassell's and Trouvelot's figures.

It appears that in an eye-piece having a small field (8′–9′), when 5, etc. is in the northern part of the field, and the eye endeavors to trace the *following* borders of the channel γ, that it is easy to gain the impression that 5 is on or near the *preceding* edge of A, and that *preceding* 5, 27, 28 the dark channel γ was prolonged toward the *north*. In this way the appearances of Herschel's, Mason's and Trouvelot's figures are reproduced.

Placing 5 in the center of the field, and thus avoiding the disturbing effect of the well marked border of the channel γ near

6 and 11, the appearances of Lassell's figure are most nearly represented. As before described, the nebulosity between 5 and 26 is mostly faint, but near 26 it becomes brighter, so that 26 is involved now more deeply in the brighter parts of (A) than is given by Lassell, and not so much as given by Trouvelot.

The nebulosity immediately about 4, 27, 28 is faint. The dark channel γ ceases to have well marked edges south of 5. The faint nebulosity about 5, however, does not seem to be connected (as in Lassell's figure) with (B).

August 3, 1877.

Night very clear. 1 and 14 $(\Delta\delta) = -211''\cdot37$ (2), $-0''\cdot30$ refraction, $\Delta\delta = -211''\cdot67$ (2). Lassell gives $-243''\cdot7$, and I presume there is an error in the numbering here.

Order of brightness of the principal stars.

1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, 18, 20, 26, 21, 25. 39 and 24 are quite faint. Lassell's order of brightness is therefore maintained. Nebulosity was traced *north following* Sh. 379 a considerable way, about half a degree to a nebulous star 8^m, but I was hindered in this by clouds which finally covered the whole sky. The same hindrance occurred in the same way on the clear night of July 31. The connection of this nebula with neighboring ones deserves examination, as it is widely extended, but no opportunity offered during 1877 for this work.

With regard to the triple star: It was first seen double by Wm. Herschel, and triple by South and Herschel. Lassell with his four-foot reflector saw only three stars. Two stars, D and E, are to be seen on any clear night, D being about equal to star 20 in brightness and E tolerably faint. [I find among my notes several times a suspicion recorded that D is variable.] D and E were first seen by Prof. Langley with the Harvard College 15-inch refractor. They are both given by Trouvelot in his figure, together with a star *s.f.* 1, and very close to it. I have not seen this star in 1877. A = Lassell 1; B = 2; C = 3; F = 39.

The approximate positions of the various components are:

		p.		s.	
A and B	:	211°	:	10″·8	} Sh. 379
A and C	:	22	:	6·5	
B and D	:	283	:	2·5	
A and F	:	107	:	19·5	
B and E	:	193	:	5·8	

This nomenclature includes Trouvelot's star s. f. 1. I have several times suspected the existence of a small star *n. p.* A. $p = 310° \pm$; $s = 6''$. For measures of the above stars, see the Washington Astronomical Observations and Burnham's Catalogue of Double Stars.

Prof. Eastman, U. S. N., has kindly undertaken to observe the triple star Sh. 379 on the Transit-Circle, in order to fix its position b solutely.

The Washington observations of star positions are given in the table following. It will be noticed that in the column "Holden-Mason" the errors are usually within the limits set by Mason himself.

Table II.—Summary of Washington Observations of Stars in M. 20.

Date. 1877.	p. from 1.	Obs'd $\Delta\alpha$ from 1.	Diff. Refr.	$\Delta\alpha$.	No. Obs.	Obs'd $\Delta\delta$ from 1.	Diff. Refr.	$\Delta\delta$.	No. Obs.	Star No.	Holden—Mason. $\Delta\alpha$.	Holden—Mason. $\Delta\delta$.	Holden—Lassell. $\Delta\alpha$.	Holden—Lassell. $\Delta\delta$.
		″	″	″							″	″	″	″
July 6	55·9°(3)					+113″·71	0″·15	+113″·9	2					
12	--	+166·56	+0·02	+166·6	3	--	--							
13	56·1 (2)	--				--	--			5	−10·0	+1·0	−8·1	−11·2
16	--	+167·25	+0·01	+167·3	2	--	--							
25	--	+167·92	+0·01	+167·9	1	+113·53	0·14	+113·7	2					
Means	56·0			+167.27				+113·80						
July 6	56·6 (3)	--	--			+67·35	0·08	+67·4	2					
12	--	+101·22	+0·01	+101·2	2	--	--			6	+5·4	+7·1	--	--
13	56·8 (2)	--	--			+66·86	0·09	+67·0	2					
16	--	+101·41	+0·01	+101·4	2	--	--							
Means	56·7			+101·30				+67·20						
July 6	65·3 (3)	--	--			+39·20	0·05	+39·3	2					
12	--	+83·78	+0·01	+83·8	3	--	--			11	+4·0	+0·1	--	--
13	65·5 (2)	--	--			+38·53	0·05	+38·6	2					
16	--	+83·66	0·00	+83·7	2	--	--							
Means	65·4			+83·75				+38·95						
July 6	23·6 (3)	--	--			+119·67	0·15	+119·8	2					
12	--	+51·58	+0·02	+51·6	2	--	--			13	+1·8	+9·7	--	--
13	23·3 (2)	--	--			--	--							
16	--	+51·66	+0·01	+51·7	3	--	--							
25	--	+51·52	+0·02	+51·5	1	+119·13	0·15	+119·3	4					
Means	23·5			+51·60				+119·55						

Table II—continued.

Date. 1877.	p. from 1.	Obs'd Δα from 1.	Diff. Refr.	Δα.	No. Obs.	Obs'd Δδ from 1.	Diff. Refr.	Δδ.	No. Obs.	Star No.	Holden—Mason. Δα.	Holden—Mason. Δδ.	Holden—Lassell. Δα.	Holden—Lassell. Δδ.
		″	″	″							″	″	″	″
July 6	19°·2(3)					+75″·41	0″·09	+75″·5	2					
12	--	+26·00	+0·01	+26·0	2	--	--							
13	19·5 (2)	--	--			+75·18	0·10	+76·3	2	**12**	+0·2	+4·0	--	--
25	--	+26·00	+0·01	+26·0	2	--	--							
Means	19·4			+26·00				+75·90						
July 12	--	+11·84	+0·03	+11·9	2	--	--			**14**	--	--	+0·9	−2·4
13	4·1 (2)	--	--			--	--							
25	--	+12·86	+0·06	+12·9	3	+174·19	0·23	+174·4	2					
Means	4·1			+12·40				+174·40						
July 6	213·0 (3)	--	--			−33·1::	0·04	−33·1::	3					
12	--	−22·9	−0·00	−22·9	3	--	--			**20**	--	--	--	--
13	--	--	--			−34·46	0·04	−34·5	2					
25	--	--	--			−33·43	0·04	−33·5	3					
Means	213·0			−22·90				−33·7						
July 6	--	--	--			+88·34	0·11	+88·45	2					
12	--	−69·18	+0·01	−69·2	1	--	--			**18**	+1·0	+7·6	--	--
13	321·9 (2)													
Means	321·9			−69·20				+88·45						
July 6	334·4 (3)	--	--			+212·39	0·25	+212·64		**4**	--	−3·9	--	−2·2

Besides the above measures, which are all referred to Star 1, the following angles of position have been measured:

July 12: Stars 12 and 13, $p = 30°·5$ (3) } 1875, Aug. 5: Angle of position of β : 160°·0 (1)
July 13: Stars 14 and 20, $p = 189°·7$ (1) } 1877, July 30: Angle of position of β : 162°·7 (1)

It should be noted that the measures on which the above positions depend have all been made under very unfavorable circumstances.

Table III.—Star Positions according to Herschel, Mason, Lassell, Langley and Holden.

Star's Number.			Magnitude.		Herschel.		Mason.†		Lassell.		Langley.		Holden.	
Lass.	Hersc.	Mason.	Hersc.	Mason.	Δα.	Δδ.*	Δα.	Δδ.	Δα.	Δδ.	Δα.	Δδ.	Δα.	Δδ.
8									−293″·8	+259″·0				
4	1	2	12	11·12	−120″·0	+211″·3	−111″·8	+216″·5	−110·2	+216·8	−103″·1	+210″·8	--	+212″·6
21									−106·7	−72·9			--	−65·8
--	2		15		−103·5	+93·6								
40 ?		3		16			−98·7	+28·9						
21 ??		4		16			+83·7	−39·1						
18		5		15			−70·2	+80·9					−69″·2	+88·5
35	5		15		−61·5	−72·1								
{36, 37, 38}	?	6		16			−41·7	−63·1						
20													−22·9	−33·7
14	7 ?		15		−4·5	+199·5			+11·5	+176·8	+11·0	+176·6	+12·4	+174·4
12	10	11	13	15	+27·0	+86·5	+25·8	+71·9			+26·1	+74·6	+26·0	+75·9
{15 ?, 16 ?}		12		15			+33·3	−187·1						
13	11	13	13	15	+48·5	−128·6	+49·8	+109·9			+50·5	+118·2	+51·6	+119·6
15‡									+52·4	−243·7				−211·7
10		16		14			+66·3	−34·1	+77·1	−47·2	+68·5	−37·8		
11		17		14·15			+79·8	+38·9			+84·1	+37·9	+83·8	+39·0
11 ?	13		13		+99·0	+27·6								
6	15	19	11	12·13	+106·5	+69·7	+95·9	+60·0			+100·9	+68·2	+101·3	+67·2
{22 ?, 33 ?}	17		12		+114·0	−67·3								
3	18	21	11	11·12	+114·0	+240·4	+118·7	+239·7	+117·3	+243·3	+119·1	+237·0		
7		24		12·13			+172·1	−70·4	+161·7	−81·8	+159·9	−76·1		
5	24	25	11	12	+178·5	+108·0	+177·3	+112·8	+175·4	+125·0	+169·2	+114·3	+167·3	+113·8

* The sign of Δδ as given by Herschel in C. G H. Obs. has here been changed. ‡ There is some error in the numbering of 15.

† Mason estimates the mean errors of his star positions as $\pm 0^s{\cdot}399$ and $\pm 6''{\cdot}37$.—*Op. cit.*, p. 192.

Position of the mass A relative to the triple star.

It will be convenient to examine the various drawings with regard to special points, and to lay down a series of propositions (so to say) from each figure which can afterwards be compared among themselves. The situation of the triple star with respect to the adjacent nebulosity being of importance, I give in what immediately follows five statements derived from each drawing, which go to show the position of the nebulosity *A* near the triple star at the epoch of the drawing.

The statements derived from each drawing are here placed together, in order to facilitate the comparison between the original engravings and the propositions I have derived from them. In the actual examination of the drawings, each one was studied separately, and all the evidence to be derived from it recorded, and the various data were subsequently collated. In this way a tolerably independent judgment can be formed.

In Sir John Herschel's Cape of Good Hope figure we find:

I. Stars 1–2–19 are on the very edge of A.

II. The line 12–13 does not intersect A.

III. The star 20 is not laid down.

IV. The line 1–10 is not involved *preceding* 1.

V. The star 35 is not laid down on the drawing, although given in the Catalogue.

In general the agreement with Mason's drawing is good for the mass *A* near 1, 2, 19. In the figure given by Mason and Smith:

I. Stars 1–2–19 immersed in A.

II. The line 12–13 does not intersect A, but passes *west* of it by about 15″.

III. The star 20 is not laid down, as it was too faint for Mason's telescope.

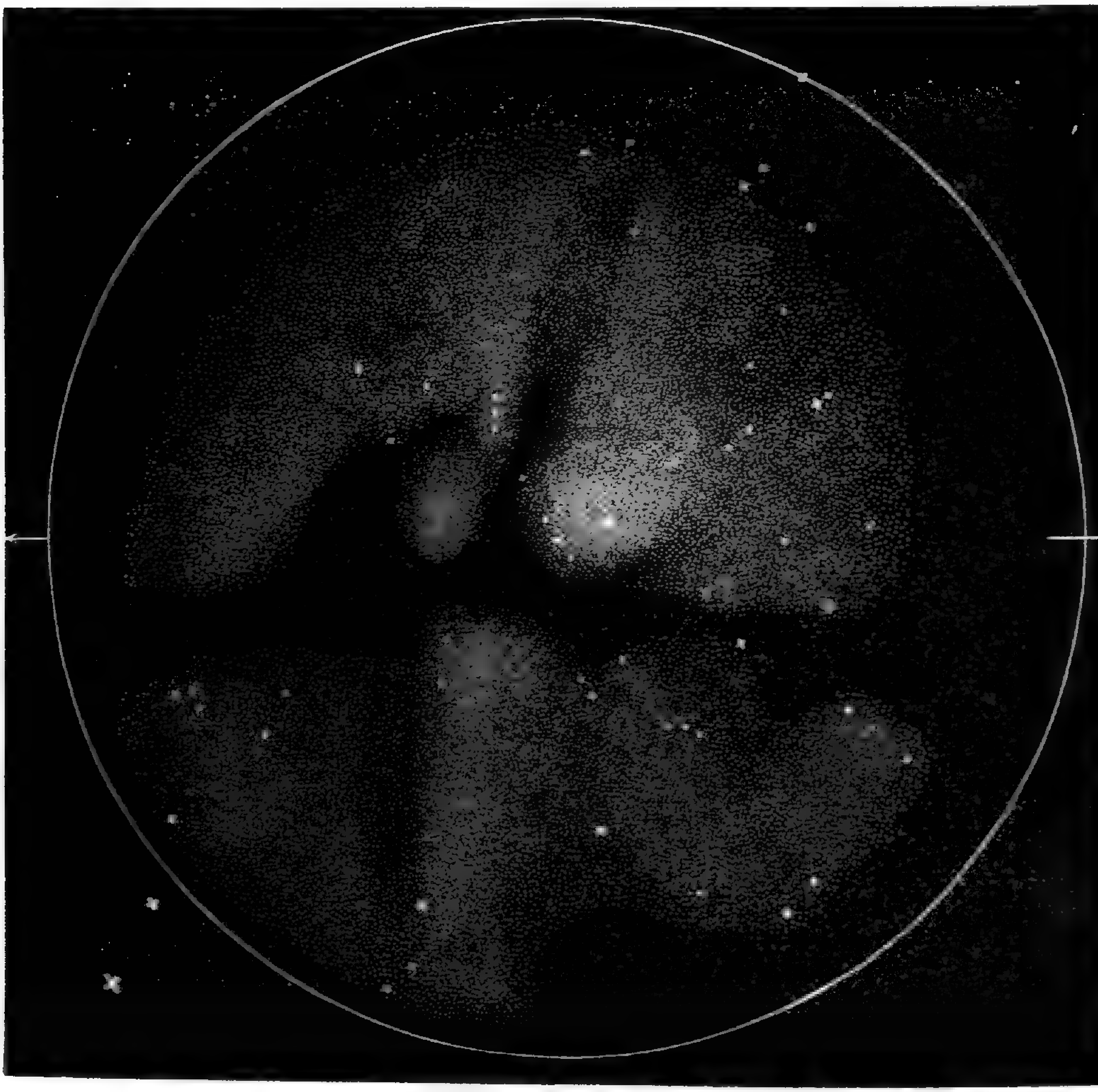
IV. The line 1–10 *preceding* 1 is involved in A by a little over 14″.

V. 35 is not laid down in his drawing.

These measures are not made on the engraving representing the nebula as it appears to the eye, but on the contour map (Mason's Plate II). The two plates agree however, but the second is more useful for a purpose like the present one, as it was seen by Mason that it would be.

During his residence at Malta in 1862–4, Lassell presented to the Royal Astronomical Society a figure of this nebula drawn under his direction, which is referred to in the *Memoirs* of that society, vol. xxxiii, p. 121, and figured in Plate I of that work. This figure need not be here given, as essentially the same observations are represented in Lassell's second figure in the vol. xxxvi of the same series (p. 48 and fig. 32, Plate VIII), which we give below. The first of these figures we may, however, briefly describe in some important points, using Lassell's nomenclature for the stars, as given in the last cited work and Mason's nomenclature for the nebulosity, as in our Index-map.

S.



N.

Fig. 5. LASSELL, 1862.

Lassell's first figure.

I. Stars 1, 2, 19 are immersed in the nebula.

II. The line of stars 12–13 prolonged passes through the nebulosity of A. If we draw the shortest line from star 2 to the preceding edge of *A* this line is cut by the line 12–13, prolonged at about one-third its length from its preceding end, and this line is involved in the nebula near 1, 2, 19, for about 30″ of its length.

III. The line from 14 to 20 cuts the line from 2 at about its middle point, and is involved in the nebula near 1, 2, 19 for about 30″ of its length.

IV. The line 10–1 is involved in nebulosity *preceding* 1 by about 16″·6.

V. The line 35–3 is nearly tangent to the *preceding* edge of the nebula A.

Lassell's second figure.

This figure is the result of repeated observations and is to be considered as more trustworthy than the former.

I. Stars 1, 2, 19 are immersed in *A*.

II. The line of stars 12–13 prolonged passes through the nebulosity A *preceding* 1, and is involved in the nebula *A* for about 25″ of its length.

III. The line 14–20 is involved in *A* for about 17″. It is to be noted here that all of A which *precedes* the line 1, 2, 19 is in this drawing considerably fainter than that just on the border of which 1, 2, 19 are situated.

This is not so given in the earlier figure, but probably this second figure represents more exactly the careful observations of Lassell himself. Returning to the second figure we find:

IV. The line 10–1 is involved in nebulosity *preceding* 1 by about 16″·6.

V. The line 35–3 is approximately tangent to the *preceding* shore of A.

From the Harvard College observations by Professor Langley and from sketches accompanying them the following conclusions may be drawn. As remarked by Prof. Langley these conclusions are not of the same weight as the micrometric observations.

I. Stars 1, 2, 19 are *not* immersed in A, but are in the dark channel which, however, is filled with faint nebulosity.

II. The line 12–13 prolonged is not involved in the nebulosity A.

III. Stars 14–20 not laid down.

IV. Line 1–10 *not* involved preceding 1.

V. 35 not laid down.

In the drawing made by M. Trouvelot at Harvard College Observatory*—

I. Stars 1, 2, 19 are immersed in *A*.

II. The line 12–13 does not intersect A, but passes *west* of it by many seconds.

III. The line 14–20 is not involved in A at all.

IV. The 1–10 preceding 1 is involved in A.

V. The star 35 is not laid down.

From the Washington observations it appears that—

I. 1, 2, 19 are immersed in *A*.

II. The line 12–13 prolonged passes through *A*. Half way from this line to the line 1, 2, 19 the nebulosity becomes brighter,

* Annals Harvard College Observatory, vol. viii, plate 32. This figure is not copied, as it is but lately published and is in the hands of astronomers.

and so continues up to 1. That is, the line 12–13 is involved in the fainter nebulosity.

III. The line 14–20 cuts off the *preceding* borders of *A*, but is involved only in fainter nebulosity. It is, however, about tangent to the brighter nebula about 1, 2, 19.

IV. The line 10–1 prolonged is involved in A *preceding* 1.

V. The line 35–3 is almost exactly parallel to the line 12–13 [$p=30°\cdot5$], and intersects A near the triple star. This line is tangent very exactly to the preceding edge of the brighter nebulosity about these three stars.

We may make the following summary of the evidence with regard to the position of the triple star relative to the nebulosity.

I. The stars 1, 2, 19 are situated in Herschel's (1837) figure on the very edge of *A*, but in Mason's figure and in his notes, "Things Certain," he places these stars *within* the nebula, and probably a consideration of the two memoirs will result in the conclusion that here Mason was right and that we must suppose the triple star to have been involved in 1837–9. It is all the more proper to come to this conclusion as Herschel does not expressly say that the stars are on the edge, his evidence, at the best, being negative on this point. We therefore may assume with confidence that Mason's figure and memoir give the relative position of these stars and the nebula correctly for 1837–9. It is to be noted here that this position is utterly different from the one derived from the evidence of the earlier observations.

In the absence of *satisfactory* micrometric measures (which indeed are almost impossible to make on this point even with faintly illuminated wires), it may be said that Lassell's (2 figures), Trouvelot's and my own observations agree in this respect with Mason's, allowing for difference of telescopes. We may therefore say with certainty that—

B. *From* 1839 *to* 1877 *the triple star was not centrally situated between the three nebulosities, but was involved in A.* The evidence to be derived from the earlier observations at Harvard College is alone opposed to this conclusion, and these may perhaps be explained by supposing the brightness of the stars 1, 2, 19 to have overpowered that of the nebula near them. At the same time it must be noted that in several respects these observations vary from other later ones, and it is to be remembered that the evidence is here mostly derived from verbal and definite descriptions, and therefore are of greater weight than if deduced only from drawings.

II. The line 12–13, according to Herschel, does not intersect *A*; Mason—does not intersect *A*; Lassell (1)—does intersect *A*; Lassell (2)—does intersect *A*; Langley—does not intersect *A*; Trouvelot—does not intersect *A*; Holden—does intersect *A*.

III. The line 14–20, according to Herschel, cannot be traced; Mason—cannot be traced; Lassell (1)—is involved in *A*; Lassell (2)—is involved in *A*; Langley—is not involved in *A*; Trouvelot—is not involved in *A*; Holden—is involved in *A*.

IV. The line 10–1; the evidence under this head corroborates that under I, except in the case of Harvard College, 1866.

V. The line 35–3: Herschel, star 35 not laid down; Mason, star 35 not laid down; Lassell (1), stars 35–3 about tangent to *A*; Lassell (2), stars 35–3 about tangent to *A*; Langley, star 35 not laid down; Trouvelot, star 35 not laid down; Holden, line 35–3 intersects the fainter nebulosity A, but is about tangent to the brighter part of A near the triple star.

In these points I–V, it appears that there are few discrepancies that the difference in telescopes will not explain, and inference 𝔅 is confirmed.

General notes on the brighter portions of the Nebula.

The *brighter portions* only are considered, in order to avoid as much as possible the discrepancies arising from differences of instrumental power.

In this examination again it will be convenient to derive a series of propositions from each drawing in succession, which can afterwards be compared.

The following analysis may be made of the figure of Herschel (1837).

A. The brightest nebulosity is that *following* 1–2–19, that called B, and that called C. The bounding line of C is strangely different in Herschel and Mason's figures, as remarked by the former. Mason refers in his notes to the outline as given by Herschel.

