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JAMES D. DANA.

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ERRATA.

Page 4, line 11 from bottom, for ‘zinc,’ read ‘wire.’
P. 20, “ 15 “ top, for ‘acid in chlorine,’ read ‘acid and chlorine.’
P. 63, “ 2 “ top, for ‘Wutz,’ read ‘Wurtz.’
P. 218, “ 6 “ bottom, for ‘1227·75,’ read ‘1227·45,’ and erase first half of next line.
P. 286, “ 22 “ top, for ‘2·97,’ read ‘2·957.’
P. 286, “ 17 “ bottom, for ‘soda,’ read ‘potash.’
P. 407, “ 13 “ top, for “Pseudomorphism,” read “Isomorphism.”
P. 419, bottom line, for ‘soda, or the,’ read ‘soda, and the.’
Vol. VIII, page 379, line 15 from top, for ‘Chester Co.,’ read ‘Delaware Co.’
“ p. 383, in table, analysis 2, for ‘Emerylite, Pennsylvania,’ read ‘Margarite.’
“ “ “ “ 3, “ ‘Margarite,’ read ‘Emerylite.’
“ “ “ second part, for the numbers of the analyses, 1, 2, 3, 4, 5, substitute, 1, 3, 4, 5, 2.
“ p. 387, in formula of Kyanite, for ‘$\dddot{\bar{\mathrm{A}}}\mathrm{l}^2\,\dddot{\mathrm{Si}}^3$,’ read ‘$\dddot{\bar{\mathrm{A}}}\mathrm{l}^3\,\dddot{\mathrm{Si}}^2$.’
“ p. 387, line 23 from top, for ‘775·5,’ read ‘·7755.’

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April, 1849.

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AND

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43. 300 species of Cephalopoda, including the genera Ammonites, Ancyloceras, Baculites, Belemnites, Clymenia, Conularia, Crioceras, Endoceras, Gonioceras, Goniatites, Hamites, Lituites, Nautilus, Onychoteuthis, Orthoceratites, Ptychoceras, Scaphites, Toxoceras and Turrilites,	75 00

II. CASTS.

Persons wishing to purchase casts, can be furnished with two plates of engravings, representing them.

1. Mastodon giganteum, Pl. II, fig. 6.	
Lower jaw complete, 2¼ feet long; from the diluvium of the Missouri River,	$6 00
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Two teeth, from the tertiary group of Alabama,	00 75
4. Iguanodon, Hylæosaurus and Gavial.	
14 different bones from the Weald clay of Sussex, England,	5 00
The originals are in the British Museum.	
5. Pterodactylus crassirostris, Goldf., Pl. II, fig. 7.	
Two pieces from the lithographic slate of Bavaria,	3 00
The original is in the Museum of Bonn.	
6. Mystriosaurus species Teleosaurus