B. } To understand the distribution of the fainter nebulosity,
C. } a reference must be made to the drawing.

D. Star 12 is on the very edge of the *following* side of B. It might even be supposed to have been intended to be laid down in the channel γ. 13 is immersed, but not much.

E. Star 11 is immersed in *A*.

G. Star 6 in immersed in *A*.

H. Star 5 is on the *preceding* side of *A*.

J. The triangle defined by stars 40, 44, 21 [these stars not being laid down by Herschel makes this inference somewhat doubtful] would be largely free from nebulosity of any considerable degree of brightness.

K. Although the stars of Mason 6 and 4 are not laid down, yet the general agreement of the northern boundary of C near 1, 2, 19 as laid down by Mason and Herschel respectively, is very good.

L. . . . . . From the engraving I find that about 7^s *preceding* 1 the $\Delta\delta$ of the southern well defined and bright edge of B is $38''$; the width of the channel α is $85''$, and therefore the $\Delta\delta$ of the north edge of C near where star 21 would be, is $123''$.

With reference to the distribution of the nebulosity in Mason's figure we may lay down the following propositions:

A. The brightest nebulosity is that immediately following 1, 2, 19; that surrounding his star 5 [= Lassell No. 18], and that near Mason 6.

B. } The fainter orders of nebulosity are pretty uniformly and
C. } symmetrically disposed about these three brighter centers. This is better understood from the figure than from a description.

D. Stars 12 and 13 are immersed in nebulosity.

E. Star 11 *follows* the edge of the nebula a considerable distance.

G. Star 6 is somewhat immersed in *A*.

H. Star 5 is on the *preceding* edge of *A*.

J. The triangle whose vertices would be in the positions of Lassell's stars 40, 44, 21 is completely filled with tolerably bright nebulosity.

K. The stars Mason 6 and 4 are both immersed in nebulosity, 6 in very faint nebulosity, 4 in a brighter part. The channel α is south of these. The $\Delta\delta$ of 6 and 4 is according to Mason $-63''$ and $-39''$.

L. The $\Delta\delta$ of the south edge of B is about the mean of the $\Delta\delta$'s of stars [Mason] 4 and 6, that is, about $51''$. About 7^s preceding 1, the $\Delta\delta$ of the extreme *northern* limit of C is about $187''$.

In regard to the distribution of the nebulosity in Lassell's figure we may remark:

A. The brightest nebulosity is immediately about and *following* 1, 2, 19.

B. The next order of bright nebula is about stars 35, 36, 37; i. e., just *south* of 1, 2, 19 in the line 1–20.

C. The third order of bright nebulosity is between stars 12, 48, 40 and stars 40, 18.

D. Stars 12, 13, 52 and 53 are immersed in nebulosity.

E. Star 11 is just on the edge of *A*.

F. Star 26 is just on the edge of *A*.

G. Star 6 is nearly in the middle of the dark channel γ.

H. Stars 5, 27, 28 are immersed in the *following* border of B.

J. The triangle 40, 44, 21 is free of nebula.

K. The stars 21, 36, 35 are immersed in C *south* of the channel α.

L. The *southern* limit of B instead of being as in Herschel and Mason's figures over $100''$ *south* of 1, is over $60''$ *north* of it. The $\Delta\delta$ of the *north* shore of C is (roughly) about $-70''$.

Lassell's first figure confirms the above propositions in general. The only changes necessary to introduce are with regard to—

D. 12, 13, 52 on the edge or *following* the edge of B.

F. Star 26 outside of *A*.

H. 5, 27, 28 *follow* the *east* edge of B.

J. The triangle has a patch of faint nebulosity in it (*A'*).

From the MS. observations and drawings of Professor Langley the following conclusions may be drawn:

A. "The brightest nebulosity is about 1" (August 2d). "The region *south* of 1 is judged to be the brightest" (Sept. 10).

B. }
C. } See the observations in detail.

D. Stars 12, 13 are immersed.

E. Star 11 is, if anything, outside of *A*.

F. Star 26 not laid down.

G. Star 6 is, if anything, outside of *A*.

H. Star 5 is near the *preceding* edge of *A*, but immersed.

J. 40, 44, 21 not laid down.

K. Stars 36 ? 35 ? are immersed in C *south* of the channel α.

L. No measures possible on the sketches, but it in general agrees with Trouvelot.

From the drawing of M. Trouvelot, which gives the general effect of the nebula to the eye better than any other, we deduce what follows:

A. The brightest part of the nebula is in *A south* following 1, 2, 19.

B. Next in order of brightness is the nebulosity about star 40.

C. The northern borders of C are next in order of brightness.

D. Stars 12 and 13 are immersed in B.

E. Star 11 *follows* the extreme edge of *A* a little (see his outline-map of stars in Annals H. C. Obs., vol. viii).

F. Star 26 is uniformly surrounded by tolerably light nebulosity.

G. Star 6 is within the *preceding* edge of *A* (outline-map).

H. Star 5 is within A (outline-map).

J. The triangle 40, 44, 21 contains a considerable amount of pretty bright nebulosity.

K. Star 21 is on the *northern* border of C. Stars 35 and 36 are not laid down.

The results A, B, ... K, for the Washington observations are laid down in the detailed transcription of those observations (1877, July 30) and need not be repeated here. As to L, we may say that the $\Delta\delta$ of the *north* shore of C, 7^s *preceding* 1 is about $-65''$.

We may summarize the foregoing results as follows: First as to the distribution of the brightest portions (A, B, C). In all of the drawings the nebulosity closely *following* the triple star is of the first order of brightness, while in the Washington observations between 1 and 10 a darker band exists. I am disposed to believe that this band has simply been overlooked, although the two careful figures of Lassell might be supposed to militate against this view. In these no dark band closely *following* 1, exists.

It is possible that the brightness of the stars 1, 2, 19 produces by contrast part of the effect noted.

D. In spite of minor differences the general agreement as to the situation of stars 12 and 13 is good. Lassell's first drawing if not corrected by his second would be difficult to explain in this respect.

E. According to Herschel: star 11 is immersed in A; Mason, star 11 is deeply immersed in A; Lassell, star 11 is just on the edge of A; Langley, star 11 is not immersed in *A*; Trouvelot, star 11 is very slightly immersed in A; Holden, star 11 is on the very edge of the brightest portion, but *follows* the extreme edge a little.

Here Herschel and Mason agree with each other, but differ from the later authorities.

F. According to Lassell: star 26 is just on the edge of *A*; that is, the space between 26 and 5 is totally black. In his first figure 26 is completely free from A, *preceding* the edge; Trouvelot, star 26 surrounded on all sides by uniform nebulosity; Holden, star 26 is within the *brighter* nebulosity of A, whose boundary line runs between 5 and 26 at a distance from 26 equal to about $\frac{1}{5}$ the distance of these stars.

The evidence under this head should be considered in connection with that under H, which is for comparison next given.

H. According to Herschel: star 5 is on the *preceding* edge of *A*; Mason, star 5 is on the *preceding* edge of *A*; Lassell, stars 5, 27, 28 are immersed in the *following* border of B. In Lassell's first figure these three stars are entirely free from nebulosity and *follow* the *east* edge of B; Langley, star 5 is within *A*; Trouvelot, star 5 is within A; Holden, stars 5, 27, 28 are on the *preceding* edge of a fainter strip of nebulosity which begins (at 6) to border A and continues northward beyond 28. The *preceding* edge of the brightest parts of A is very close to 11, a little *east* of 6, about $\frac{1}{5}$ [26—5] preceding 26, etc. If one follows the edge of the nebula A northward from 1 to 5 at the telescope and without previous familiarity with the actual contours, 5 will certainly at the first glance appear to be on or near the extreme edge of A. A little examination shows that the description given in the Washington observations is correct (in 1877), but I have not been able to see how the exact effect given in Lassell's two drawings (by two different observers, be it remembered, at different times) can be produced. At the same time, I have no doubt that the appearance given by Lassell was a true one for 1862–4, and a slight change in the intensity of the nebulosity between 26 and 5 would reduce the nebula as described in the Washington observations to the appearance as given by Lassell. A change in the reverse direction is needed to reconcile the appearances given by Lassell and Mason

While, therefore, no definite conclusion can be reached (as Lassell's drawings of nebulæ in general are of the highest value, being among the very best extant, and as, therefore, we must not only accept them as evidence, but as very positive and conclusive evidence), it is possible that some slight changes of brilliancy (apparently none of situation) may have occurred in the region 28, 17, 13, 26 during the past forty years.

Resuming the previous order:

G. According to Herschel: star 6 is immersed in A; Mason, star 6 is immersed in A, but is very near the edge; Lassell, star 5 is nearly in the middle of the dark channel γ. Both figures confirm this; Langley, star 6 is not immersed in A; Trouvelot, star 6 is within the extreme boundary of A, but close to edge of the brightest part; Holden, star 6 is about midway between the *preceding* edges of the faint nebulosity bordering A, and the edge of the brighter parts of A.

The evidence above seems to me to indicate some decided changes in the brightness [and position] of the edge of A near 6. The first two and the last two authorities agree, and both differ from Lassell and from Langley. Accepting Lassell's authority, some change has here taken place, and it appears that it is connected with the suspected changes *F* and *H*. Langley's observations are not widely different from the later ones, but seem to confirm Lassell's.

J. The triangle defined by 40, 44, 21 is, according to Herschel: free from any marked nebulosity; Mason, completely filled with tolerably bright nebulosity; Lassell, free from nebula (2d figure), free from nebula except *A'* (1st figure); Trouvelot, contains a considerable amount of pretty bright nebulosity; Holden, contains no nebulosity at all bright except *A'*.

Here the various accounts do not agree. Positive evidence is more to be considered than negative, and this triangle in 1837 was probably filled with nebula considerably bright. It is not so now. Trouvelot's figure really agrees with Lassell's and my own, if we correct a little distortion of his figure near this part.

K and L. The point to be settled is, has the channel α remained unchanged? From Herschel's figure we derive the following:

The apex of A' (which in his figure is continuous with B, and is indeed about the brightest portion of the nebula, quite different from now) is about 38 seconds of arc *south* of 1. The $\Delta\alpha$ of this apex is (approximately) -7^s. The width of the channel α at this point is 85 seconds. Hence the *north* shore of C in the R.A. -7^s (from 1) is in $\Delta\delta$ -123°.

From Mason's figures (assisted here by the measured positions of stars 4 and 6 of his list) we find the *south* shore of B in $\Delta\delta$ $-51''$; and the $\Delta\delta$ of the *extreme* northern limit of C 187''. An acquaintance with Mason's memoir is necessary in order to understand the great dependence to be placed on his work.

In Lassell's figure we find star 21 nearly on the *northern* limit of C, and hence in the (measured) $\Delta\delta$ $-73''.9$. In Lassell's figures the part A' is completely detached from B by a wide, black opening. In Trouvelot's drawing A′ is continuous with B, and in my own sketches A′ is indeed separated from B, but by a narrow and not very obvious channel. In respect to the *southern* parts of B we have then the following successive results.

From my own observations the contour of the *north* shore of C near stars 21, 36, 37, 38 is similar to Lassell's, and the $\Delta\delta$ of 21 which gives the $\Delta\delta$ of this north shore is $-65''$. Collecting the various authorities—

Herschel:	$\Delta\delta$ of north shore of C $= -123''$.	
Mason:	$\Delta\delta$ of north shore of C $= -187''$.	(measured.)
Lassell:	$\Delta\delta$ of north shore of C $= -\ \ 73''$.	"
Trouvelot:	$\Delta\delta$ of north shore of C $= -\ \ 60''$.	
Holden:	$\Delta\delta$ of north shore of C $= -\ \ 65''$.	"

The last three authorities may be said to agree: the first two agree in placing the *north* shore of C 1′ or more further *south*. The amount by which it is further to the *south* is probably best given by Mason's figures, for reasons already cited here, and spoken of in general by Herschel himself (*loc. cit.*, p. 11, foot note.)

If there had been no stars (Mason's 4 and 6) near the area in question, this conclusion would not be so definite as it now appears to be. In fact, the positions of these stars were fixed and then the nebulosity was drawn about them. It is certainly not about these stars now.

The space A′ about 7^s *preceding* 1 and between the parallels of $\Delta\delta=0''$ and $\Delta\delta=-38''$ is, according to Herschel, about the brightest portion of the nebula and continuous with the rest of B; Mason, nearly equal to the brightest parts of the nebula, and continuous with the rest of B; Lassell, totally black; Trouvelot, pretty bright, and part of B; Holden, bright, but separated from B by a narrow channel.

In this respect, regarding all the drawings as of equal or nearly equal accuracy, there has undoubtedly been a decided change.

RECAPITULATION OF THE PRECEDING RESULTS.

We may now collect such of the preceding results as we have found important. First it has appeared—

𝔄. *From* 1784, *July* 12 *to* 1833, *the triple star was centrally situated between the three nebulosities.*

Again,

𝔅. *From* 1839 *to* 1877 *the triple star was not centrally situated between the three nebulosities, but involved in A.*

It has previously been seen that each of these propositions rests on a firm basis. Granted that 𝔄 and 𝔅 are correct, I know of but three ways to reconcile the opposing facts:

a. The triple star has a large proper motion.
b. The nebula A has a large proper motion.
c. The nebula A is subject to decided changes of brilliancy.

The first point will be settled by meridian observations now in progress. The relative positions of 1 and the various stars of the group seem to have been unchanged since Mason. If, as is probable, the proper motion of the triple star is small, there remain the two alternatives *b* and *c* to choose between.

We have seen that the evidence with regard to the position of the nebulosity A relative to the star 6, indicates changes in the brightness and position of this part of A. This appears to be connected with changes much less certain near star 5, etc. It has also appeared that in 1839 the nebula B was about the stars Mason 4 and 6. This is confirmed by Herschel's earlier figure, and is totally and entirely different from present appearances. This conclusion is also confirmed by the marked and glaring differences in the description of the region *A′*.

Each of the above inferences rests on undoubted authority, and only cases are included here in which no doubtful points have arisen. It therefore appears to me to be a just conclusion that—

The evidence as recorded *with regard to this nebula indicates marked changes of position or brilliancy, or both, during the period* 1784–1877. The conjecture of Sir John Herschel, "perhaps this singular object has a proper motion," will be recalled in this connection.

I have, in my own mind, no doubt but that the *evidence as recorded*, if thoroughly examined by any competent person will lead to the same conclusion. The examination of many drawings of nebulæ has, however, led me in common with others, to the conclusion that too great care cannot be exercised in interpreting drawings of this class. Drawings and observations made from one point of view have to be interpreted from quite another and a different one, and misreadings and misinterpretations are likely to occur. It is for this reason that I have given my own observations in detail, so that they may be repeated step by step at any subsequent time; and for the same reason, I have given in full the analysis of the separate drawings so that each point can be verified or rejected by any one who has the original drawings before him.

This method of examining each drawing, deducing from it all the evidence on all the points in question, and then collating the various data under each separate head, not only enables the whole work to be quickly verified, but it enables the person collating the evidence to form the final conclusions with little or no danger of bias or prejudice. The principal question is as to the goodness of the evidence itself. It may be worth while in this case to examine the evidence and to see *what must be rejected* in order to suppose that this nebula has remained *unchanged* from 1784 to 1877. First then, Sir William Herschel speaks of the triple star as being "in the middle" of the three nebulosities on several occasions. Sir John Herschel is explicit as to its being "in the midst" and "exactly in the center" of the "central vacuity." Inference 𝔄 rests on these statements, which could not have been made more definite by Sir John Herschel and which are strongly corroborated by Sir William Herschel. 𝔅 is undoubtedly correct. Hence I believe that the previous inferences regarding the relative motion of the triple star and the nebula should stand, and are correct.

The further conclusions as to change, as I have given them, could have been deduced from the drawings of Mason and Lassell alone, combined with my own observations. The observations of Langley, Trouvelot and Herschel simply corroborate the others in general but are not *essential*. The internal evidence of Mason's paper shows that in spite of his inexperience he was fully aware of the nature of the problem to be solved, and his results are entirely trustworthy. In every point noted as "certain," (and only such points are recorded in the drawing,) his work was verified by his coadjutor, Mr. H. L. Smith. Lassell's drawings are well known, and his series is among the best we have. In this case fortunately we have *two* separate and independent drawings by different hands which support each other. There can be no doubt of their standard character. In regard to my own observations, I am satisfied that they are, in the main and on essential points, correct. The season of 1877 was very unfavorable and the star positions could be improved, but I do not think any error of moment remains. It therefore seems to me that the evidence remaining to be examined is such that it ought not to be rejected, and that the previous conclusions should stand.

ART. XLIX.—*The Northern Part of the Connecticut Valley in the Champlain and Terrace Periods;* by WARREN UPHAM.

A CAREFUL exploration of the stratified drift bordering Connecticut River on both sides, from its source to the north line of Massachusetts, has been made for the geological survey of New Hampshire. Much of the present essay, which is based on this work, will be published, with additional details, in the third volume of the report on that survey.

At the end of the *Glacial period*, this valley, like every other prominent valley in New England, received thick beds of gravel, sand and clay, or fine silt. These were deposited during the *Champlain period*, which embraces the time occupied by the final melting of the great ice-sheet. During the *Recent or Terrace period*, the work of deposition has not been equal to that of erosion, and the rivers have excavated deep and wide channels in the Champlain deposits.* This erosion along Connecticut River has been 100 to 200 feet in depth, and a quarter of a mile to one mile or more in width.

The river-lands here to be considered include the interval, or present flood-plain, frequently known as meadow along the Connecticut, and called bottom-land in the western States; and terraces, which rise in steps on each side of the river, the highest often forming extensive plains. This highest deposit is found to have about the same height upon both sides, and to extend continuously, with nearly the same slope as that of the river, along the whole valley, being broken only by the entrance of tributaries or occasional projecting hills. These terraces are remnants of the river's flood-plain at the end of the Champlain period. The lower terraces agree less frequently in their height on opposite sides of the river, and are commonly short, seldom extending more than one or two miles, and succeeded by others higher or lower. An examination of them over long distances, however, sometimes shows a well-marked series, descending with the river, and recording a height at which during the process of erosion, the river remained nearly stationary in height for an unusual length of time, forming a broad and continuous flood-plain, now interrupted and nearly swept away by the further deepening of the channel. These terraces are almost always level-topped, and bounded at the

* It will be seen that these terms are adopted from Prof. James D. Dana, who has given much attention to surface geology, and has brought into due prominence the abundant deposition of drift, both stratified and unstratified, during the Champlain period. See this Journal, III, v, p. 198; x, pp. 168, 280, 353, 409 and 497. These divisions of Quaternary time are well marked in New England, and apparently in all countries, which have been overspread by ice. They are distinctly characterized as successive periods of glaciation, deposition and erosion.

face by a steep escarpment; and their appearance is sometimes very striking, and even grand, as they rise in gigantic steps on the side of the valley, shaped with a smoothness, order and beauty, which could not be surpassed by art.

The most interesting discovery made during the survey of this valley is, that a massive gravel ridge, often nearly covered by the alluvium of the highest terraces, extends from Lyme, N. H., to Windsor, Vt., a distance of twenty-four miles. It is principally gravel, always waterworn, the largest pebbles being one to two feet in diameter, with occasional layers one or two feet in thickness of coarse sharp sand. These deposits are very irregularly bedded, and a section always shows a somewhat anticlinal stratification, conforming to the slopes of the ridge. Its height is 150 to 250 feet above the river, by which it has been frequently cut through, as well as by tributary streams. This ridge occupies nearly the middle of the valley, and as the river has cut its channel through the alluvium, this has been often a barrier rising steeply upon one side and protecting the plains behind it. In two or three places it has been swept away by the river for a distance of one half mile to one mile, and below these places the terraces show by their coarseness that the ridge has supplied a portion of their material. Similar ridges of gravel have been often described by European geologists, under the various names of *kames* in Scotland, *eskers* in Ireland, and *åsar* in Sweden. They have also been described by geologists in many portions of the northern United States. In both the Connecticut and Merrimack Valleys they extend long distances, but have hitherto escaped notice, owing to the large amount of levelly stratified alluvium, forming the conspicuous terraces and plains, by which these underlying gravel ridges, or kames, are often nearly concealed. The kames are thus shown by their position to be the oldest of our modified drift deposits.

The series of kames already mentioned lie along the middle or lowest part of the valleys, which are bordered by high ranges of hills; but in the southeast part of New Hampshire, in some parts of Maine, and in eastern Massachusetts, where there are only scattered hills, with the valleys not much below the general level of the country, these ridges, of smaller size than in the great valleys, are found extending usually north and south without special regard to the present water-courses.

The origin of the kames has been a question much discussed by European geologists, and the theory commonly accepted on both sides of the Atlantic was, that they were heaped up in these peculiar ridges and mounds through the agency of marine currents during a submergence of the land. Even if such ridges could be formed by this cause under any circumstances, it seemed impossible to account thus for the kames in the Connecticut and Merrimack Valleys, which, being bordered on both sides by high hills, would have been long estuaries open to the sea only at their mouths, and therefore not affected by oceanic currents. From the position of these peculiar accumulations of gravel, which are overlain by the horizontally stratified drift, the date of their formation is known to be between the period when the ice-sheet moved over the land, and that closely following, in which this more recent modified drift was deposited in the open valley from the floods that were supplied by the melting ice. We are thus led to an explanation of the kames, which seems to be supported by all the facts observed in New Hampshire, and which appears to apply, also, to the similar deposits which have been described in other parts of the United States and in Europe.

At the beginning of the Champlain period, or final melting of the great ice-sheet, its nearly level surface of pure ice lay above our highest mountains. That it overtopped Mt. Washington in New Hampshire, has been recently discovered by Prof. C. H. Hitchcock, the State geologist, who has found transported rocks, and shown that glacial drift, or till, underlies the angular blocks at the summit. The melting of the ice-sheet appears to have taken place mostly upon the surface, which was moulded into basins and valleys; and near the terminal front of the ice, these came gradually to coincide with the contour of the land. Here the surface of the ice became covered with the abraded material which had been contained in its mass, and which was now exposed to the washing of its innumerable streams. Its finer portions would be commonly carried away; and the strong current of the rivers which would be formed near the terminal front of the ice-sheet could transport coarse gravel or even boulders of considerable size. In the lower part of their channels, while still walled on both sides by ice, these glacial rivers deposited materials which had been gathered from the melting glacier. By the low water of winter layers of sand would be formed, and by the strong currents of summer layers of gravel, often very coarse, which would be very irregularly bedded, here sand and there gravel accumulating, and without much order interstratified with each other. Sometimes the melting may have been so rapid that the entire section of a kame may show only the deposition of a single summer, which would then be very coarse gravel without layers of sand. When the bordering and separating ice-walls disappeared, these deposits remained in the long ridges of the kames, with steep slopes and irregularly arched stratification. Very irregular short ridges, mounds, and enclosed hollows resulted from deposition among irregular masses of ice.

The glacial rivers which we have described appear to have flowed in channels upon the surface of the ice-sheet; and the formation of the kames took place at or near their mouths, extending along the valleys as fast as the ice-front retreated. Large angular boulders are sometimes, but not frequently, found in the kames or upon their surface. They appear to have been transported by floating ice. Their rare occurrence forbids the supposition that these deposits were formed in channels beneath the ice-sheet, from which many such blocks must have fallen upon the kames.

The necessity of referring the formation of these gravel ridges to glacial rivers became apparent during the exploration and study of our modified drift in 1875; and in August, 1876, this was announced in a paper "On the origin of Kames or Eskers in New Hampshire."* In this essay it was supposed that these rivers more commonly had their course beneath the ice-sheet, but subsequent examination of the underlying till shows that this was seldom the case, and that the kames were deposited in channels formed on the surface of the ice. Prof. Otto Torell, of Sweden,† had pointed out a division of the till into two members, the lower characterized by its blue color, its compactness and hardness and its glaciated stones; the upper being marked by a yellow and reddish color, comparative looseness of the mass, and its angular or unworn bowlders. This division is found throughout New Hampshire; there being almost always a definite separation, at a depth varying from two or three feet, as is most common, to fifteen or twenty feet, between the upper and lower till. It should be added that the lower till in a majority of cases has no distinct blue tint, but is dark gray; being always somewhat darker than the upper till, which is colored by ferric oxide. The lower till may be distinguished by an imperfect cleavage in planes parallel to the surface, noticeable wherever an excavation has been for a short time exposed to the weather. Before this, Professor James D. Dana had insisted that the deposition of a great part of the till took place in the Champlain period, being dropped from the melting ice-sheet. This suggested the origin of the upper till, and an explanation of its difference from the lower till; the latter being the ground-moraine, while the former appears to have been material contained in the body of the ice-sheet, and allowed to fall loosely on the surface when this melted. As the kames overlie both members of the till, they plainly were deposited in superficial ice-channels.‡

* Proceedings of the American Association for the Advancement of Science, vol. xxv.

† See this Journal, III, xiii, p. 77.

‡ Similar conclusions respecting the origin of the kames had been reached by other observers, but were unknown to me when my views were proposed in August, 1876. Probably the first of these was Professor N. H. Winchell, State

When the glacial river entered the open valley from which the ice had retreated, its current was slackened by the less rapid descent, causing the deposition successively of its gravel, sand and fine silt or clay. The valleys were thus filled with extensive and thick deposits of modified drift, which took the same slope with the descending floods, increasing in depth in the same way that additions are now made to the bottom-land, or intervals, of our large rivers by the annual floods of spring.

The terraces began to be formed as soon as the supply of material became insufficient to fill the place of that excavated by the river. We must suppose that this process of erosion was slow, allowing the river to continue for a long time at nearly the same level, undermining and wearing away its bank on one side, and depositing the material on the opposite side, till a wide and nearly level lower flood-plain would be formed, bordered on both sides by steep terraces. When the current became turned to wear away the bank in the opposite direction, a large portion of this new flood-plain would be undermined and re-deposited at a lower level; but the direction of the current's wear might be again reversed in season to leave a narrow strip, which would then form a lower terrace.

In placing theories before our description of this valley, their first order has been reversed, since these explanations have been arrived at or confirmed by long study of these deposits in this valley and throughout New Hampshire.

The sources of Connecticut river are a series of four lakes, the highest of which, covering only a few acres, is 2,550 feet above the sea. The lowest of the series is Connecticut Lake, three square miles in area, 1,618 feet above the sea. Heights of the river, with distances from Connecticut Lake, are as follows: Mouth of Hall's stream, 15 miles, 1,085 feet above sea; at Colebrook, 24 miles, 1,010; at North Stratford, 37 miles, 891; at Groveton, 49 miles, 854; at Lancaster, 56 miles, 835; mouth of John's river, 63 miles, 830; at Upper Waterford, 74

Geologist of Minnesota, who held this opinion as early as 1872. See Proc. Amer. Assoc. for Adv. of Science, vol. xxi, 1872, p. 165; Geology of Minnesota, First Annual Report (for 1872), p. 62; and same, Report for 1873, p. 194. In the revised edition of Geikie's Great Ice Age, published in London in the winter of 1876–77, this distinguished glacialist retracts his former opinion that the kames were heaped up by marine currents, and attributes their formation to sub-glacial rivers. See work cited, pp. 217, 237, 240, 243, and 478. By p. 414 it appears that this theory was first proposed by Mr. D. Hummel of the geological survey of Sweden, in 1874; and on page 415 allusion is made to a recent paper by Dr. N. O. Holst, also of Sweden, in which the kames have been explained in the same manner as in this article. On pp. 49 and 50 large rivers are mentioned as having been observed in summer upon the surface of Arctic glaciers. These would be formed on a grander scale in the Champlain period, when the melting of the ice appears to have been much more extensive and rapid than is anywhere to be seen at the present day. The small sub-glacial tunnels which probably existed through the glacial period, would be insufficient to discharge these increased floods, and would become obstructed by the detritus which they brought.

miles, 674; mouth of Passumpsic River, 83 miles, 460; at Wells River, 95 miles, 407; at Hanover, 130 miles, 373; at White River Junction, 134 miles, 333; at Windsor, 146 miles, 304; at Bellows Falls, 170 miles, fall from 283 to 234; at Brattleboro', 192 miles, 200; at South Vernon (Massachusetts line), 202 miles, 180.

The general course of the river to the mouth of Hall's stream is S. 60° W. High wooded hills border the valley which is destitute of modified drift for half of the way. The largest alluvial area is on Indian stream, and the highest terraces are of coarse gravel, 30 to 40 feet above the river.

From the mouth of Hall's stream to that of John's River, at the head of Fifteen-miles Falls, the general course is S. 13° W., with a descent in nearly fifty miles of only 255 feet, one-fifth of which takes place in the first two miles, and two-fifths more in the nine miles between Columbia bridge and North Stratford. Below the first two miles the modified drift is continuous along this whole distance; and, including both sides, it is usually a half mile to one and a half miles wide. It is very simple, having two heights, and consisting of the present flood-plain, bordered by remnants of that which filled the valley in the Champlain period. This ancient flood-plain is represented by a lateral terrace of sand or fine gravel, from 40 to 120 feet above the river, usually remaining at both sides, and in many places forming considerable plains.

At Colebrook we find an interesting gravel ridge or kame, portions of which remain north of the junction of Beaver brook and Mohawk River, but most noticeably west of the village, extending nearly a mile parallel with the river. Its height is about seventy feet above the river, and fifty above the low alluvium on each side. Its material is the same as that of the long kame farther south in this valley, being principally coarse water-worn gravel, with abundant pebbles six inches to one foot in diameter. In Stratford and Brunswick both heights of the alluvium are well shown, the highway being on the upper terrace and the railroad on the meadow. At Lancaster the upper terrace of Connecticut River is only fifteen or twenty feet above the present flood-plain. The only higher modified drift has been brought down by tributaries. Part of Lancaster village is built on one of these deltas, formed by Israel's River on its south side, fifty feet above the terrace of the main valley. This delta sloped rapidly westward, and formerly occupied the whole area of the village; a portion of it, twenty feet lower than the former, remains at the cemetery opposite the court-house.

Between South Lancaster and Fifteen-miles Falls the broad river-plain is unterraced. It seems probable that a lake existed here while the original high plain northward was being deposited. When this was channelled out by the river, so as to leave only terraces as we now see them, the materials excavated were sufficient to fill up the lake. It would be interesting to know the depth of the stratified drift in this basin; it is probably deeper than the height of the highest terraces northward above the river.

From the mouth of John's River, the Connecticut has a rapid descent for twenty miles, falling from 830 to 460 feet above the sea. Its general course is deflected to S. 70° W. along this distance, beyond which the direction of the upper is again followed in the lower valley, with but slight deviation, to Massachusetts line. The noticeable features of the valley along these rapids are, that it is deep and narrow, with sloping sides of till, and destitute of the level alluvial terraces and intervals which occupy a large width everywhere else along the river. Where any modified drift does occur, it is coarser than usual, being generally gravel, sometimes imperfectly rounded or water-worn, and its surface has commonly an irregular slope. The river flows in a nearly continuous descent over coarse till, showing abundant bowlders, but with scarcely any exposure of solid ledges. The falls farther south are produced by ledges; and the channel, except at such falls, is composed of gravel, sand or silt, which is also the case along the nearly level upper valley. The irregular surface left by the ice has been here reduced to a channel of nearly regular slope with no abrupt falls, cut through the till, which still covers the ancient bed in which the river flowed before the glacial period.

In a direct distance of 119 miles from the mouth of Passumpsic River, which is near the foot of these rapids, to the Massachusetts line, the river flows 137 miles, descending from 460 to 180 feet above the sea, or two feet to the mile. The principal falls in this distance are Beard's falls, at Barnet, five feet; McIndoe's falls, ten feet; Dodge's falls, three and a half miles south, five feet; at Woodsville, about ten feet; White River falls, between Hanover and White River Junction, thirty-five feet; Sumner's or Quechee falls, two miles below the mouth of Quechee River, five feet; and Bellows Falls, forty-nine feet, —making a total of 119 feet, and leaving an average descent, excluding falls, of one and one-sixth feet per mile.

The modified drift of this lower valley is everywhere well developed, and occurs in extensive terraces and various heights, three or four often on each side, the upper one being usually from 150 to 200 feet above the river, while the lowest is the interval or meadow. The largest plains are expanses of the upper terrace or of still higher tributary deltas. These areas are generally of a clayey, moist, productive soil quite in contrast with the dry sandy plains of Merrimack River and other parts of New Hampshire. The most extensive intervals or meadows are between Woodsville and Bradford, twelve miles long and one half to one mile wide, including the Lower Coös intervals of Newbury, Haverhill and Piermont; and in Charlestown and Rockingham, six miles long and half a mile wide. In addition to these, smaller areas, up to a mile or more in length and a few rods to a half mile wide, are of common occurrence. These bottom-lands are very fertile, being composed of the finest silt, and enriched every year by a coating of mud from the turbid freshets of Spring. Many of the lower terraces which are not overflowed are of the same material; but the higher terraces usually show some intermixed sand or fine gravel.

The greatest widths of modified drift that can be measured in this valley on the west side of New Hampshire, are in Haverhill and Newbury, two miles, and in Hinsdale and Vernon, two and a half miles wide. The average width is fully one mile. The narrowest places are at Shaw's Mountain, near the south line of Bradford, and at Barber's Mountain, in Claremont, both of which occupy the middle of the valley, with narrow belts of alluvium on each side; at the west side of Rattlesnake Hill, Charlestown; and at the south end of Wantastiquit Mountain, below Brattleboro'. We do not discover, however, at these places or elsewhere, any evidence of former barriers, which could have made the valley a series of lakes. The vast amounts of modified drift which accumulated here appear to have been rapidly deposited from the immense floods supplied by the melting ice-sheet. Such deposits, for which there appears no other adequate cause, should rank with the till, striæ and embossed ledges, as proof of a former continental glacier.

At Woodsville a great depth of material was brought into the valley by the Lower Ammonoosuc and Wells Rivers. The former stream has cut its channel 200 feet deep through its delta, wide areas of which still remain on both sides. An old outlet of Wells River may be seen on its north side, one mile above its mouth, occupied at the close of the ice-period until it cleared away a hundred feet or more of modified drift from the pre-glacial rocky bed in which it now flows. A well marked kame occurs here, commencing in Bath half a mile northwest from the Narrows. It has been cut through by the river, and appears on the east side of the railroad at and above the junction, and again at the southwest side of Wells River Depot, being more than a mile long. It is composed of coarse gravel and sand, anticlinally stratified, with varying height from 80 to 150 feet above the river. It is well shown by cuttings, but otherwise might escape notice, as most of it is partially or wholly concealed by the ordinary alluvium. In the twenty-four miles from Wells River to Lyme no similar ridge is found.

In Thetford and Lyme we come to an abrupt change in the height of the upper terrace-plain. This slopes in thirty-three miles between the mouth of Passumpsic River and the south line of Orford, from 650 to 440 feet above the sea, gradually declining from 190 to only 60 feet above the river. At North Thetford this line of the highest terrace suddenly rises to 525, and in a mile and a half farther south to 545 feet. This formation is well shown through Thetford, with remnants in Lyme, and continues well developed and nearly level for twenty-five miles to Windsor, varying from 560 to 500 feet above the sea, and from 150 to 220 feet above the river. It forms extensive terraces or plains on one or both sides along the whole distance and is clearly the original flood-plain of the river. Frequent delta-terraces rise above it, sometimes 100 feet higher, being more than 300 feet above the present river channel. It is a notable coincidence, that along this same distance we have a continuous kame, occupying the center of the valley, commonly rising somewhat above the highest plain, but not seldom entirely covered by it. Super-position and conformable stratification show the fine material of the terrace-plain to have been deposited upon this kame or gravel ridge, which beforehand extended like a windrow along the empty valley. To the south from Windsor the highest terrace shows a somewhat regular slope, descending with the river, and preserving a height about 150 feet above it.

This high and continuous flood-plain, extending from Thetford to Massachusetts line, seems to have been formed during a gradual and slow melting of the ice along this distance. It would appear that the greater part of the depth of ice, as far northward as to the Passumpsic River, had been melted in the last part of this time, sending down its floods laden with gravel to form the kame. A comparatively shallow mantle of ice remained, and when the melting advanced to the north from Thetford and Lyme this disappeared too rapidly to give time for the formation of a kame, or the deposition of a high flood-plain.

In Norwich we find an interesting example of a well marked ancient river-bed high above its present level. This extends two miles from Pompanoosuc River, one-third of a mile above its mouth, to the bend of Connecticut River a half mile south of Tilden pond, which occupies a depression of this old channel. Its highest point, from which there is a gradual descent both ways, is 520 feet above the sea or 145 feet above the river. On the east side of this ancient channel is the steep gravel kame, which for a while turned the Pompanoosuc River in this course, till a direct passage was cut through its ridge.

Two miles north of Hanover the Connecticut River has cut through the kame, and thence flows close on its west side to White River Falls. Along this distance of four miles we find the high plain well developed in New Hampshire, averaging three-fourths of a mile wide. Hanover common, 545 feet above the sea, and 172 above the river, represents its greatest altitude. In digging the first well at this place (near the residence of Professor H. E. Parker), a large log was found in this alluvium forty feet below the surface, but no prospect of water, which caused this site, selected for the buildings of Dartmouth College, to be abandoned, and led to their location farther east, upon coarse glacial drift. This log shows that the glacial age had here been succeeded by a temperate climate, under which forests grew again upon the land; and that floods, sent out freighted from the melting ice-sheet, which still remained farther north and on the highlands, brought down drift-wood to be buried with their alluvium. It was not till considerably later that the river ceased its work of accumulation and began to cut its present channel.

Near the south line of Lebanon, east of Sumner's Falls in Plainfield, and at several places in Cornish, we find banks of sand, or dunes, destitute of vegetation, and blown in drifts by the wind. These vary in height from a few feet to 100 feet above the highest terrace, from which they appear to have been carried up by the prevailing northwest winds. Southward through New Hampshire they are found in many places on the east side of this valley, but none were seen in Vermont.

From Lyme to Windsor we find a continuous gravel ridge or kame, extending twenty-four miles along the middle of this valley, with its top from 150 to 250 feet above the river, or from 500 to 600 feet above the sea. The gravel, which always forms the principal part of the ridge, varies in coarseness from layers with pebbles only one or two inches in diameter, to portions where the largest measure one and a half or two feet. The finer kinds prevail; and the channels of brooks cutting through the ridge frequently show no pebbles exceeding one foot in size. All the materials of this kame, and of its remnants southward, are plainly water-worn and stratified.

Large and unworn bowlders, which could not have been brought in the same way with the gravel and sand, occur very rarely upon or in the Connecticut kame. The only instance of this discovered was three fourths of a mile south of Pompanoosuc River, at the point where the kame reaches its greatest height above the sea. Two angular bowlders, each of five feet dimension, were found here at the top of the ridge, one lying on the surface, and the other partly imbedded. Several miles at least of journey on foot along the top of this ridge, and the examination of many sections where the river or its tributaries have cut through it, failed to reveal other bowlders of this kind.

One or both sides of this kame are generally covered by the alluvium of the upper terrace; but its top usually projects in a long, rounded ridge, 10 to 30 feet above the adjoining highest plain. At one place, east of Hartland Depot, this plain has been swept away from both sides, and the kame forms a conspicuous steep ridge 125 feet in height. Wherever it is exposed, it is readily recognized by the pebbles which strew its surface, and which are very rarely found in the ordinary modified drift of the valley.

The most important feature of this kame, if we compare it with others in New Hampshire, is, that along its entire extent it constitutes a single continuous ridge, which runs by a very direct course nearly in the middle of the valley, having no outlying spurs, branches, parallel ridges, or scattered hillocks of the same material associated with it. In calling it continuous from Lyme to Windsor, however, it is not meant to imply that it is now entire, since it has been frequently cut through and considerable portions swept away by the main river and by tributary streams; but that so much of it remains as to make it certain that it originally formed an unbroken ridge. The portions now separated by gaps always lie in a continuous line.

Probably a similar ridge once existed along the valley southward, though now shown by only a few fragments. These occur in Charlestown between Springfield Depot and the Cheshire bridge; at Bellows Falls, where a remnant forms the pine-covered plateau, used as a picnic ground, in the north part of the village; in Dummerston, a third of a mile southwest from the depot; and in Brattleboro', at the north side of West River, lying on ledges between the railroad and highway.

Near Bellows Falls, Cold and Saxton's Rivers have brought down large amounts of modified drift seventy-five feet above the normal high plain. The delta of the former has been eroded so far as it occupied the main valley, but the escarpments thus formed remain at the mouth of the valley of Cold River, from 100 to 200 feet high. On the south side of Saxton's River a considerable part of its delta remains, and the upper terrace is increased in height by this cause for two miles south. The excavation of this delta by Saxton's River has formed a most interestingly terraced basin, situated less than a mile south from Bellows Falls Junction. On both sides of this river, and crossed by a road, is an interval about one fourth of a mile in diameter. Around this on all sides are ranged terraces, which rise in succession like the seats of an amphitheater, the highest on the northwest being 220, and on the south 200 feet above the arena below. They do not, however, show a perfect regularity either in correspondence of height or in continuous extent, and no single section would embrace all of the eight distinct and separate terraces which were noted on each side of the river.

The most extensive plain on Connecticut River in New Hampshire or Vermont is in Hinsdale, being three miles long, with a width decreasing from two miles to two-thirds of a mile. The road from Hinsdale to Brattleboro' passes over the south end of this plain. Here its height is 350 feet above the sea, or 165 above the Connecticut at the mouth of Ashuelot River. It is mainly composed of sand, nearly level, but with a slight slope to the west and south, being as usual towards the river and in the direction of its course. Its northern portion changes to gravel which becomes coarse on the southeast side of Wantastiquit Mountain, containing pebbles one foot or sometimes a foot and a half in diameter. The position and slope of this plain show that it was not deposited wholly from currents of the main valley, but that a considerable portion was contributed from the melting of the ice-sheet east of this mountain.

ART. L.—*Descriptions of two new species of Fishes (Macrurus Bairdii and Lycodes Verrillii) recently discovered by the U. S. Fish Commission, with notes upon the occurrence of several unusual forms*; by G. BROWN GOODE and TARLETON H. BEAN.

AMONG the many interesting discoveries made during the present summer by the United States Fish Commission (Prof. S. F. Baird, Commissioner) is that of a species of *Macrurus* believed to be undescribed. A single specimen was taken in a trawl net, August 19, 1877, on the voyage of the U. S. Steamer "Speedwell" from Salem to Halifax. It was found in the Gulf of Maine, forty-four miles from Cape Ann (east ½ south) in 160 fathoms, muddy bottom (locality 35). Two members of this family are included by Professor Gill in his Catalogue of the Fishes of the East Coast of North America (Washington, 1873). One, *Coryphænoides norvegicus*, has been recorded only from Greenland and the northern and western coasts of Norway. The other, *Macrurus rupestris*, has much the same geographical range: a fish found floating at sea near Gravesend, N. Y., in 1876, and now in the U. S. National Museum, has been identified with this species.

The genus *Macrurus*, auct., has been subdivided into three, viz: *Macrurus*, *Coryphænoides* and *Malacocephalus*. The most important diagnostic character given by Dr. Günther as separating *Macrurus* from the other genera is the joining of the ridge of the suborbital ring to the angle of the preoperculum as in *Scorpænidæ* and *Cottidæ.* This character does not hold good in the species here under consideration, which in all other respects agrees with *Macrurus*, as defined in Günther's Catalogue of Fishes in the British Museum.

The closest affinities of *Macrurus Bairdii* are with *M. sclerorhynchus*, described by Valenciennes from the Canary Islands. Its relations to this species and to the other representatives of the family in North America are shown in the following table:

	Macrurus Bairdii.	*Macrurus sclerorhynchus.*	*Macrurus rupestris.*	*Coryphænoides ? norvegicus.*
Snout.	Sharp, conical, quadrate, shorter than eye, less than one-third of head.	Sharp, trihedral, shorter than eye, which is two fifths of head.	Sharp, triangular, as long as eye.	Obtuse, obliquely truncated.
First Dorsal.	Second spine denticulated from base to tip, not extending to origin of second dorsal.	Second spine denticulated, extending far beyond origin of second dorsal.	First spine denticulated only towards the top.	First spine denticulated anteriorly.
Vent.	Under middle of first dorsal.	Behind vertical from last ray of first dorsal.	Behind vertical from origin of second dorsal.	Before vertical from origin of second dorsal.
Scales.	Spiny. Median row of spines forming keel upon scales of head and upper anterior portion of body.	Spiny. Median row of spines forming keel.	Each with a strong longitudinal keel terminating in a point.	Spiny, without keel.
Transverse rows of scales	6 + 19 or 20.	5 + 21 or 23.	5 +	4 or 5 + .
Radial formulæ.	D. II. 11. 137. A. 120. V. 7.	II. 9 or 11. 87. 72.	11. 124. 148. 8.	11 + . 8.

Macrurus Bairdii, sp. nov.

Extreme length of specimen described,* 0·296 m. (11·7 inches). Body tapering from first dorsal to tip of tail, much compressed posteriorly, its greatest height over origin of pectorals (0·037 m.) contained eight times in length; its greatest width at same point (0·022 m.), contained 13 times in length.

Scales irregularly polygonal, the free portions covered with transparent, vitreous spines, arranged in from ten to twelve irregular longitudinal rows. On head, and upper part of body, in advance of first dorsal, the median row of spines is the most prominent, and presents the appearance of a low median keel.

Lateral line nearly straight, formed by a smooth groove which replaces two or three median rows of spines of each

* Cat. No. U. S. National Museum, 21,014.

scale. Number of scales in lateral line, 152; six transverse rows above it, and nineteen or twenty rows below it, counting from vent obliquely backward.

Head.—Greatest length (0·045 m.) equals distance between first and twenty-third anal rays, and is contained six and one-half times in extreme length. Greatest height, at posterior margin of orbit, (0·028 m.) greater than width at same point (0·023 m.), and contained one and four-seventh times in length of head. Width of interorbital area (0·012 m.) equal to vertical diameter of orbit (0·012 m.), and almost equal to length of snout (0·013 m.) and length of maxillary (0·013 m.). Length of post-orbital region (0·017 m.) about equal to horizontal diameter of orbit (0·016 m.). Length of operculum (0·007 m.) about half the length of mandible (0·015 m.).

Snout sharp, a front view presenting four ridges radiating from the tip at right angles to each other, the lower one being merely a fold in the skin of the under surface of the head. The horizontal ridges are continued into the ridges upon the suborbitals. Ridge extending backward from tip of snout upon top of head is lost in the interorbital space. Branches of the horizontal ridges are continued upon the upper margins of orbits, and there disappear. Nostrils immediately in front of orbit, the posterior pair much the longer.

Mouth situated entirely on lower side of head; symphysis of lower jaw in vertical from anterior margin of orbit, and articulations of mandibles in vertical from posterior margin of orbit; width of cleft of mouth (0·012 m.) equal to distance between symphysis of maxillaries and line connecting their articulations. Upper jaw protractile vertically. Barbel 0·005 m. in length.

Teeth conical, somewhat recurved, of nearly uniform size, arranged in villiform bands. Palate smooth.

Distance of first dorsal from snout (0·057 m.) about four times the length of its base (0·014 m.), and from anterior margin of orbit equal to length of head. First spine very short (0·002 m.), not much longer than the teeth of second spine. Second spine in length (0·032 m.) twice horizontal diameter of orbit, stout, its anterior margin armed from base to tip with fifteen teeth pointing upward, the uppermost being longest and most slender: its length to tip of filament (0·037 m.) is almost equal to distance from origin of first to origin of second dorsal (0·038 m.), this tip when laid back reaching almost to second dorsal. Rays decreasing regularly in length so that, when the fin is upright, its shape approximates that of a right angled triangle, the hypothenuse of which is the second dorsal spine and its perpendicular side a line touching the tips of the rays.

Length of base of second dorsal (0·204 m.) less than that of the anal, its origin over the 30th scale of lateral line. Length of longest ray (in posterior third) 0·004 m., which is less than length of barbel. All rays very feeble. Membrane scarcely perceptible.

Distance of anal from snout (0·070 m.) three and four-fifth times in its length of base, its origin under 18th scale of lateral line. Length of first ray (0·006 m.) one-half the length of tenth ray (0·012 m.), and three times the length of last ray (0·002 m.), the length of rays increasing to a point beneath anterior part of first dorsal, and thence gradually decreasing to tip of tail.

Distance of pectoral from snout (0·048 m.) four times width of interorbital area; its length (0·029 m.) twice the length of mandible. Insertion above the middle of the depth of the body, on a level with center of orbit, its third ray longest, its tip reaching to vertical from base of fourth anal ray.

Insertion of ventral behind pectoral and almost under that of first dorsal; its distance from snout (0·053 m.) slightly exceeding twice its length (0·025 m.). Tip of ventral filament reaches to base of third anal ray.

Radial formula: D. II, 11. 137; A. 120; P. 15; V. 7.

Color: Ground color, light brownish gray; under parts, silvery; belly, darker, bluish. Under surface of snout, pink, as is also the first dorsal except spines. Spines of dorsal, ventral and anterior anal rays, blackish. Throat, branchiostegal membrane and isthmus, rich deep violet. Sclerotic coat, green. Eyes, very dark blue.

Spermaries well developed, but milt not mature. Individual apparently adult.

This species is dedicated to Professor Spencer F. Baird, LL.D., Assistant Secretary of the Smithsonian Institution, Director of the U. S. National Museum and U. S. Commissioner of Fish and Fisheries.

Another interesting form is a species of *Lycodes* taken in the trawl thirty miles south of Cape Negro, N. S. (localities 44 and 45), in ninety fathoms, fine sand and mud bottom, and twenty-seven miles south of Chebucto Head, Halifax, (locality 83) 101 fathoms, fine sandy mud. Five specimens (Cat. No. U. S. Nat. Mus. 21,013) were taken in the first locality and one (No. 21,015) in the latter.

Eleven species of this genus have been described, eight of which are found in arctic seas, three in antarctic, the latter being separated by Dr. Günther into a distinct section of the genus. The form under consideration is distinguished by (1) its elongated form, which it shares, with *L. Sarsii*; (2) the great proportional length of the maxillaries; (3) by the presence and arrangement of scales; (4) by various proportions of parts which distinguish it from one or all the allied species; (5) the presence of five rays in the ventral fin, and; (6) by coloration.

Lycodes Verrillii, sp. nov.

The extreme length of specimen described 0·127 m. (five inches).

Body more elongate than in any other described species of that section of the genus occurring in arctic seas, except *L. Sarsii* Kroyer: its greatest height (0·010 m.) equal to its greatest width between pectorals (0·010 m.) and nearly one-thirteenth of its total length.

Distance of vent from ventrals (0·023 m.) slightly greater than length of head (Om. 022), which is contained about five and two-third times in total length. Distance of vent from snout (0·041 m.) about one-third length of body.

Head, body and fins enveloped in tough lax skin.

Scales cycloid, circular and ovate, 0·00025 m. to ·00035 in diameter, with numerous concentric striæ, and with about eighteen lobes upon margin, the whole perrimeter being lobed: they are deeply imbedded in the skin at distances from each other equal to their own diameters: they are most numerous upon the upper half of the body, and extend upon the base of the dorsal; very few upon the lower half of the body; and are absent from the anal fin.

Head much depressed, its width (0·014 m.) considerably greater than its height (0·010 m.) which equals length of post-orbital portion of head (0·010 m.) and double the width of the inter-orbital space (0·005 m.). Length of maxillary (0·011 m.) is half the length of the head (0·022 m.): the maxillary extends nearly to the perpendicular from the posterior margin of the orbit. Diameter of orbit (0·004 m.) is half the length of snout (0·008 m.).

Viewed from above the snout is somewhat obtusely rounded, and a line drawn through the center of the eyes would form with the sides of the snout a figure approximating in shape an equilateral triangle, the angle of the snout being rounded.

Upper jaw far overlapping under jaw; gape extending from ventral to center of orbit.

A series of large pores, six on each side, extends backward from nostril toward angle of operculum, following line of upper jaw at a distance above it about equal to diameter of pupil. The fourth of this series, counting backward, is under the center of orbit, the last is situated about two-thirds of the distance from snout to angle of operculum.

A similar series, seven on each side, follows line of lower jaw from its symphysis obliquely upward toward angle of operculum, in such direction that if the maxillary row were continued by the addition of a single pore to the series, the two lines would intersect. A line connecting the fourth pore of the one series with the fourth pore of the other would intersect the articulation of the jaws. The first four pores of the mandibular series are slit-like; all the others in both series are circular or nearly so, their diameter equal to one-third to one-half that of the pupil. The profile of the head resembles that of *Zoarces anguillaris;* the top of the post-orbital tract is on a level lower than that of the top of eye, the outline of the head then rising to a point over the center of the orbit, thence sloping abruptly to the snout.

Cleft of mouth horizontal, in width equal to post-orbital length of head (0·010 m.), also to distance from snout to angles of gape.

Nostrils at extremities of fleshy tubes, the length of which is equal to the diameter of the largest pores.

Teeth in lower jaw in two rows and nearly uniform in size, in upper jaw, in a single row, some larger ones near symphysis with patches of smaller ones behind them. About seven teeth on the vomer. A single row of teeth on palatines. All the teeth are curved.

Gill openings narrow; gill membranes attached to isthmus.

Distance of dorsal from snout (0·033 m.) one and one-half times the length of head (0·022 m.).

Distance of anal from snout (0·045 m.) twice the length of head.

Dorsal and anal fins are about equal in height, with even margins, not differentiated from caudal; the rays increase somewhat in length toward extremity of tail, though the fins do not increase in height.

Distance of pectoral from snout (0·023 m.) about equal to length of head, twice length of pectoral (0·011 m.) and more than three times breadth (0·007 m.). Pectoral extends to vertical from base of second dorsal ray.

Distance of ventrals from snout (0·021 m.) less than length of head (0·022 m.), their length (0·002 m.) less than one-fourth the length of pectorals, placing this species in the first section of the genus as defined by Dr. Günther.

Radial formula: D, 92; A, 88; P, 15; V, 5. Color: Body above lateral line light grayish brown with numerous minute circular dots marking the position of the scales; below lateral line pearly white. Brown irregular patches upon the sides, bisected by the lateral line, the part lying below lateral line is of the dorsal hue, that above a darker shade of the same color, and exhibiting the white dots already described. These brown patches are seven to ten in number on each side, in some specimens regularly alternating with each other, in others approximating each other in such manner as almost to form broad irregular bands across the back. A spot of brown upon the tip of tail. Abdominal region livid blue In a very small specimen* the brown patches are for the most part circular and are not confluent over the back.

* 21,015 of the U. S. National Museum Catalogue.

Four of the six specimens taken had a lernean parasite on the gills.

This species is dedicated to Professor Addison E. Verrill, of Yale College, who has been in charge of the invertebrate work of the U. S. Fish Commission since its organization.

In addition to the above species a number of new or unusual forms have been taken or observed, among which may be specified the following:

Alutera cuspicauda Dekay. A specimen of this species which has not before been recorded north of Cape Cod, was taken in Halifax Harbor, September 6.

Euchalarodus Putnami Gill. Several specimens of this uncommon species, which had been taken in Salem harbor in winter, were found in the collection of the Peabody Academy of Sciences.

Myzopsetta ferruginea (Storer) Gill. Taken in Massachusetts Bay in forty-five to ninety fathoms; near La Have Bank in ninety fathoms; and at the mouth of Halifax Harbor in sixteen to eighteen fathoms.

Pleuronectes glaber (Storer) Gill. Several specimens, taken in Salem Harbor, Mass., were noted in the collection of the Peabody Academy.

Glyptocephalus cynoglossus (Linn.) Gill. This fish, the Craig Flounder or Pole of Europe is cited by British authors as one of the rarest of arctic flounders. It has hitherto been unknown to the coast of North America. At least one hundred specimens have been secured, representing great variety of form, age and other conditions. The species was first taken August 6, 1877, off Salem in forty-five fathoms. It has since been secured near La Have Bank in eighty-eight fathoms, and in Bedford Basin, Halifax, in from twenty-five to thirty-five fathoms.

Hippoglossoides platessoides (Fabr.) Gill. Taken on La Have Bank in eighty-eight fathoms. Heretofore recorded only from Greenland. It is not identical with *H. limandoides* as suggested by Dr. Günther.*

A species of the genus *Hippoglossoides* which is distinct from *H. platessoides* and may prove to be identical with the *H. limandoides* of Günther has been taken in company with *Glyptocephalu scynoglossus* in Bedford Basin, Halifax.

Rhinonemus caudacuta (Storer) Gill. Several specimens taken in Massachusetts Bay, and on La Have Bank.

Cryptocanthodes maculatus Storer. One specimen taken in Massachusetts Bay, August 13, 1877, in forty-eight fathoms.

Eumesogrammus subbifurcatus (Storer) Gill. A single specimen was taken August 25, 1877 in the mouth of Halifax Harbor in sixteen fathoms.

* Cat. Fish. Brit. Mus., iv, 1862, p. 405.

Stichœus punctatus (Fabr.) Reinh. A single specimen of brilliant scarlet color, was taken in the same locality with the preceding.

Eumicotremus spinosus (Fabr.) Gill. One specimen was dredged by the U. S. Fish Commission six miles off Half Way Rock, Salem, Mass., August 10, 1877, in thirty-five fathoms. "It is of very rare occurrence. Two specimens were dredged in 1861 by Professor Verrill, off Anticosti in ten fathoms, and another was taken by U. S. Fish Commission at Eastport, (Maine), in 1872." (*Putnam.*)

Aspidophoroides monopterygius (Bloch) Storer. Up to the time of the visit of the U. S. Fish Commission to Salem, this species has been very rarely taken south of Greenland, and that mainly from the stomachs of cod, haddock, halibut and other fishes. Several specimens were dredged by the Commission at Portland and Eastport, Maine. Many specimens were taken in Massachusetts Bay, often a dozen coming up in a single haul of the trawl.

Icelus uncinatus Reinhardt. Trawled in considerable numbers in Massachusetts Bay in forty-two to ninety fathoms. One or two were secured by the U. S. Fish Commission at Eastport, Maine, in 1872. No other specimens are known to have occurred on the coast of North America.

Triglops, sp. An undetermined member of this genus, has been taken in deep water in several localities.

Fistularia serrata Cuv. Specimens from Massachusetts Bay are in the museums of the Boston Society of Natural History and the Peabody Academy, Salem; also one from the Western Atlantic in the Colonial Museum at Halifax. Later writers have excluded this species from the fauna of North America, following the lead of Dr. Günther who gives its distribution as exclusively Indo-Pacific. A specimen taken by J. Matthew Jones, Esq., in Bermuda, was identified by Dr. Günther with *F. serrata.* This species must be restored to the faunal relations claimed for it by the earlier American authors, to whom Dr. Günther makes not the slightest reference in his synonymy.

Raia radiata Donovan. This species is well described by Fabricius under the name of *Raia fullonica.* Adults and young have been taken sparingly in Massachusetts Bay, on La Have Bank, in Halifax Harbor, and in Bedford Basin.

Canthorhinus occidentalis (Gthr.) Goode. A specimen of this fish, not before recorded north of Bermuda and Key West, was taken in the summer of 1875 at Linen Island near the entrance to Chesapeake Bay, and presented to the National Museum by Captain John Evans.

Hypeneus maculatus (Bloch) Cuvier. A specimen was taken at Wood's Holl, Mass., July, 1877, by Vinal N. Edwards. The species occurs in Bermuda, the West Indies, and on the coast of Brazil.

Chilichthys Spengleri (Bloch) Goode. A single individual was taken by Vinal N. Edwards at Wood's Holl, in August, 1877. A West Indian and Madeiran form.

Lactophrys trigonus (Linn.) Poey. Ten or twelve individuals were taken at Wood's Holl, 1877. The species has only once before (in 1833) been taken north of Florida.

ART. LI.—*Volumetric Determinations by Chromic Acid;* by C. W. HINMAN.

IN the early part of the year 1870, while a student at the Institute of Technology, Boston, I endeavored to devise a volumetric assay of lead ores, especially galena. The process first used was briefly this: The finely pulverized ore was decomposed by strong nitric acid and the resulting lead sulphate dissolved by ammonium acetate. The lead solution was then titrated by a standard solution of potassium bichromate, using silver nitrate as an indicator: reddish brown silver chromate being formed as soon as the lead was all precipitated. This process of titration was first given by H. Schwarz, (Dingl. polyt. Journ., clxix, 284). This method worked fairly well except that the reaction at the end was not sufficiently delicate. It has since been recommended by F. Maxwell Lyte (Chem. News, xxx, 293). While searching for a more delicate indicator I found that a drop of a mixture of starch paste, potassium iodide, and some acid would be turned blue by a very small quantity of bichromate; also by suspended lead chromate when the ordinary strong acids were used. But if the mixture was acidified by a solution of one part crystallized citric acid to six of water, lead chromate gave the blue color only after the lapse of some minutes, while bichromate gave it immediately. Quite a number of analyses of pure lead nitrate were made by one of the present professors and myself, using the indicator just described; and the results were quite satisfactory. On trying to use the method in titrating the solution of lead sulphate in ammonium acetate it was found that no blue coloration was produced until there was quite an excess of bichromate present. This was owing to the amount of ammonium salts present, but a number of other substances have the same effect. I then abandoned the process. Th. Rosenbladt (Jahresbericht f. Chemie, 1875) recommends a similar indicator for chromic acid in estimating the quantity of sulphuric acid in drinking water.

During the last few years I have had occasion to make a large number of determinations of the quantity of sulphur in coal gas, and have often wished for some process of determining sulphuric acid less tedious than the ordinary gravimetric one by barium sulphate and more accurate than the volumetric methods in ordinary use; and nearly a year ago I began some experiments to find such a method. Sulphuric acid can be determined by means of chromic acid, and the latter is reduced by quite a number of reagents. I had previously found a delicate test for chromic acid in the acid solution of starch paste and potassium iodide. It remained to be seen if the blue color disappeared as soon as the chromic acid was all reduced. I found that of the ordinary reducing agents only an acid solution of stannous chloride produced this result, even when a large excess of acid was present. I found that a given quantity of potassium bichromate and water always required the same quantity of stannous chloride, but the larger the quantity of water the more stannous chloride was required. This was accounted for on the supposition that the oxygen dissolved in the water was acted on before the chromic acid was all reduced. It was finally found desirable to boil the bichromate solution and cool it out of contact with the air; when this was done the quantity of water present made no difference in the amount of stannous chloride required. The following are the details of the process. The chromate is weighed or measured into a small flask which is then filled with water nearly to the neck. The flask is closed with a stopper through which passes a glass tube, at the end of which is a rubber valve opening outward. The contents of the flask are boiled for some minutes and then cooled; the valve preventing the access of air. A few centimeters of hydrochloric acid are added and then stannous chloride from a glass cock burette until the color is nearly pure green, but taking care to leave a little chromic acid unreduced. A few drops of a mixture of starch paste and potassium iodide added to the contents of the flask produces a dark blue color which is to be removed by the cautious addition of stannous chloride. The exact point is easy to hit as at last the color changes rapidly with a small addition of the chloride. The following determinations were made in this manner, a standard solution of potassium bichromate containing 14·761 grams per liter being used.

$K_2Cr_2O_7$	$SnCl_2$	Ratio.
25 cc. req.	19·26 cc.	·770½
13	10·04	·772
10	7·72	·772
10	7·73	·773
3	2·33	·777
3	2·32	·773
3	2·34	·780

Of course bodies like ferric and cupric salts that are reduced by stannous chloride must be absent and the solution must not be so concentrated that the green of the chromic chloride obscures the iodo-starch blue. Stannous chloride has had the reputation of changing rapidly on standing, but I have found it quite stable, when properly protected from the air, as the following results show:

March 9,	10 cc.	potassium	bichromate	required,	7·74	cc. stannous	chloride.
" 12,	"	"	"	"	7·72–3	"	"
April 16,	"	"	"	"	7·73–4	"	"
May 21,	"	"	"	"	7·74	"	"

The following determinations can be made by means of chromic acid. The chromates of lead, barium, and bismuth can be accurately precipitated, barium from an ammonical solution, the others from an acetic solution. The determination of lead is given as an example.

Twenty-five cc. of a solution of lead acetate, fifty cc. of which gave 0·5908 gram lead sulphate, were diluted with water and a little acetic acid, heated to boiling in a small beaker and 10 cc. standard bichromate solution added. The precipitate of lead chromate was filtered off after standing a few minutes, washed, and the excess of chromic acid determined in the filtrate. The quantity of stannous chloride required was 0·20 cc.; other experiments gave 0·21, 0.21, 0·20, and 0·20, by calculation from the amount of lead sulphate there should have been required 0·19 cc. being an error of one or two parts in about 750.

If a known quantity of bichromate is added to acid solutions of arsenious or antimonious acids they will be oxidized to arsenic and antimonic acids and the excess of chromic acid can then be determined. Twenty-five cc. of a solution of arsenious acid, containing 5·2675 grams per liter, plus 10 cc. standard bichromate solution, required 1·36, 1·35, 1·33, and 1·35 cc. of stannous chloride. If the arsenious acid had been pure only 1·22 cc. stannous chloride would have been required instead 1·35. In other words the arsenious acid contained about one and four-tenths per cent impurity. The only antimony compound I happened to have at hand was tartar emetic, but tartaric acid in that seemed to interfere with the reaction to a certain extent so that the results were not satisfactory.

Sulphuric acid can be determined as follows: To a slightly acid solution of a sulphate heated to boiling is added a small excess of a solution of barium chromate in hydrochloric acid, barium sulphate is precipitated; then the solution is neutralized with ammonia which precipitates the remaining barium chromate, the precipitates of barium sulphate and chromate are filtered off and the chromic acid determined in the filtrate is equivalent to the sulphuric acid in the original solution.

H_2SO_4 sol.	$SnCl_2$ sol.	Calculated.
3 cc. req.	1·87 cc.	1·85 cc.
5	3·10	3·08
10	6·16	6·15
25	15·38	15·37

Twenty-five cc. of the sulphuric acid solution gave 0·4633 grams barium sulphate.

Perhaps the oxygen in drinking water can be determined by means of the chromic acid method, but my experiments are as yet incomplete.

Having worked for some time with the method of estimating iron by means of stannous chloride, I am convinced that its importance is not yet recognized generally. The following modification seems to simplify the process as given in the last edition of Fresenius' analysis. To the iron solution which has just been decolorized by stannous chloride, add a small pipette full of iodine solution, equivalent to about one-fourth cubic centimeter of stannous chloride, cool, then add a little starch paste and stannous chloride until the color disappears. The equivalent in stannous chloride of the pipette of iodine solution substracted from the whole amount used leaves the quantity required by the iron. By this means the use of a second burette is avoided and less calculation is required.

Office of State Gas Inspection, 32 Hawley street, Boston.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Gases enclosed in Lignite.*—Thomas, in continuation of his researches upon the gases enclosed in coals, has examined with this view the lignites of Bovey Heathfield, Devonshire, and also a specimen of mineral resin, the "retinasphaltum" of Hatchett. A leafy lignite weighing 100 grams, on being kept in a Sprengel vacuum at 50° for twelve days, evolved 56·1 c.c. of gas, consisting of CO_2 87·25, O 0·24, CO 3·59 and N 8·92=100. It was then kept at 100° for eighteen days, and evolved 59·9 c.c. of gas, of which 89·53 was CO_2, 0·33 C_nH_{2n} gases, 5·11 CO and 5·03 N. At a higher temperature, decomposition set in, evolving H_2S and apparently allyl sulphide, mixed with the gaseous products. The gas evolved at 250° contained H_2S 5·85, CO_2 71·13, C_nH_{2n} 1·09, CO 16·20, CH_4 5·46, N 0·27=100. The mineral resin gave no gas at 50°, but at 100° yielded 21·4 c.c. of gas for each 100 grams of resin, consisting of CO_2 88·24, O 0·23, C_nH_{2n} gases 0·47, CO 7·90, N 3·16=100. On further heating the resin began to melt, and decomposition set in at 110° to 112°, the gases collected below 150° consisting of H_2S 0·41, CO_2 78·88, C_nH_{2n} gases

2·67, CO 7·82, CH_4 8·05, C_3H_8 1·86, nitrogen 0·31=100. Compared with the coals proper, lignites show therefore a marked difference in their gaseous contents, approaching most nearly, however, the cannels. But while the greater portion of the gas enclosed in both cannel and lignite consists of CO_2, the former contains the gases and other compounds of the paraffin series and the latter C_nH_{2n} gases as well as oily aromatic bodies and CO. Moreover lignites decompose much easier than coals.—*J. Chem. Soc.*, xxxii, 146, Aug., 1877. G. F. B.

2. *On the Reaction between Insoluble Carbonates and Soluble Oxalates.*—Watson Smith, observing that ammonia was evolved on mixing ammonium oxalate and chalk or marble powder, repeated the experiment with sodium oxalate, and obtained even in the cold a distinctly alkaline reaction. On heating the two substances together and then filtering, the filtrate effervesced on adding hydrochloric acid. This led to a series of experiments to determine the character and extent of this reaction, and to compare it with that of alkali carbonates upon the earthy oxalates. Regarding the possible Na_2CO_3 formed when the decomposition is complete as 100, calcium carbonate treated with sodium oxalate gave 19·83 Na_2CO_3 in the cold and 22·90 when heated; strontium carbonate gave 7·63 in both cases; barium carbonate gave 4·84 and 4·98; and lead carbonate 6·35 and 13·08. Conversely, if 100 represent the possible Na_2CO_3 converted into oxalate, calcium oxalate converted 16·07 in the cold and 52·34 when heated; strontium oxalate 57·24 and 79·96; barium oxalate 73·20 and 87·96; and lead oxalate 81·54 and 90·61. In the cold, calcium carbonate is as much more acted on by sodium oxalate than is barium carbonate, as barium oxalate is by sodium carbonate more than calcium oxalate. In the case of soluble oxalates, the reaction does not appear to be facilitated materially by heat.—*J. Chem. Soc.*, xxxii, 245, Sept., 1877. G. F. B.

3. *On the new Metal Davyum.*—In the month of June last, Sergius Kern succeeded in isolating a new metal belonging to the platinum group, to which he gave the name Davyum, in honor of Sir Humphrey Davy. To prepare it, 600 grams of the platiniferous sand were treated by Bunsen's method for the separation of the platinum, iridium, rhodium, osmium, palladium, ruthenium, iron and copper which it contained. The mother liquors after the separation of the rhodium and the iridium were heated with an excess of chloride and nitrate of ammonium. A dark red precipitate was obtained, which, calcined at a red heat, gave a grayish mass resembling platinum sponge; and this, fused by the oxyhydrogen flame, gave a silver white ingot weighing 0·27 gram, and having a density of 9·385 at 25° C. The metal is hard and malleable at a red heat; it is easily attacked by aqua regia and feebly by boiling sulphuric acid. Potassium hydrate precipitates its solutions yellow. Hydrogen sulphide gives a brown precipitate in solutions of davyum chloride, which changes to black on drying. Potassium sulphocyanide colors this solution red, like

ferric salts, when dilute, and gives a red precipitate when concentrated. In Mendelejeff's classification, the author thinks davyum is the hypothetical element placed between molybdenum and ruthenium.

In a subsequent paper, Kern gives the reactions of the new metal obtained by dissolving his ingot in aqua regia. The yellow hydrate is readily soluble in acids, even in acetic. The nitrate appears as a brown mass, which on calcination gives a black monoxide. Dissolved in potassium cyanide, davyum chloride gives beautiful crystals of a double cyanide. Cyanodavic acid is very unstable. The sulphide is soluble in alkali sulphides, giving sulphosalts. The sulphocyanide crystallizes in large crystals, and becomes black on heating. The chloride is soluble in water, alcohol and ether, and its crystals are not deliquescent. It forms double chlorides easily, that with sodium being almost insoluble in water and alcohol. No second chloride is known. New determinations give the density 9·389. Its atomic weight has not yet been determined, but it is probably between 150 and 154.—*C. R.*, lxxxv, 72, 623, July, Oct., 1877. G. F. B.

4. *Upon Metalacetyl-acetic ethers.*—CONRAD has extended the law that negative radicals are found in a molecule in the vicinity of negative groups, by supposing that the energy of the carbon is so raised by the presence of negative radicals, that the hydrogen combined with it may be replaced by positive atoms. In proof of this he shows that a salt obtained by Geuther and supposed by him to have its metal atoms united to the carbon by oxygen, has them in fact united directly to the carbon. In the case of copper-acetyl-acetic ether, prepared by the action of an ammoniacal solution of copper sulphate on acetylacetic ether, the author establishes the formula as

$$\begin{array}{ccc} CH_3CO\text{–}CH & \text{—Cu—} & CH\text{–}COCH_3 \\ | & & | \\ COOC_2H_5 & & COOC_2H_5 \end{array}$$

, in which the carbon atoms of the two groups are linked directly by copper. Nickel, cobalt, magnesium, aluminum and mercury compounds were also prepared.—*Liebig's Ann.*, clxxxviii, 269, Aug., 1877. G. F. B.

5. *On Phyllic acid, extracted from leaves.*—BOUGAREL has succeeded in isolating from the leaves of the cherry-laurel, a new acid to which he gives the name phyllic acid. The leaves are extracted with boiling alcohol, the extract left on distilling off the alcohol, is treated with ether, the solution is clarified with animal charcoal, the ether distilled off, and the amorphous grains dissolved in dilute potash solution and several times crystallized. On re-dissolving and adding an acid, phyllic acid is precipitated as a resinous mass. It is soluble in alcohol, ether, chloroform, CS_2, essential oils and fats, but insoluble in water. Several times precipitated from ether, it forms a fine powder without odor or taste, having a density of 1·014, rotating in alcoholic solution, $\alpha_j = +28$, melting at 170°, and decomposing at 200°. Analysis of the potassium salt fixed the molecular weight at 624; and ultimate analysis, conse-

quently, the formula $C_{72}H_{64}O_{16}$, which the author regards as provisional only. The sodium and ammonium salts are well crystallized. The acid has also been obtained from the leaves of the quince, apple, peach, almond, sycamore, lilac and jaborandi.—*Bull. Soc. Ch.*, II, xxvii, 148, Sept., 1877. G. F. B.

6. *On the Constitution of Euxanthon.*—SALZMANN and WICHELHAUS have experimented to determine the constitution of euxanthon, prepared from euxanthic acid (which exists in the form of magnesium salt in the yellow coloring matter called purree or indian yellow) by solution in concentrated sulphuric acid and precipitation by water. It has the composition $C_{13}H_8O_4$. Its vapor passed over zinc powder in a current of hydrogen gave the product $C_{13}H_8O$. This, oxidized with nitric acid or permanganate gave $C_{13}H_8O_2$; treated with fuming nitric acid, gave a nitro-product $C_{13}H_6(NO_2)_2O_2$; and suspended in water containing bromine formed two bromine derivatives $C_{13}H_2Br_6O$ and $C_{13}HBr_7O$; euxanthon itself heated with acetyl chloride to 100° gave diacetyl-euxanthon, $C_{13}H_6(C_2H_3O)_2O_4$. From these reactions, taken in connection with the fact that Baeyer obtained a hydroquinone-like body on reduction with sodium amalgam, the author regards euxanthon as a carbonein of hydroquinone $CO\begin{matrix}C_6H_3\diagdown OH \\ \quad > O \\ C_6H_3\diagup OH\end{matrix}$, the reduction product with zinc being carbodiphenylene $CO\begin{matrix}C_6H_4 \\ C_6H_4\end{matrix}>$, giving on oxidation carbodiphenylene oxide $CO\begin{matrix}C_6H_4 \\ C_6H_4\end{matrix}>O$.—*Ber. Berl. Chem. Ges.*, x, 1397, Oct., 1877. G. F. B.

7. *Density of Vapors.*—One of the most important of the recent additions to chemical methods is that of Victor Meyer for determining the density of the vapor of substances which have a high boiling point. As in the method of Gay-Lussac or in the modification of that method as employed by Hoffman, a given weight of the substance used is converted completely into vapor and the volume of this vapor measured under determinate conditions. An amount of the substance not exceeding seven or eight centigrams but varying naturally with the density of the vapor to be determined is weighed out in a small glass tube of such size and shape that it can easily be passed through the curved neck into a glass bulb holding about twenty-five cubic centimeters. The glass tube at the end of which the bulb is blown is bent into a U shape and cut off so that its open mouth is on a level with a capillary opening on the top of the bulb, and the little apparatus is suspended by a wire holder so that these openings are always uppermost. The glass having been weighed to decigrams and the material introduced, the interior is filled at 100° C. with Wood's fusible alloy which melts at 70° C., the capillary opening at the top of the bulb allowing the air to escape while the melted metal is poured in through the open mouth. As soon as the bulb is filled this capillary opening is closed by a blow-pipe; and as soon as, after exposure in a steam bath, the excess of metal has overflowed, the

apparatus is wiped and again weighed, but as before, only to decigrams. The apparatus is now immersed in the vapor of boiling sulphur, which, according to the experiments of Regnault has a constant temperature of 442·2° when the barometer stands at 723·5 mm.* The substance passes into vapor and a considerable portion of the alloy overflows and the tension of the vapor thus formed is evidently measured by the height of the barometer column at the time, plus the equivalent in mercury of the height of the column of melted metal which fills the neck of the apparatus above the level of the metal in the bulb. The last is easily measured with a millimeter scale if at the instant of lifting the apparatus from the sulphur bath the level of the metal is marked on the bulb, which may be easily done with melted sealing wax, using a heated glass rod as a pen. When now the apparatus has partially cooled and the adhering particles of metal have been removed, it is weighed for the third time and from the three weights we easily ascertain what quantity of metal has overflowed in the sulphur bath. This amount is obviously a measure of the volume of the vapor formed. It is not, however, a direct measure, for the overflow is caused not only by the formation of the vapor, but also by the expansion of the alloy, while, on the other hand, it is diminished by the expansion of the glass. Before, therefore, the data thus obtained could be used in calculating the density of a vapor it was necessary to determine the density of the alloy at the boiling point of sulphur, also the apparent expansion of the alloy in the ordinary German glass when heated from 100° to the same temperature. This Victor Meyer has done, and according to his determinations the apparent expansion of the alloy was, on the average, 0·036, and at 444° one gram had the volume of 0·1092 c. c., so that its density was about two-thirds of that of mercury. From these values he deduces the following formula for the calculation of the vapor density from such observations as we have described:

$$\text{Density (referred to air as unity)} = \frac{w\ 14146000\dagger}{(W - 0{\cdot}036\ W')(H + \frac{2}{3}h)};$$

* This is the mean height of the barometer at Zurich where Meyer's determinations were made. At the mean level of the sea with the mean height 760 mm. the boiling point is more nearly 447·7°.

† At the sea level when the barometer stands at 760 mm. this constant becomes 14216000. Either value is easily deduced.

The amount of substance taken gives at 444·2° a definite volume of vapor at a measured tension. Let that volume in cubic centimeters be represented by v and the tension in millimeters by H′. The density of the vapor is equal to its weight divided by the weight of the same volume of air at the same temperature and tension, or $\delta = \frac{w}{w'}$ and as is well known,

$$w' = 0{\cdot}001293\ \frac{1}{(v1 + 0{\cdot}003665 \cdot 444^{\circ}{\cdot}2)} - \frac{H'}{760}.$$

But in the process we are considering the volume of the vapor is evidently equal to the volume of the overflow at 444·2° less that of the overflow which would have resulted from the expansion of the metal and glass alone, or V = 0·1092 (W − 0·036 W′) and as we have seen, $H' = H + \frac{2}{3}h$. Making now the substitutions and combining the numerical values we obtain the expression given above.

here w is the weight of the substance used, W′ the weight of alloy which filled the bulb at 100°, and W the weight which overflowed in the sulphur bath; also H the height of the barometer and h the difference of level of the alloy in the bulb and neck of the apparatus at the moment it was withdrawn from the bath.

Wood's fusible alloy is exceedingly well adapted to the use to which it has been so beautifully applied by Victor Meyer. As prepared and sold by Dr. Schuchardt of Görlitz it appears to have a very constant composition and equally constant physical qualities. Moreover, it is but slightly acted on by boiling sulphur and can readily be recovered from the sulphur bath into which it overflows. It can then be easily cleaned and used over again repeatedly. But for these and other details we would refer to the very full description of the process which has recently appeared in Fresenius' Zeitschrift für Analytische Chemie, xvi, 482. Of course the method has a limited application and can not be used with any substance which would act chemically upon the alloy. Still it has already very considerably extended our knowledge of the vapor densities of the less volatile organic products, and for such substances it is both more easy of application and more accurate than the only comparable method, that of Dumas as modified by Deville and Troost. We add two examples for illustrations.

Anthrachinon.

Substance used	w	= 0·0652 grm.	
Metal used	W′	= 264·4	"
" which overflowed	W	= 179·6	"
Barometer height	H	= 728·5 mm.	
Difference of level	h	= 33·	"
Resulting density		7·22	
Theory for $C_{14}H_8O_2$		7·19	
Found by Gräbe with the process of Deville and Troost		7·35	

Paradibrombenzol.

Substance used	w	= 0·0772 grm.	
Metal used	W′	= 261·5	"
" which overflowed	W	= 187·4	"
Barometer height	H	= 728·5 mm.	
Difference of level		38	"
Resulting density		8·14	
Theory for $C_6H_4Br_2$		8·15	

J. P. C., JR.

8. *New Results in Physics.*—(1.) A. F. Berggren concludes that the chlorides of the alkalies and alkaline earths possess greater electrical conducting power than the soluble sulphates of the same bases.—*Ann. der Physik und Chemie*, new series, vol. i, p. 499.

(2.) Silow has undertaken an investigation of weak magnetic substances. His method consists in observing the deviation of an astatic system of needles, produced by appending to it a cylindrical vessel containing the magnetic substance under consideration. He discusses the method by the aid of the theory of potentials and obtains for an aqueous solution of chloride of iron of density 1·475 a magnetizing constant of $K = 0{\cdot}0000815$.—*Ib.*, p. 481.

(3.) HANKEL discusses the results of previous experiments upon the electrical effect of light rays upon metal plates, immersed in fluids, and adds some experiments of his own which show that the difference of potential of certain metal plates immersed in fluids is sensibly altered by light; and that in certain cases this effect is opposite to that caused by the heat rays.—*Ib.*, p. 402.

(4.) CLAUSIUS shows that if there are a number of conducting bodies C_1, C_2, C_3, etc. which influence each other and if these bodies are first charged with the quantities of electricities Q_1, Q_2, Q_3 etc. giving the potentials V_1, V_2, V_3 etc., and afterwards charged with the quantities $\mathfrak{Q}_1$, $\mathfrak{Q}_2$, $\mathfrak{Q}_3$; with the potentials $\mathfrak{B}_1$, $\mathfrak{B}_2$, $\mathfrak{B}_3$; the equation $\Sigma V\mathfrak{Q} = \Sigma \mathfrak{B}Q$ results.—*Ib.*, p. 493.

(5.) HERMAN HERWIG collects the facts in regard to the different mechanical actions of positive and negative electrical poles; joins to these some observations of his own in regard to the behavior of flames placed between their poles, and discusses the generality of these phenomena together with their bearing upon the two-fluid theory of electricity.—*Ib.*, p. 516.

(6.) According to an investigation of W. von MUNCHHAUSEN carried on in the laboratory of A. Wullner, the specific heat of water at $t°$ is represented by the expression $K = 1 + 0{\cdot}000302t$.—*Ib.*, p. 592. J. T.

II. GEOLOGY AND MINERALOGY.

1. *China*, by FERDINAND FREIHERRN VON RICHTHOFEN. 1st vol. Introductory Part. 758 pp. roy. 8vo, with 11 charts (several colored), and 29 wood cuts. Berlin, 1877.*—Baron von Richthofen left Europe on his first visit to China in 1860, under the auspices of the Prussian Government. Only a few prominent points in China were visited, the interior of the country not being then accessible, owing to the Taiping rebellion. He also went to Siam, Formosa, the Philippines, Celebes and Java. Japan was not at the time open to foreigners.

The year 1867 and part of 1868 were spent in California, in connection with the Geological Survey of that State under J. D. Whitney; and a volume treating learnedly of the Natural System of volcanic rocks, and describing those of Western North America was one result of his labors.

In July, 1868, he left for a second visit to China. He was there the larger part of four years, and made seven long journeys over the country, and among the islands and peninsulas of the coast. He visited many of the Provinces, reaching, at his farthest point

* *China.* Ergebnisse eigener Reisen und darauf gegründeter Studien; von FERDINAND FREIHERRN VON RICHTHOFEN. Erster Band. Einleitender Theil. Berlin, 1877. (Verlag von Dietrich Reimer.)

west, the center of the Province of Sz-tschwan, over 900 miles west of Shanghai, and to the north, the borders of Mongolia, northwest of Pekin. During a portion of the years 1870, 1871 (from August, 1870, to the spring of 1871), he was in Japan.

The work, of which the 1st volume, out of the four to be published, has recently been issued, will embrace the results of his observations and studies with reference to the topography of China, its geography, climate, density of population in different parts of its history, its productions and their mercantile importance, its geology, paleontology, etc. Besides the account of China, the work will contain a sketch of the author's observations also in Japan, Formosa, Manilla, Java and Siam; and, in conclusion, a discussion of some problems connected with the earth's general features and history, as illustrated by the special facts observed.

The fourth volume, on the Paleontology, will be prepared by prominent specialists, among them, Dr. Kayser of Berlin, Prof. Schenk of Leipzic and Dr. Schwager of Munich. There will also be an atlas of forty-four charts, besides numerous cuts and maps in the text. The atlas will contain twenty-eight special charts on the scale of 1 : 750,000; a general chart of China, on that of 1 : 3,000,000; and other charts to illustrate the geology, geography of products, density and movements of population, etc., in China; also, a general chart and several special charts of Japan. The volume issued is princely in its style of publication; and it manifests, besides, that the work will be thorough in its discussion of the subjects taken up.

The first volume commences with a survey of the general topography of China and Central Asia. It next treats of the löss-formation of Northern China—its features, structure and origin, and its relations to the salt steppes of Central Asia and the löss-deposits of other countries. The mountain-systems of Central Asia are then described, and with this subject Part I closes. Part II consists of a history of geographical knowledge with regard to China, and treats of ancient Chinese geographies and charts, Chinese geographical learning, and the development, during the different periods of Chinese history, of the intercourse of the people with the people of Southern and Western Asia, and, after the arrival of the Portuguese, in 1817, with the nations of Europe.

The account of the *löss-formation of Northern China* is of special interest, because of its wide distribution and its connection with the social condition and welfare of the people. Baron von Richthofen observes that west of the alluvial plain of the sea-border —which plain in the vicinity of Pekin extends 175 English miles west from the Petschili gulf—there is a terrace of löss thirty to eighty meters in height. Continuing west, there is, next, a mountainous region on the east border of the Province of Shansi, and then succeeds a plateau largely covered with löss, which is 600 to 1,000 meters above the sea-level. Again, farther west, after passing a mountain range, there is a second plateau, 1,500 to 1,800 meters above the sea-level, which is covered in great part with löss. The river Fönn-ho (a stream flowing southward into the Hoang-ho, through the center of the Province of Shansi), occupies a deep channel cut through it along its western border. West of this plateau there is another mountainous region, in which flows north and south, for 300 miles, the Hoang-ho or Yellow River. Beyond, through the Provinces of Shensi and Kansu, the löss is widely spread; and, on the authority of the missionaries and the Chinese, it continues in the valleys to the most western sources of the affluents of the Hoang-ho, over 900 miles from the coast. The löss spreads northward along the plains or valleys into Mongolia. Southward, it occupies basins in the broad valley of the Wei, the largest tributary of the Hoang-ho; and it also occurs in the valley of the Han. It is found also farther east over parts of the low near Nanking, Tung-ting Lake, and Po-yang Lake, which are its lands of Honan and Shantung. South of Honan it exists in isolated areas along parts of the valley of the Yang-tsze River, as extreme southern positions. Its greatest areas are in the region of the Hoang-ho and its tributaries, in some portions of which it has a thickness of several hundred feet—even 2,000 to 2,500, according to Baron von Richthofen.

The material of the löss, like that along the Rhine, is a brownish-yellow earth (whence the name "Yellow River," given to the Hoang-ho), very porous, exceedingly fine in grain, and friable when dry; and affording on chemical analysis, more or less carbonate of lime. It often contains, at different levels, calcareous concretions (Löss-männchen); and also in some places the shells of land-snails and bones of terrestrial mammals, but never, according to the author, shells of fresh-water snails. Vegetable remains also occur in it. From top to bottom it is penetrated by very small tubular passages, which are like those that are now in many places left by the rootlets of grasses and other small plants, after their decay; and these are set down as evidence that the whole mass of the löss has been successively penetrated by the rootlets of growing plants. The löss deposits have very generally, as on the Rhine, a vertical cleavage structure leading to its becoming eroded vertically, and is without the thin horizontal lamination or planes of bedding of ordinary alluvium. There are often, however, at intervals usually of more than fifty feet (but varying from a few feet to more than a hundred), horizontal divisional planes which are usually connected with planes of concretions. In consequence of these structural peculiarities, the löss fronts the valleys with high vertical walls, in which are occasional horizontal terrace-like shelves. It becomes reduced by intersecting streams or streamlets, and the rills from the heavy rains, to regions of deep and narrow labyrinthine passage-ways, groups of lofty obelisks, castles, clustered towers. Instructive views of its scenery are given in the volume.

Baron von Richthofen discusses the theories as to the origin of the löss, and adopts that which he had advocated in his memoirs on the Provinces of Honan and Shansi, published at Shanghai in 1870. He objects, with reason, to the theory of marine submergence, advocated by T. W. Kingsmill, Esq., in the Quarterly Journal of the Geological Society for 1871 (p. 376,) on the ground that the shells, bones and vegetation are all terrestrial; that there are no marine relics of any kind in the deposits; and states that it would require an oscillation of level of several thousand feet, which would give a chance for the introduction over the area of China, within comparatively recent times, of all kinds of marine life. He rejects also the view that the löss is of freshwater origin deposited from the waters of vast lakes that formerly covered a large part of the country—the opinion brought out by Raphael Pumpelly in his valuable "Geological Researches in China, Mongolia and Japan," published in 1866;* urging that the shells are not transported shells, but instead occur where they were left by their animals; that there are no freshwater species; that the indications of vegetation (mentioned above) are so extensively distributed through the löss, that the plants must have grown abundantly over its surface as the accumulation went forward instead of being a deposit by transporting waters; that the bones of mammals indicate also that they have not been transported. He says also that there is no evidence of glacial origin, no moraines or other marks of glaciers having been observed in any part of the country.

Baron von Richthofen holds that the löss formation is a subaerial accumulation, due to the drifting action of the winds; to transportation by rivulets from the hills immediately adjoining each löss basin; and to the mineral material left over the basin by the growing grasses and other plants. The first and the last of these causes are made the most effectual. The degradation of the rocks of the neighboring hills by decomposition and alternate changes of temperature, produces the loose grains for transportation. The plants covering the great plains served to stop the wind-drifted earth, and so keep the accumulation ever in progress. He observes that the true löss is made over a dry surface and he calls it *land-löss.* But the löss basins have generally had a lake at center; and about the lake the deposit is thin-laminated or stratified; and

* Mr. Pumpelly's Memoir was published in a quarto of 144 pages, with maps, by the Smithsonian Institution, as No. 202 of the Smithsonian Contributions to Knowledge, Washington, D. C., October, 1866. The author visited the region northwest of Pekin on the borders of Mongolia. His descriptions of the features of the löss regions are like those of von Richthofen. He says, after alluding to its vertical cleavage: "The country is often cut up by gullies thirty to seventy feet deep, and from ten to twenty feet wide, with vertical walls. In these channels wagon-roads run for many miles without rising to the plain. In the valley between the Kwantung (pu) and the Yangkau defile, I crossed a gully forty or fifty feet deep and not more than four feet wide, having the same breadth all the way down, and following, with these dimensions, a tortuous course for more than a mile." "Wherever a cliff of this deposit presents itself, the beginning of this action is visible. The surface drainage of a small neighboring area of the plain being concentrated toward one point on the edge of the cliff, cuts, in its fall, a channel from top to bottom, and this with each succeeding rain works its way backward toward the mountain. As the erosion progresses, the sides of the gullies offer new starting points for tributary ravines."

this he calls *lake-löss.* The lakes had formerly greater width than now; and in the valley of the Wei where the true löss is extensive, he has seen it overlying the laminated lake-löss. About the dried-up basins, under the present dry climate, salt efflorescences are common.

From all the facts he concludes that the löss-basins were originally sites of salt lakes; that the land had less height in the interior to the northward than now, as shown by the succession of löss basins going west, and that the basins had consequently very great extent; that the climate was so dry that the evaporation exceeded the fall of water, and consequently the streams were very feeble, or dried up, and that this was another occasion for great undrained basins; that the true löss was formed about the dry borders of the basins by the methods above mentioned, and gradually spread inward covering the lake-löss as the water of the basin diminished, so giving the upper surface of the deposit a slight pitch inward, which feature he states (as also Pumpelly) is common; that the condition of Northern China, at the time, was much like the present state of the salt-steppes of Central Asia; and that the löss-making era was brought to an end by a change of climate in which great rains changed the rivers to floods, which led to their cutting channels through the basins and opening up the present system of drainage. Thus the Hoang-ho came into its modern existence. The reference to a less height formerly over the interior than now would seem to imply that this drainage result was promoted also by an elevation to the present level. The löss where it adjoins the hills often contains alternating beds of pebbles and earth; and this is attributed to rivulets from these hills. The salt-steppes of Central Asia are particularly described in order to illustrate the views advanced.

Mr. T. W. Kingsmill's article, referred to above, was written as a criticism of Baron von Richthofen's views; and it is of interest here to have his arguments. The most important are these: that the disintegration going on over the hills is a very inadequate source of material for such great and thick deposits, and the winds an insufficient means of transportation; that the plants could furnish to the mineral accumulations only what they took from it, and hence would add nothing; that the löss is so easy of removal that, if terrestrial in origin, it would have been more or less carried off, and hence so thick accumulations could not have been made. Mr. Pumpelly's memoir appeared in advance of Baron von Richthofen's. He argues (from facts observed northwest of Pekin and about Kalgan) for the freshwater and lacustrine origin of the löss from the presence of shells in the deposits (at Té Hai); from the uniform constitution and fineness of the löss, this "proving that it has not come from what were the neighboring shores, but that it was brought into the lakes by one or more large rivers, which must have drained an area of great extent." J. D. D.

2. *International Geological Congress.*—The number of this Journal for December of 1876 contains the announcement of the

appointment of a Committee, by the American Association for the Advancement of Science, to take action with reference to holding an International Geological Congress at Paris, during the Paris Exposition of 1878; and also the resolution adopted, and a statement of the objects to be accomplished; the facts being derived from a Circular issued by the Committee, of which Prof. James Hall is Chairman.

At the recent meeting of the Association, at Nashville, a report on the subject was presented by the Secretary of the Committee, Dr. T. Sterry Hunt. According to it, the circular was sent to learned societies over the world, and has everywhere called forth gratifying responses. The Geological Society of France has expressed its hearty coöperation; and English, Russian, Swedish, Norwegian, Austrian, Spanish and Italian geological societies and geologists have given their approbation, and assurances that they will further the objects of the Congress. Prof. Capellini has, in this connection, called attention to the fact that in 1874 he laid the project of a similar International Geological Congress, to be held in Italy, before the Italian Minister of Agriculture, Industry and Commerce. Germany has declined to take any part in the French International Exhibition, but this may not prevent her geologists from joining in the proposed Congress. The precise date of the Congress has not yet been fixed. The Secretary of the Committee is now in correspondence with the Secretary of the Geological Society of France upon this point, and believes that a time convenient to all will be agreed upon.

The Report also embodied a resolution of the Standing Committee of the Association recommending that the Presidents, for the time being, of the Geological Societies of France, London, Edinburgh, Dublin, Berlin, Belgium, Italy, Spain, Portugal, and the Imperial Geological Institute of Vienna, be invited to form part of the Commission.

After the presentation of the report to the American Association, the Secretary received official notice that the Geological Society of France, had, in coöperation with the above plan, appointed in Paris a local committee of organization for the proposed Congress, constituted as follows: HÉBERT, President; TOURNOUER and ALBERT GAUDRY, Vice-presidents; BIOCHE, Treasurer; JANNETAZ, Secretary-general; DELAIRE, SAUVAGE, BROCCHI and VÉLAIN, Secretaries; with the following: BELGRAND BUREAU, DE CHANCOURTOIS, G. COTTEAU, DAMOUR, DAUBRÉE, DELAFOSSE, DELESSE, DESCLOIZEAUX, DESNOYERS, FOUQUÉ, GERVAIS, GRUNER, DE LAPPARENT, MALLARD, MILNE-EDWARDS, PELLAT, MARQUIS DE ROYS and L. VAILLANT, members of the Committee.

A circular issued by this Committee, bearing date July 31, invites all those interested in geological, mineralogical and paleontological studies, to take part in the approaching Congress, and to subscribe the sum of *twelve francs* each, which will give a card of admission to the Congress, and right to all the publications thereof. All those who intend to be present are at the same time invited to send, as soon as possible, a list of the questions which seem to them worthy of general discussion, as well as of the communications which they intend to make touching these questions. They are also invited to indicate what time appears to them most convenient for the meeting of the Congress.

As regards an International Geological Exhibition, the Paris Committee of organization state that the difficulty of finding a suitable locality seems to them an obstacle in the way of realizing this part of the programme. They hope however that there will be many special collections sent, and beg the exhibitors of such to give the committee due notice of these, in order that a special catalogue of them may be prepared.

The circular issued by the Committee of the American Association did not contemplate, as Dr. Hunt states, the holding of an International Geological Exhibition apart from the Universal Exhibition, but, in the language of that circular, *the making as complete as possible the geological department* of the Universal Exhibition. It is certain that, as at all previous similar exhibitions, the different nations will contribute more or less of geological material; and it was conceived that such collections, extended and systematized in accordance with the plan set forth in the circular, would, while forming a part of the Universal Exhibition, without farther cost meet all the requirements of an International Geological Exhibition. To the accomplishment of this end it will only be necessary for the exhibitors of all nations to send a list of their geological contributions to the local Committee of organization at Paris.

All correspondence relating to the Congress should be addressed to Dr. Jannetaz, Sécretaire-général, Rue des Grands Augustins, 7, Paris, France, and all moneys sent to Dr. Bioche at the same address.

3. *Palæontology of New York. Illustrations of Devonian Fossils: Gasteropoda, Pteropoda, Cephalopoda, Crustacea and Corals, of the Upper Helderberg, Hamilton and Chemung Groups;* by JAMES HALL. Over 140 quarto plates. Albany, 1876. Published in advance of the Palæontology of New York, by authority of the Legislature of the State of New York.—Volume IV of Professor Hall's great work on the Paleontology of New York was published in 1867, and contained descriptions and figures of the fossil Brachiopods of the Upper Helderberg, Hamilton, Portage and Chemung groups, illustrated by about seventy plates. Since its publication, as the Preface to this new volume states, the drawings for the plates of the remaining part of the Devonian fossils have been going forward, while, through duties connected with the care of the Museum, in connection with impaired health, the descriptions still remain incomplete. In 1875, *eighty* plates of the Lamellibranchs had been drawn and lithographed, and the drawings of the greater part of the Gasteropods, Pteropods, Cephalopods and Crustacea, now issued in this new volume, had

been finished, while those of the Corals were in progress. During that year the Legislature of the State authorized the publication, by the albertype process, of a hundred copies of each of one hundred of the plates, and, the following year, of thirty additional plates. Through this means the new volume of plates, with the explanatory pages of text, has been issued. All the plates it contains were photographed from excellent original drawings, excepting part of those of the Corals which are direct from the specimens. The most of the drawings were made under the supervision of Mr. R. P. Whitfield, and many of those of the Gasteropoda and Cephalopoda with his aid.

The plates form a beautiful volume, and, with the explanations accompanying each, they constitute a work which will be of great immediate service to the science even without the promised volume of text. The albertypes, by E. Bierstadt, are admirable, and those direct from the specimens of corals are unusually fine. In preparing the explanations of the plates of Corals, Dr. Rominger, whose labors and publications in connection with the Michigan Geolological Survey have made him an authority in that department, was conferred with, in order to avoid any duplication of species.

Professor Hall states that to complete the Devonian Cephalopoda, the number of plates—here forty—will have to be doubled, the plates of the Crustacea will need some additions, and those of the Corals, here over forty, will have to be greatly increased in number. Prof. Hall's labors have been of vast service to American Paleontology, and of great honor to the State under whose auspices his Reports have been published, and it is to be hoped that they will not be brought to a close before every fossil species of the New York rocks has been illustrated and described.

4. *Twenty-eighth Annual Report of the New York State Museum of Natural History, by the Regents of the University of the State of New York.* 100 pages, 8vo, with 34 plates. Transmitted to the Legislature, March 30, 1875. Albany, 1875.—This Report, whose contents are mentioned on page 432, is one of special paleontological value. The chief article is by Prof. Hall, and consists of plates and their explanations illustrating "the fauna of the Niagara Group in Central Indiana." The number of plates is thirty-two. The figures include species of fossil Sponges, Corals, Crinoids, Bryozoans, Brachiopods, Gasteropods and Trilobites, many among them new.

The first two plates illustrate new species of Fungi, described by the State Botanist, C. H. Peck. The new Trenton fossils described by C. D. Walcott are of the genera *Conularia*, *Conchopeltis* (new patelliform shell), *Bathyurus* and *Asaphus*.

5. *Notes on some new sections of Trilobites from the Trenton Limestone and descriptions of new species of fossils*, by C. D. Walcott. 22 pp. 8vo, with one plate. Published in advance of the Rep. N. Y. State Museum, Sept. 20, 1877.—In this paper Mr. Walcott gives an account of the discovery of articulated append-

ages connected with the mouth of Trilobites, derived from sections of Trenton specimens of *Calymene senaria*, *Ceraurus pleurexanthemus* and *Aciduspis Trentonensis.* Only two sections are figured and their precise position across the head is not stated. More sections are needed before the facts observed can be satisfactorily interpreted.

Mr. Walcott has also observed in sections of the body of a *Ceraurus pleurexanthemus* what he regards as remains of the ova of the animal, similar to those described by Barrande as occurring in *Barrandia crassa.* The space between the dorsal shell and the ventral membrane, and the cavity of the head in part, were found to be filled with the ovoidal bodies, over 200 of which were counted in one section. The diameters were one-quarter and one-half of a millimeter. The eggs of Crustaceans are so destructible that the question naturally arises whether the ovoidal bodies are not of concretionary origin.

6. *Large Bowlders in New Hampshire.*—One of the largest of bowlders has been recently found by Governor Prescott upon the land of E. H. Chase in the west edge of Nottingham, New Hampshire, at the base of Pawtuccaway Mountain. It measures 62 feet long, 40 wide and is at least 50 feet high. The cubic contents are about 70,000 feet, giving for the weight nearly 6,000 tons. Close by this are two others, each including nearly 50,000 cubic feet; and within the distance of one-fourth of a mile are nine more of about the same size.

The largest bowlder in Vermont is called the Green Mountain Giant, lying on a hill in Whitingham; it contains 40,000 cubic feet.—*Daily Monitor, Concord, New Hampshire*, Oct. 15.

7. *Application of Organic Acids to the Examination of Minerals;* by H. Carrington Bolton, Ph.D. 36 pp. 8vo, with one plate. New York Acad. Sci., i, 1877.—Professor Bolton presents in this memoir the results of a long investigation with regard to the action of citric, tartaric, and oxalic acids on minerals, and their use in the determination of species; and also of a few trials with malic, formic, acetic, benzoic, pyrogallic, and picric acids. The minerals were subjected to the acids in powder, the solid acids having been made into saturated solutions.

From a table in the concluding part of the memoir, we take the following reactions of citric acid. CO_2 is given off when the cold acid acts on the mineral carbonates, excepting magnesite and siderite which require heat. CO_2 is also given off, when acting with the hot acid on wad, hausmannite, manganite, and psilomelane. H_2S is liberated when acting with the cold acid on stibnite, galenite, sphalerite, pyrrhotite, and, with the hot acid on bornite and bournonite as well as the preceding. A jelly is formed when the hot acid acts on willemite, datolite, pectolite, calamine, natrolite; and non-gelatinous silica, when the same acts on wollastonite, chrysolite, chondrodite, chrysocolla, prehnite, apophyllite, rhodonite, analcite, chabazite, stilbite, serpentine, retinalite, deweylite. The following minerals are decomposed by boiling with citric acid and KNO_3: argentite, chalcocite, pyrite, marcasite, niccolite, smaltite, chalcopyrite, ullmannite, arsenopyrite, tetrahedrite, uraninite, and also the species above enumerated as decomposed with the H_2S. The following are decomposed by boiling with citric acid and NH_4Fl: olivine, wernerite, orthoclase, albite, labradorite, augite, diopside, hornblende, cyanite, talc, spodumene, almandine garnet, epidote, and also the above-enumerated species which yield silica.

Professor Bolton remarks that solid citric (or tartaric) acid is far more convenient than hydrochloric for the traveling mineralogist; and also that potassium nitrite, KNO_2, should be added to the usual list of blowpipe reagents; for it yields with citric acid, nitric acid, and it affords a convenient means of carrying this reagent. We refer to the memoir for special details with reference to the several mineral species studied by Professor Bolton.

8. *Note on Uranium minerals in North Carolina;* by W. C. Kerr, State Geologist. (Communicated.)—Besides the samarskite of the Wiseman Mica Mine in Mitchell County, with the associated hatchettolite of Dr. Smith, the minute crystals of microlite found in several mines, and some stains and incrustations of uranium compounds, a new locality, the Flat Rock mine, recently visited, has yielded the following, in immediate association, viz: *Uraninite*, *Gummite*, *Uraconite*, and, as incrustations on the outside of the latter, and of the fragments of rock adjacent, *Torbernite* and *Autunite*. These minerals occur only in one part of the mica-bearing portion of a very large granite vein, and are found in irregular nodules and rounded masses, some with a nucleus of uraninite of one-half to three-fourth inch, enveloped with a heavy layer of gummite, outside of which is a pale yellow earthy coating from an eighth to a fourth of an inch thick, which is uranochre, or uraconite. One lump, the largest, weighs just a pound, and in all I obtained between three and four pounds. The quantity of pitchblende remaining unaltered is very small and by far the greater part of the mass of the nodules, probably nine-tenths, is gummite; and the smaller ones are nearly or entirely changed to uraconite.

I have recently obtained specimens, one pound in weight, of samarskite from a new locality, viz: Grassy Creek Mine, in Mitchell County. Previously this mineral had been found chiefly, I believe only, at the Wiseman Mine.

A notable fact in connection with the occurrence of these uranium compounds is their association with a characteristic pinkish feldspar, which suggests the inquiry whether there may not be another mineral of this group not yet determined; and this is rendered the more probable by the presence, in the Wiseman Mine at least, of a thin earthy coating on the cleavage surface of the feldspar of a pronounced pinkish color. Professor Julien has some of this in hand for determination, as soon as he can isolate enough for that purpose.

III. Botany and Zoology.

1. *The Wild Flowers of America;* illustrated by Isaac Sprague. Text by George L. Goodale, M.D., Assistant Professor of Vegetable Physiology and Instructor in Botany in Harvard University. Part II. Boston, H. O. Houghton & Co.—No color-printing of flowers in this country had at all equalled that of the first part of this beautiful work. Yet the long interval between its appearance and that of the present fasciculus need not be regretted, since it has enabled the lithographers to do still better justice to Mr. Sprague's drawings, and to the beautiful subjects of them. Those unacquainted with the perfection to which the art has been brought will find it hard to believe that these plates have not been painted by the hand, and by no ordinary hand. The text is well done, especially where, as in the Iris or Blue Flag, and the Arrow-leaved Violet, the subject allowed of interesting treatment. The flowers not having been selected for other than pictorial representation, it sometimes happens that there is little to say about them. But when the nomenclature has been brought up to date so closely as to adopt the genus *Steironema*, it might have been mentioned that the cogent reason for the rehabilitation of Rafinesque's genus was not the sterile filaments, which were known from the first and suggested the name, but the involution of the petals in the bud around the filaments, separately enwrapping each, which was a new discovery. In the letter-press accompanying the very pretty plate of *Viola sagittata* (which is well set off with a tuft of sedge behind it), the method of the discharge of the seeds is clearly explained, and the nearly similar mode in *Hamamelis* is incidentally alluded to as if it were a recent discovery of the persons mentioned. Far earlier dates are referred to in this Journal for Feb., 1873, with a reference to the amusing muddle of the subject into which an English scientific periodical was led. Eastern flowers have served hitherto; but in the present fasciculus the ultra-Mississippian *Rudbeckia* (*Lepachys*) *columnaris* figures, and to great advantage, especially the two-colored variety. The velvety red-brown bases of the drooping yellow rays is admirably rendered. A. G.

2. *Cleistogamy in Impatiens.*—When M. A. Loche, a year ago, read a paper before the Botanical Society of France (printed in its Bulletin, xxiii, 367), in which he described the production of fruit and seeds in *Impatiens Nolitangere*, apparently without participation of the male sex, and when two learned botanists present suggested that this might be a case of clandestine flowering or close-fertilizing in the bud, as in *Lamium* and in *Viola*, it is remarkable that no one called attention to the fact that this case of Impatiens was described and properly explained by Adrien de Jussieu thirty-three years ago, in a classical work, and the observation credited to Weddell, the excellent botanist whom we have since lost. A. G.

3. *Catalogus Plantarum in Nova Cæsarea Repertarum.*—This is the title on the cover. The title page, all English, is "Catalogue of Plants growing without cultivation in the State of New Jersey, with a specific description of all the species of Violet found therein, Directions for Collecting, Drying, Labeling and Preserving Botanical Specimens, and a description of suitable apparatus therefor; with suggestions to Teachers prosecuting the study of Botany; to which is added Directions for commencing the study of Botany; also a Directory of living Botanists of North America and the West Indies. By Oliver R. Willis, Ph.D., Instructor of Natural Science in the Alexander Institute. Revised and enlarged edition, (A. S. Barnes & Co.: New York, &c." 8vo, pp. 88.) This full title leaves no need and little room for any particular account of this compendious volume. It lacks only a date, which we may put at 1877, and it has an Index. The preface to the first edition bears the date 1874. We gave a notice of the original edition at the time; the present edition is much enlarged and improved. The author, supposing that his publication "will fall into the hands of men who can form a just estimate of the difficulties and labor incident to the preparation of a work like this," adds that, "consequently I expect to be judged with lenity and criticised with charity." We see no good reason for disappointing his expectations. We will add—since the title page does not mention it—that, while the catalogue stops with the *Lycopodiaceæ*, it is supplemented by one of marine Algæ, by Samuel Ashmead, and that there is a monograph of the forms or varieties of the fruit of one of the States' staple products, the cranberry. New Jersey has a rich flora, as is well known. This catalogue enumerates 1,603 species of Phænogamous plants, and states that there are fifty-seven first class and thirty-seven second class trees. But this includes introduced species. A. G.

4. Sir Joseph Dalton Hooker reached his home at Kew on the 19th of October, after an unusually long voyage of almost a fortnight. In his rapid reconnoissance of the botanical features of the United States he traveled over between nine and ten thousand miles of American territory, ascended some of the highest mountains, and botanized with a vigor and industry which he could hardly have excelled in his youthful days. The time—all too short—was almost wholly given to the wide regions between the Mississippi and the Pacific, for which, through the connection with Dr. Hayden's Survey, and with his personal assistance and companionship (as well as that of a fellow botanist of long experience), unusual facilities were afforded. He promises to renew his visit as soon as possible, and then to endeavor to see something of the Atlantic States (its institutions as well as its natural productions), and also of New Mexico, Arizona and Southern California, which are now becoming readily and promptly accessible to the rapid-moving traveler.

Nature for October 25 contains an excellent steel portrait of Sir Joseph Hooker as one of the series of Scientific Worthies; the accompanying biographical notice is by his companion in American travel, Professor Gray, but was written in May, and was in type before Sir Joseph reached this country. The same number of Nature contains two pages of Notes on the Botany of the Rocky Mountains, a brief sketch, drawn up by him on the homeward voyage. A. G.

5. GEORGE HADLEY, M.D., Professor of Chemistry in the University of Buffalo, died, at Buffalo, N. Y., Oct. 16, in the 63d year of his age. So passes to his rest the last and the oldest of the three gifted sons of gifted and most excellent parents. The subject of this notice, called to a less conspicuous position, did not attain the eminence of his brother James, but rather followed in the footsteps of his father, Professor James Hadley, the first Professor of Chemistry in the Medical College of the Western District, N. Y., at Fairfield, then at Geneva, and lastly at Buffalo, where his son succeeded him. The father and the son were singularly alike, model teachers and model men, truthful to the core and loveable exceedingly, modest and quiet to a degree that masked from the world their ability and their learning: but these traits could not be hidden from those who in two generations came under their influence and shared their abiding friendship. From the father the writer of these lines received, when a youth of sixteen, his first help as a student of botany, and later his first encouragement in essaying a scientific career. He would lay this tribute to the memory of both father and son upon the tomb now opened to receive the mortal remains of the latter. A. G.

6. JOHN DARBY, who graduated in 1831 at Williams College, was born in North Adams, Mass., Sept. 27, 1804. His life was devoted with remarkable steadfastness to teaching in the departments of Mathematics, Chemistry and Natural History, for which he had a great fondness. For some years after his graduation he taught these subjects at the Barhamville Female Institute in Columbia, S. C. He subsequently taught the same subjects for many years in the Georgia Female College at Macon. He filled the chair of Mathematics for one year in Williams College, his alma mater. From this chair Professor Darby went to Auburn in Alabama as Professor of Chemistry and Natural History in the East Alabama College, where he continued until his death in August, 1877.

Professor Darby's scientific work outside the time occupied in teaching—to which he ever gave a most conscientious and willing devotion—was chiefly in botany, of which science he was an enthusiastic student. In 1855 he published his "Botany of the Southern States," in two parts: I. Structural and Physiological Botany and Vegetable Products. II. Descriptions of Southern Plants, arranged on the natural system, preceded by a Linnæan and Dichotomous Analysis. In a critical notice of Professor Darby's work, Dr. Gray (this Journal, vol. xx, p. 131, 1855), says, "the book is excellently planned, and is well adapted to its purpose, —that of a text-book for the Colleges and High Schools of the

Southern States." Professor Darby also published a Class-book of Chemistry. He was married August 20, 1833, to Miss Julia P. Sheldon, daughter of Calvin Sheldon, of Manchester, Vt. Professor Darby enjoyed the enviable reputation of a man of high character and pure life, zealously devoted to teaching in his chosen departments. B. S.

7. *Herbarium for sale.*—The herbarium of the late Arthur Schott is offered for sale, for the benefit of his family. It is said to contain 7,000 species, in good condition, and to be rich in plants of the U. S. and Mexican Boundary, of Mexico, and of Central America; a good many from Southern Germany and Hungary. Application to be made to H. Schott, Georgetown, D. C.

8. *Zoological Diagrams;* by LEUCKART and NITSCHE.*—Professors R. Leuckart and H. Nitsche have just issued the first number of an extended series of zoological diagrams for the use of universities and schools. They propose to issue from one hundred to one hundred and ten such diagrams, both plain and colored, to illustrate the structure and development of the principal forms of animal life. They intend to copy their illustrations mainly from the monographs of special investigators of acknowledged excellence, and to reproduce the figures of a sufficient size to be easily seen in a class-room of moderate dimensions. The diagrams are to be accompanied by an explanation of the figures, with German, French and English text. The authors intend to take special care not to follow any school of zoology and always to indicate in the text the sources from which their figures have been derived; they do not propose to follow a strictly systematic order in the issue of the parts, but the separate numbers will always contain figures from different types and groups of the animal kingdom. Professors Leuckart and Nitsche will indicate by their initials the plates for which each is personally responsible. The plates are issued at a very moderate price, at far less than an ordinary draughtsman can afford to make similar diagrams.

The three plates of the first number are devoted to Corals, Rhizopods and Isopods; the coloring of the various organs and of special parts is identical in the different figures, thus greatly facilitating the comparison of different animals.

It is a great pity that both the French and English text should be marred not only by serious misprints but also by the most extraordinary translations of the German explanation of the figures. The structure of some of the French and English sentences is truly marvellous, and we earnestly hope that the authors will employ a Frenchman and an Englishman to revise the text for the succeeding numbers. It would often puzzle a reader who does not know French and English as well as German, to make out the meaning of the text.

But these are minor defects, and if the work is carried out as it has been commenced, it cannot fail to be a most valuable guide to

* Zoologische Wandtafeln; v. Dr. R. Leuckart u. Dr. H. Nitsche. Erste Lieferung Tafel I–III. Cassel, 1877.

teachers of zoology, for they may rest assured that the distinguished editors will give them nothing which has not stood the test of time, and we most cordially recommend the series.

A. AG.

IV. Astronomy.

1. *The Sun's Distance.* (Abstract of the Report of the Astronomer-Royal on the Telescopic Observations of the recent Transit of Venus, from Nature of Nov. 1).—A most interesting state paper has just been issued; we refer to the Report by the Astronomer-Royal on the Telescopic Observations of the Transit of Venus of 1874, made by the Expeditions sent out by the British Government and the results deduced from them. The Astronomer-Royal suggests that another report may be called for when the photographs of the transit have been completely measured and worked out, if possible in combination with the results of similar observations made in the expeditions organized by other governments.

It will be seen from the present report that the plan of operations actually pursued has been very nearly that proposed by the Astronomer-Royal in his communication to the Royal Astronomical Society on December 11, 1868, when for the third time directing attention to the arrangements which it would be necessary to make for the efficient observation of the transits of 1874 and 1882. The method of absolute longitudes was to be applied for observations both of ingress and egress; it being therefore essential that the longitudes of the observing stations should be determined with precision; and the longitudes recommended to be fixed by Great Britain were Alexandria, stations in New Zealand and in the Sandwich Islands, Kerguelen's Land, and Mauritius or the two islands of Rodriguez and Bourbon.

The stations eventually selected for observatins by the British expedition were fixed upon "entirely by consideration of the influence which their positions would have in determining with accuracy the necessary alteration of parallax." They were: Egypt, the Sandwich Islands, the Island of Rodriguez, New Zealand, and Kerguelen's Land. It was intended to adopt in each of these districts one fundamental station, the longitude of which was to be independently determined, for conversion of local times into Greenwich times, and subordinate to this primary station, other stations were proposed to be selected at such distances that advantage might be taken of different states of weather that might possibly prevail.

In Egypt his Highness the Khedive rendered every possible assistance, tents being supplied with military guards for the protection of the observers and their instruments, and telegraph wires erected. The Astronomer-Royal acknowledges the obligations of the expedition to the liberality of the Eastern Telegraph Company, in affording the means of determining with extreme accuracy and great facility the longitude of the principal station Mokattam.

Greenwich was easily connected with Porth Curno, in Cornwall, whence there is an uninterrupted line to Alexandria, the longest submarine line in the world; Alexandria was connected with Mokattam by aid of the special line constructed by the Khedive from Cairo to the station. It is further stated that time-communication was also made from Mokattam through Cairo to Thebes, and to Suez by the ordinary telegraph, Thebes and Suez being the other Egyptian stations where the transit was observed.

In the Sandwich Islands much assistance was received from King Kalakaua and members of the reigning family. The principal station was at Honolulu, the longitude of which was determined partly by meridian-transits of the moon and partly by transits of the moon observed with the Altazimuth instrument. Waimea, in the island Kauai, where observers were also placed, was connected with Honolulu by means of chronometers carried in H.M.S. *Teredos.* At the Island of Rodriguez the longitudes were determined in the same manner as for the Sandwich Islands stations, for three positions, viz: Point Venus, the Hermitage, and Point Coton; and communication was further made with the Mauritius and with Lord Lindsay's expedition with the aid of H.M.S. *Shearwater*, the preliminary results being stated by Sir George Airy to agree closely with those given by the lunar observations. At Kerguelen's Land, again, the operations were similar; Supply Bay and Thumb Peak being the stations chosen.

In New Zealand unfavorable weather much interferred with the observations, and Sir George Airy had at first been led to suppose that all useful observation had been lost; it subsequently appeared, however, that this was not the case, one phase of the transit being well seen at Burnham, the longitude of which was fixed by meridian transits of the moon.

The report is divided into three sections or tables. In the first are given the descriptions of the various phenomena, in the words of the observers, with the Greenwich sidereal times of the different phases, obtained from accurate reduction of the observations for longitude here particularized; where such longitudes depend upon lunar observations the places of the *Nautical Almanac* were carefully corrected by observations on nearly the same days at Greenwich, Paris, Strasburg, and Königsberg. In studying these original descriptions, Sir George Airy was led to infer that it was "possible to fix upon three distinct phases for the *Ingress* and four for the *Egress*," though it might have been supposed that Egress and Ingress would exhibit the same number of distinct phases in inverse order; this was not the case in practice. The first phase, α, utilized in the calculations is the appearance of the planet just within the sun's disc, but the light between the two limbs being very obscure. After an interval of about twenty seconds "the light begins to clear, and the observers generally think that the contact is passed;" this is phase β. About twenty seconds later, the light which at phase β was not equal to that of the sun's limb, is free from all shadow, and the phase is called γ. Sir

George Airy finds that of these phases β is the most exact, observers, even in the presence of clouds of moderate density, agreeing within three or four seconds, though for other phases much greater discordances are exhibited. Similarly at the Egress, the first appearance of a fine line or faint shadow is called δ, this becoming definite, or a "brown haze" appearing, is called ε. When most observers record "contact," the shadow having reached a maximum intensity, the phase is called ζ, and in this phase there is an agreement amongst observers, much closer than in other phases at Egress. The "circular" contact at Egress is called η.

In the second section of the report, or Table II, these "adopted phases are massed for each district in which the parallax-factor is nearly identical," and several of the details of reduction are included. With the longitudes determined as above, the recorded time of the various phases of the transit were converted into Greenwich sidereal times. With the calculated apparent places of the sun and Venus in the *Nautical Almanac*, as deduced from Leverrier's Tables, an ephemeris was prepared exhibiting the predicted geocentric places for every tenth second of Greenwich sidereal time throughout the transit, and from these numbers the apparent positions of sun and planet at each station were computed. Calculations were further made, showing how the predicted places would be affected by alteration of the local longitude, by change in the tabular places of the sun and Venus, and by alteration of their tabular parallaxes; the first two alterations were not essential in these reductions, but the determination of alterations of the third class, as it is remarked, constituted "the special object of the expedition." The form of the reductions was "entirely determined by the consideration that such alterations must be made in the parallaxes as will render the observations of the same phenomena in different parts of the earth consistent with each other." In Table III. we have "the mean solar parallax deduced from every available combination." Thus Ingress accelerated at the Sandwich Islands is compared with Ingress retarded at Rodriguez and with Ingress retarded at Kerguelen's Land; Egress retarded at Mokattam and Suez with Egress retarded at Rodriguez, and likewise with Egress accelerated at the two stations in Kerguelen's; and again the retarded Egress at Thebes is compared with Egress retarded at Rodriguez and with Egress accelerated at Kerguelen's. The greatest separate value of the solar parallax resulting from these different comparisons is $8''\cdot933$ and the least $8''\cdot407$. Weights are given to the various determinations depending firstly, upon the number of observations and the magnitude of the parallax-factor; and secondly, upon the particular phase α, β, γ, δ, ε, and ζ being included. Thus it is found that all the combinations for *Ingress* give the mean solar parallax $8''\cdot739$, weight 10·46, and all the combinations for *Egress* give $8''\cdot847$, weight 2·53, whence the general result is $8''\cdot760$, from which Sir George Airy finds the mean distance of the sun equal to 93,300,000 miles. The New Zealand observations were not included in these calculations; their mean result is 8″·764, almost identical with the above. It is remarked that many persons may perhaps consider that the more closely-agreeing phases β and ζ should be employed in deducing the value of the parallax to the exclusion of the others. If this be done we shall have from the *Ingress* 8″·748, and from the *Egress* 8″·905, or with their due weights a mean value 8″·773.

In this outline of the details contained in the Astronomer-Royal's first report upon the observations of the transit of Venus, and the conclusions to be drawn from them we have adhered closely to his own words. Pending the appearance of the deductions to be made from the complete measuring of the photographs, the results before us are perhaps to be regarded as provisional ones only, or we have not yet learned all that may be done from the work of the British expeditions, so laboriously organized by Sir George Airy. Many astronomers we can imagine will regard with some suspicion so small a parallax as 8″·76, which is a tenth of a second less than has been given by the most reliable previous investigations, upon different principles. In illustration we may quote the separate results from which Prof. Newcomb obtained his value of the parallax, now adopted in most of our ephemerides:—

From meridian observations of Mars, 1862	8″·855
From micrometric observations of Mars, 1862	8″·842
From parallactic inequality of the moon	8″·838
From the lunar equation of the earth	8″·809
From the transit of Venus, 1769 (Powalky's reduction)	8″·860
From Foucault's experiments on light	8″·860

To these may be added Leverrier's value subsequently deduced from the planetary theories, which is also 8″·86. Newcomb's mean figure, taking account of weights corresponding to the probable errors is 8″·848, which, with Capt. Clarke's measure of the earth's equator, implies that the mean distance of the sun is 92,393,000 miles. Sir George Airy's 8″·760 would similarly place the sun at a mean distance of 93,321,000 miles.

It is well known that some astronomers have not expected our knowledge of the sun's distance to be greatly improved from the observations of the transit of Venus, regarding such an opportunity as is presented by a close opposition of Mars as affording at least as favorable conditions, and the result of Mr. Gill's expedition to Ascension to utilize the late opposition will be on this account awaited with much interest. Nevertheless, whatever degree of opinion might be entertained by competent authorities, it appears to have been felt by those immediately responsible for action, in different civilized nations where science is encouraged, that so rare a phenomenon as a transit of Venus could not be allowed to pass without every exertion being made to utilize it, and this country may lay claim to an honorable share in the great scientific effort, thanks mainly to the long-continued and admirably-directed endeavors of the Astronomer-Royal to secure this result.

Several of the stations occupied during the transit of 1874 will be available for the transit of 1882, Kerguelen's Land in particular, where at Ingress the sun will be at an elevation of 12°, the factor of parallax being 0·98. In that year there will also be the advantage of observations along the whole Atlantic sea-board of the United States and Canada, where, as pointed out by the Astronomer-Royal in 1868, the lowest factor is 0·95, and the smallest altitude of the sun 12° for observing the retarded Ingress; and for observing the Egress as accelerated by parallax, the factors are about 0·85, the sun's elevation varying from 4° at Halifax, to 32° at New Orleans, or Jamaica. Australian and New Zealand stations are important for retarded Egress.

As is well known, the transit of Venus on December 6, 1882, will be partly visible in this country.

V. Miscellaneous Scientific Intelligence.

1. *Notes on the Rocky Mountains*; by Sir Joseph Hooker. (From Nature of Oct. 25.)—In company with Dr. Asa Gray, Professor of Botany of Harvard University, Cambridge, U. S., I availed myself of an oft-repeated invitation to us both from Dr. Hayden, the distinguished chief of the Topographical and Geological Survey of the United States Territories, to join the Survey in Colorado and Utah; this we did with the view of instituting a comparison between the floras of these central and elevated territories and those of other parts of the continent, and thus obtaining some insight into the origin and distribution of the North American flora. In order to comprehend the importance of Colorado and Utah as the basis for such investigations, I should state that they occupy a very central position in the continent, and include a section of the Rocky Mountains about 300 miles long and about as broad, namely, from N. lat. 37° to 41°, and from W. long. 105° to 112°.

The mountain region thus limited consists of extensive and often level-floored valleys, sometimes many miles broad, and elevated 4,000 to 5,000 feet above the sea, called "parks" in local topography, which are interposed between innumerable rocky mountain ridges of very various geological age and formation, which often reach 12,000 feet, and sometimes 14,000 feet elevation, the maximum being under 14,500.

Those of the so-called parks which are watered by rivers that flow to the east are continuous with the prairies that lie along the eastern flanks of the Rocky Mountains; those watered by rivers that flow to the west are continuous with the so-called desert or salt regions that lie along the western flanks of the range; but the divides between the head waters of the streams that flow either way are sometimes low, and the botanical features of the east and west may hence meet and mix in one park.

Such a section of the Rocky Mountains must hence contain representatives of three very distinct American floras, each characteristic of immense areas of the continent. There are two temperate and two cold or mountain floras, viz: (1) a prairie flora, derived from the eastward; (2) a so-called desert and saline flora, derived from the west; (3) a sub-alpine; and (4) an alpine flora; the two latter of widely different origin, and in one sense proper to the Rocky Mountain ranges.

The principal American regions with which the comparison will have first to be instituted are four. Two of these are in a broad sense humid; one, that of the Atlantic coast, and which extends thence west to the Mississippi River, including the forested shores of that river's western affluents; the other that of the Pacific side, from the Sierra Nevada to the western ocean: and two inland, that of the northern part of the continent extending to the Polar regions, and that of the southern part extending through New Mexico to the Cordillera of Mexico proper.

The first and second (Atlantic plus Mississippi and the Pacific) regions are traversed by meridional chains of mountains approximately parallel to the Rocky Mountains; namely, on the Atlantic side by the various systems often included under the general term Appalachian, which extend from Maine to Georgia, and on the Pacific side by the Sierra Nevada, which bounds California on the east. The third and fourth of the regions present a continuation of the Rocky Mountains of Colorado and Utah, flanked for a certain distance by an eastern prairie flora, extending from the British possessions to Texas; and a western desert or saline flora, extending from the Snake River to Arizona and Mexico. Thus the Colorado and Utah floras might be expected to contain representatives of all the various vegetations of North America except the small tropical region of Florida, which is confined to the extreme southeast of the Continent.

The most singular botanical feature of North America is unquestionably the marked contrast between its two humid floras, namely, those of the Atlantic plus Mississippi, and the Pacific one; this has been ably illustrated and discussed by Dr. Gray in various communications to the American Academy of Sciences, and elsewhere, and he has further largely traced the peculiarities of each to their source, thus laying the foundations for all future researches into the botanical geography of North America; but the relations of the dry intermediate region either to these or to the floras of other countries had not been similarly treated, and this we hope that we have now materials for discussing.

Our course and direction in America was directly westward to Colorado, where we followed the eastern flanks of the Rocky Mountains for about 300 miles, that is from Denver in the north, to near the borders of New Mexico, ascending the highest northern and southern peaks, and visiting several intermediate parks and valleys, watered by tributaries of the Arkansas, Platte, Colorado, and Rio Grande. From Denver we proceeded north to Cheyenne in Wyoming, and thence westward by the Central Pacific Railway, across the range to Ogden, and the Great Salt Lake in Utah, which lies on the base of the Wahsatch Mountains, themselves the western escarpment of the Rocky Mountains proper in that latitude. After ascending these we proceeded westward by rail through Utah, to Nevada, thus crossing the great dry region that intervenes between the Rocky Mountains and the Sierra Nevada, which is variously known as the Desert, Salt, or Sink region of North America, in accordance with the prevailing features of its several parts. It is elevated 3,850 to 6,000 feet, and traversed by numerous short meridional mountain-ridges, often reaching 8,000 feet, and rarely 10,000 feet elevation; unlike the Rocky Mountains or over the Sierra Nevada, these present no forest-clad slopes, and only the highest have a limited Alpine flora.

From Reno, at the western base of the Sierra Nevada, we proceeded south by Carson City, flanking the Sierra for some sixty miles to Silver Mountain, when we struck westward, ascending the Sierra, which was crossed obliquely into the Pacific slope. There we visited three groves of the "Big Trees" (*Sequoia gigantea*) at the headwaters of Stanislaus and Tuolomne Rivers, and the singular Yosemite Valley, whence we descended into the great valley of California, and made for San Francisco.

From the latter place we made excursions first to the old Spanish settlement of Monterey, which is classical ground for the botanist, as being the scene of Menzies' labors during the voyage of our countryman, Capt. Vancouver, in 1798 (whose surveys are held in the highest estimation by Professor Davidson and the officers of the Coast Survey of the United States), whom he accompanied as botanist. Then we went northward along the coast range to Russian River to visit the forests of Red-wood (*Sequoia sempervirens*), the only living congener of the Big Trees, and almost their rival in bulk and stature. Then to Sacramento, and up the valley of that name for 150 miles to Mount Shasta, a noble forest-clad volcanic cone about 14,400 feet in elevation. Returning thence to Sacramento we took the Union Pacific Railway eastward, and from the highest station visited Mount Stanford, on the crest of the Sierra Nevada, and Lake Tahoe, which occupies a basin in the mountains at about 7,000 feet elevation, and with which we finished our western journeyings.

In California the Coniferæ were a principal study, with a view of unraveling their tangled synonymy and tracing the variations and distribution of these ill-understood trees, which attain their maximum development in number of species and in stature on the Pacific slope of the American continent.

The net result of our joint investigation and of Dr. Gray's previous intimate knowledge of the elements of the American flora is, that the vegetation of the middle latitudes of the continent resolves itself into three principal meridional floras, incomparably more diverse than those presented by any similar meridians in the old world, being, in fact, as far as the trees, shrubs, and many genera of herbaceous plants are concerned, absolutely distinct. These are the two humid and the dry intermediate regions above indicated.

Each of these, again, is subdivisible into three, as follows:—

(1.) The Atlantic slope plus Mississippi region, subdivisible into (α) an Atlantic (β) a Mississippi valley, and (γ) an interposed mountain region with a temperate and sub-alpine flora.

(2.) The Pacific slope, subdivisible into (α) a very humid cool forest-clad coast range; (β) the great hot drier Californian valley formed by the San Joaquin River flowing to the north, and the Sacramento River flowing to the south, both into the Bay of San Francisco; and (γ) the Sierra Nevada flora, temperate, sub-alpine, and alpine.

(3.) The Rocky Mountain region (in its widest sense extending from the Mississippi beyond its forest region to the Sierra Nevada), subdivisible into (α) a prairie flora; (β) a desert or saline flora; (γ) a Rocky Mountain proper flora, temperate, sub-alpine, and alpine.

As above stated, the difference between the floras of the first and second of these regions, is specifically, and to a great extent generically absolute; not a pine or oak, maple, elm, plane, or birch of Eastern America extends to Western, and genera of thirty to fifty species are confined to each. The Rocky Mountain region, again, though abundantly distinct from both, has a few elements of the eastern region and still more of the western.

Many interesting facts connected with the origin and distribution of American plants and the introduction of various types into the three regions, presented themselves to our observation or our minds during our wanderings; many of these are suggestive of comparative study, with the admirable results of Heer's and Lesquereux's investigations into the pliocene and miocene plants of the north temperate and frigid zones, and which had already engaged Dr. Gray's attention, as may be found in his various publications. No less interesting are the traces of the influence of a glacial and a warmer period in directing the course of migration of Arctic forms southward, and Mexican forms northward in the continent, and of the effects of the great body of water that occupied the whole saline region during (as it would appear) a glacial period.

Lastly, curious information was obtained respecting the ages of not only the big trees of California, but of equally aged pines and junipers, which are proofs of that duration of existing conditions of climate for which evidence has hitherto been sought rather amongst fossil than amongst living organisms.

I need hardly add that the part I played in the above sketched journey was wholly subordinate to Dr. Gray's, who had previously visited both the Rocky Mountains and California, though not with the same object. But for his unflinching determination that nothing should escape my notice which his knowledge and observant powers could supply, and Dr. Hayden's active co-operation, my own labors would have been of little avail.

Moreover, throughout the expedition we experienced great hospitality, and enjoyed unusual facilities, not only from the staff of the Geological Survey, but from the railway authorities, who franked us across the continent, and on all the branch lines which we traversed.

2. *The Earths of the Cerium Groups as found in the North Carolina Samarskite.*—In my original paper and subsequent note on this group of earths as separated by sulphate of potash from the mixed earths of North Carolina samarskite, I then stated that oxide of cerium was not to be ranked among them. I have continued the researches in this direction, and while they are far from being complete, it is pretty well determined that the bulk of the earth separated by the sulphate of potash is a *new earth*, if it be not *oxide of terbium*, an earth the existence of which is denied, and of the properties of which we have but a very imperfect knowledge. The other oxides of this group are thoria and oxide of didymium. I am still prosecuting my researches, and hope before long to give more positive results.—*J. Lawrence Smith's letter of Nov.* 14.

3. *Artificial Tremors through the Earth's Crust*, at the time of the Hallet's Point explosion in August and September, 1876; abstract of a paper by HENRY L. ABBOT, Major of Engineers, Bvt. Brig. General, read before the National Academy of Sciences at its recent meeting in New York.—Mr. Mallet's results, reported many years ago to the Royal Society, were:

Velocity in ft. per second	in sand,	825 ft.
" " "	in discontinuous and much shattered granite,	1306 ft.
" " "	in more solid granite,	1665 ft.
" " "	in quarries at Holyhead (mean),	1320 ft.

The results, obtained by the officers of the United States Engineer School of Application at Willet's Point, for the rate through drift formation of Long Island, are the following:

TABLE I.

No. of observations.	Date.	Observer.	Cause of Shock.	Distance to station.	Type of seismometer.	Tremor of mercury. Arrived in	Tremor of mercury. Lasted for	Velocity of transmission.
				miles.		sec'ds.	sec'ds	ft. pr sec.
1	Aug. 18, '76.	Capt. Livermore	200 lbs. dynm.	5 ±	B	5 ±		5280 ±
2	Sept. 24, '76.	Lieut. Young	Hallet's Pt. ex.	5·134	A.	7 ±	63 ±	3873 ±
3	" " "	Lieut. Griffin	" " "	8·330	B.	5·3	72·3	8300
4	" " "	Lieut. Kingman	" " "	9·333	A.	10·9	23·5	4521
5	" " "	Lieut. Leach	" " "	12·769	B.	12·7	19·0	5309
6	Oct. 10, '76.	Lieut. Kingman	70 lbs. powder.	1·360	A.	5·8	inst't	1240
7	Sept. 6, '77.	Lieut. Kingman	400 lbs. dynm.	1·169	A.	1·8	7·8	3428
8	" " "	Lieut. Leach	" " "	1·169	B.	0·7	17·8	8814
9	Sept. 12, '77.	Lieut. Griffin	200 lbs. dynm.	1·340	A.	1·05	8·8	6730
10	" " "	Lieut. Leach	" " "	1·340	B.	0·81	17·1	8730
11	" " "	Lieut. Griffin	70 lbs. powder.	1·340	A.	1·27	4·8	5559
12	" " "	Lieut. Leach	" " "	1·340	B.	0·84	15·1	8415

In the case of No. 6 the charge was five feet below the surface. In those of Nos. 11 and 12 the charge was thirty feet below surface, giving a much more violent shock than No. 6. Lieut. Leach reports, "I should say that it (the tremor) was at least two seconds in attaining a maximum." Hence, an instrument just capable of detecting it, would have registered only 2,489 feet.

TABLE II. (Analysis of above.)

No. of observations.	Seismometer A, (power 6).		No. of observations.	Seismometer B, (power 12).	
	Velocity of transmission.	Duration of tremor.		Velocity of transmission.	Duration of tremor.
	ft. per sec.	seconds		ft. per sec.	seconds
2	3873 ±		1	5280 ±	
4	4521		3	8300	
6	1240	instant	5	5309	
7	3428	7·8	8	8814	17·8
9	6730	8·8	10	8730	17·1
11	5559	4·8	12	8415	15·1
Mean.	4225			7475	

Conclusions. In such observations a high magnifying power of telescope is essential. The more violent the initial shock, the higher is the rate. This rate diminishes as the wave advances. For one mile, through drift formation, a severe shock gives a velocity of say 8,500 feet per second. The rate for the great Hallet's Point explosion was about 8,300 feet per second for the first eight miles, and about 5,300 feet per second for the first thirteen miles. These conclusions are supported by much additional evidence that cannot be stated in a tabular form.

4. *Recherches expérimentales faites avec les gaz produits par l'explosion de la dynamite sur divers caractères des météorites et des bolides qui les apportent*, par M. DAUBRÉE.—Professor Daubrée has carried on a series of experiments with dynamite similar to those he had previously performed with ordinary powder (Comptes Rendus, lxxxii, 949; lxxxiv, 413, 526), his design being to obtain an explanation for some of the most important characters of meteorites. Prisms of planed steel, each side having a surface of 85 mm., were subjected under different conditions, to the explosion of charges of two and of five kilograms of dynamite. The cartridge was in each case simply applied to one of the faces so as to act upon a single side only. The explosion took place at the bottom of a pit, some two meters in depth, so that all the fragments of the shattered steel could be recovered for examination. The immediate results of these experiments were as follows:—The mass acted upon was broken up into numerous polyhedral fragments, the planes of fracture being mostly perpendicular to the "*surface of action*" on which the force of the gas was felt. The surface directly exposed to the explosion showed numerous spheroidal depressions; these sometimes attained a diameter of 15 to 18 mm. and a depth of 4 to 5 mm. They were often grouped in lines, like the links of a chain, and in some cases were

bordered by an elevated ring. Outside of these distinct cavities the whole surface acted upon was fretted, or covered over with minute irregular depressions. Moreover the lateral faces showed fine, regular lines, parallel to the "surface of action," and produced by the violent crushing action of the exploded gas; and further, when these lateral faces were polished and etched with dilute acid, it was found that the parts close to the surface exposed to the gas had a peculiar tint which probably resulted from a sort of tempering which the surface had undergone from its rapid cooling. Again, of the fracture-surfaces, aside from those showing only a ragged break, some were polished and others finely striated, results which were due to the rubbing of the parts against each other at the instant of fracture. Finally, numerous cracks in the fragments of steel were compactly filled with the clay and sand from the walls of the pit, which had been forced into them. Characters analogous to those above enumerated as produced on the steel by the action of exploding dynamite, are commonly observed on meteorites; these are:—their fragmentary, polyhedral form; the pitted or "*piezoglyptic*" (graven under strain or pressure) character of their surfaces; the change of texture near the surface in the case of iron meteorites; the striated, fibrous surfaces in the interior of the mass, due to the rubbing of the parts against each other; the black veins ("lignes noires") resulting from a portion of the fused surface being pressed into cracks in the interior; and finally, the black marbled surface.

Professor Daubrée concludes that, as in the case of steel subjected to the action of dynamite, so also with the bolides and meteorites the effects observed are due mostly to the action of strongly compressed and hence highly heated gas. Although it is impossible to estimate, even approximately, the pressure exerted upon a bolide, from the time it enters the atmosphere until it explodes and scatters its fragments upon the earth, the conclusion is notwithstanding justified that it is comparable to the pressure exerted by the gas in the experiments with dynamite.

The writer would also ascribe the production of the large number of individual stones which have characterized some falls, as that of Pultusk in 1868, to the fracturing of an original mass by the compression of the air, and not by the unequal contraction due to a heated surface and a cold interior. He also calls attention to the fact that the "piezoglyptic" character of the surface is true of the whole meteorite, and not to one side only, and concludes from this that the moving mass must have had a motion of rotation, so that the different surfaces were in succession placed in front and subjected to the action of the compressed air.—*C. R.*, lxxxv. E. S. D.

5. *National Academy of Science.*—At a session held at Columbia College, N. Y., Oct. 23–25, 1877, the following papers were read:

STEPHEN ALEXANDER.—(1.) On the laws of extreme distances in the Solar system.—(2.) On the inclinations in a direction retrograde of the shadow of the planets.—(3.) On the luminous band which seems to encircle the moon during a partial solar eclipse.—(4.) Whence came the inner satellite of Mars?

A. M. MAYER.—On a new and simple method of determining the number of vibrations of sonorous bodies.

A. AGASSIZ.—On the development of Flounders.

T. GILL.—On the Morphology of the Antlers of the Cervidæ.

ELIAS LOOMIS.—Contributions to Meteorology (*eighth paper*).

HENRY L. ABBOT.—Velocity of transmission of shocks caused by the explosion of gunpowder and of nitroglycerine compounds, through the earth's crust.

JOSEPH HENRY.—On the abnormal phenomena of Sound, in relation to Fog Signals,—on behalf of the U. S. Light House Board.

O. N. ROOD.—(1.) On the photometric comparison of light of different colors.—(2.) On a construction for the study of the contrast of colors.

DR. M. IHLSENG.—On a method of studying of velocity of Sound in Wood. Presented by O. N. Rood.

J. S. NEWBERRY.—(1.) On some new fossil Fishes from Ohio and Indiana.—(2.) On the geological age of the Western Lignites.

J. LAWRENCE SMITH.—(1.) Notes on the analysis of Columbates.—(2.) Notes on the native iron and basalt of Greenland.—(3.) Exhibition of specimens showing the occurrence of sulphuret of chromium in meteoric iron.

JAMES HALL.—Note on the Hydraulic Limestone and associated strata at the Falls of the Ohio.

O. C. MARSH.—(1.) On some gigantic Dinosaurian Reptiles from the Wealden of the Rocky Mountains.—(2.) American Cretaceous Birds.

H. A. NEWTON.—On Comets. (Read by title.)

A. S. PACKARD, JR.—On the Air-sacs of Locusts.

JOSEPH LECONTE.—On the glycogenic functions of the Liver, and its relation to vital force and vital heat.

A. GUYOT.—Biographical memoir of Louis Agassiz. 1st part, relating to his life and work in Europe.

6. *Canada and New England Earthquake.*—A paper on this recent earthquake by Prof. Rockwood, now of Princeton, N. J., will appear in another number of this Journal.

7. *Thin Sections of Rocks, Minerals, etc.*, are made to order by A. A. Julien, School of Mines, Columbia College, New York, who also has made arrangements for sawing and polishing rocks, and polishing and etching meteorites. He has also collections of slides of various rocks on sale.

OBITUARY.

JAMES ORTON, Professor of Natural History in Vassar College, died in Bolivia about the 24th of September while crossing Lake Titicaca, and lies buried on a little island in the lake. He was born at Seneca Falls, N. Y., in the year 1830, and graduated at Williams College in 1853. Professor Orton was on his third tour to South America. In 1867–68, he took charge of an expedition to the Upper Amazons, under the auspices of the Smithsonian Expedition and along with a party from Williams College; and, in 1873, he made a second exploration of the Amazon, penetrating to Bolivia. About ten months since he left for his third exploring tour, with the design of tracing the waters of Eastern Bolivia to the Amazon. This Journal contains communications from Professor Orton, in volumes for the years 1868, 1869, on points in the Physical Geography of Quito and of the Andes and Amazons, and on the Geology of the Andes of Ecuador; and in 1870, appeared his work entitled "The Andes and the Amazon, or across the Continent of South America," giving a full account of his observations and discoveries.

APPENDIX.

ART: LII.—*A New Order of Extinct Reptilia* (*Stegosauria*) *from the Jurassic of the Rocky Mountains;* by Prof. O. C. MARSH.

THE Museum of Yale College has recently received the greater portion of the skeleton of a huge reptile, which proves to be one of the most remarkable animals yet discovered. It was found on the eastern flank of the Rocky Mountains, in beds which I have regarded as corresponding nearly to the Wealden of Europe, and which may be classed as upper Jurassic. The remains are well preserved, but are embedded in so hard a matrix that considerable time and labor will be required to prepare them for a full description. The characters already determined point to affinities with the Dinosaurs, Plesiosaurs, and more remotely with the Chelonians, and indicate a new order, which may be termed *Stegosauria*, from the typical genus here described.

***Stegosaurus armatus*, gen. et sp. nov.**

In this specimen, some of the teeth preserved have compressed crowns, and are inserted in sockets Others are cylindrical, and were placed in rows, either in thin plates of imperfect bone or in cartilage. The latter are especially numerous, and may possibly prove to be dermal spines, having all the essential characters of teeth, as in some fishes. The vertebræ are biconcave, their neural arches being coosified with the centra, and the chevrons articulated. The limb bones indicate an aquatic life. The body was long, and protected by large bony dermal plates, somewhat like those of *Atlantochelys* (*Protostega*). These plates appear to have been in part supported by the elongated neural spines of the vertebræ.

The length of one of the compressed teeth of this species is 112 mm., and the greatest diameter of the crown 24 mm. One of the cylindrical teeth is 75 mm. in length, and 7·5 in diameter. Seven of these teeth in position occupy a space of 63 mm. A trunk vertebra measures 450 mm. from base of centrum to top of neural spine, and 170 mm. to the floor of the neural canal. The extent of seven posterior caudal vertebræ is 660 mm. One of the large dermal plates was over three feet (one meter) in length.

The present species was probably thirty feet long, and moved mainly by swimming. For its discovery science is indebted to Prof. A. Lakes and Engineer H. C. Beckwith of the U. S. Navy, who found the first remains in Colorado near the locality of the gigantic *Atlantosaurus montanus*, and in essentially the same horizon.

Yale College, New Haven, Nov. 15th, 1877.

Art. LIII.—*Notice of New Dinosaurian Reptiles from the Jurassic formation*; by Professor O. C. Marsh.

The gigantic Dinosaur, *Atlantosaurus montanus*, described by the writer in the July number of this Journal,* proves to belong to a lower horizon than at first supposed, and is really from the upper Jurassic. Additional remains of the type specimen, moreover, throw considerable light on the structure of this largest of land animals, and indicate that it is the representative of a distinct family, which may be called *Atlantosauridæ*.

In the type genus, *Atlantosaurus*, one of the most important characters is the pneumaticity of the vertebræ, as mentioned in the original description. Another noteworthy feature is the absence on the femur of a third trochanter. The shaft of the bone is somewhat thickened at the point where this process should be, but the trochanter is wanting. The size of the original specimen of *A. montanus* may be estimated from the femur, which was about seven feet in length. If the animal had the proportions of a Crocodile, it was at least eighty feet long.

Apatosaurus ajax, gen. et sp. nov.†

Another gigantic Dinosaur, allied to the above, and of scarcely less interest, is represented in the Yale Museum by a nearly complete skeleton in excellent preservation. It is from the Jurassic beds in the Eastern foot hills of the Rocky Mountains, but from a somewhat lower horizon than the type of *Atlantosaurus*.

The cervical vertebræ are strongly opisthocœlous, and are rendered comparatively light by large pneumatic cavities in the centra. The anterior dorsals have similar characters. The posterior lumbars have the articular faces very nearly flat, and transverse. The sacral vertebræ are more solid, and have their transverse processes nearer the middle of the centra than in *Atlantosaurus*. The anterior caudals are biconcave, and their

* Vol. xiv, p. 87, 1877. The name *Titanosaurus* was first given, but, being preoccupied, may be replaced by *Atlantosaurus*.

† The principal characters of this genus and its nearest allies were given by the writer in a paper before the National Academy of Science, at the meeting in New York, October 25th, 1877.

interior structure is cancellous. The chevron bones differ from those of most known Dinosaurs in having the superior articular ends of the rami not united, but separated from each other, as in the Mosasauria with free hæmapophyses.

Some of the dimensions of this skeleton are as follows:

Length of centrum of anterior dorsal vertebra	220·mm
Transverse diameter of anterior face	310·
Vertical diameter	200·
Amount of convexity	90·
Length of centrum of lumbar vertebra	240·
Transverse diameter of anterior face	410·
Vertical diameter	270·
Length of median sacral vertebra	250·
Expanse of its transverse processes	760·
Length of centrum of median caudal	190·
Length of posterior caudal	185·

This animal must have been between fifty and sixty feet in length, and more than thirty in height when erect.

Apatosaurus grandis, sp. nov.

Another huge Dinosaur, apparently of the same genus, but of smaller size, is represented in the Yale Museum by the more important parts of a skeleton, in remarkable preservation. In this specimen the cervical vertebræ have the walls of the centra very thin. The caudals preserved are elongated and slender, indicating a long tail. The femur is comparatively short, and without a third trochanter. The great trochanter is much lower than the head of the femur, and continuous with it. The metapodial bones indicate a foot of medium length.

The following measurements indicate the size of the reptile:

Length of femur	1050· mm.
Transverse diameter of proximal end	340·
Transverse diameter of distal end	290·
Length of posterior caudal vertebra	145·
Vertical diameter of anterior articular face	110·
Transverse diameter	115·

The known remains of this species are from the same geological horizon as those above described. They indicate an animal at least thirty feet in length.

Allosaurus fragilis, gen. et sp. nov.

This genus may be distinguished from any known Dinosaurs by the vertebræ, which are peculiarly modified to ensure lightness. Although apparently not pneumatic, they have the weight of the centra greatly reduced by deep excavations in the sides. Some of them have the centra hour-glass in form, the middle part being so diminished as to greatly reduce the strength. The vertebræ preserved are biconcave, with shallow cavities. The feet bones referred to this species are very slender. A lumbar vertebra has its centrum 105 mm. in length, and 89 in least transverse diameter. An anterior caudal, 35 mm. long, has its centrum so much constricted that its least transverse diameter is 38 mm., while its anterior face is 90 mm. in transverse diameter.

The animal indicated by the remains preserved was from fifteen to twenty feet in length. All the known specimens are from the upper Jurassic of Colorado.

Nanosaurus rex, sp. nov.

A diminutive Dinosaur, about as large as a fox, is indicated by some remains in good preservation, the most characteristic of which is a nearly perfect femur. In this bone, the great trochanter is prominent, and the third trochanter especially so. There is a well developed fibular ridge, directed outward and backward. The cavity in this bone is unusually large, and the walls are smooth. This femur agrees so nearly with that of the type of *Nanosaurus*, that the present species may be provisionally referred to that genus.

The dimensions of this bone are as follows:

Length of femur	100· mm
Distance from head to middle of third trochanter	30·
Transverse diameter of distal end	21·
Greatest antero-posterior diameter	18·
Least transverse diameter of shaft	11·
Diameter across third trochanter	15·

The known remains of this reptile are from the upper Jurassic of Colorado.

The specimens described in the present articles are deposited in the Peabody Museum of Yale College. They are all from essentially the same geological horizon, which I find to be upper Jurassic. The deposits which contained them may be called the Atlantosaurus beds, from their most characteristic fossils, the huge Dinosaurs of that genus.

Yale College, New Haven, November, 1877.

NDEX TO VOLUME XIV.*

* The Index contains the general heads BOTANY, GEOLOGY, MINERALOGY, ZOOLOGY, and under each the titles of Articles referring thereto are mentioned.

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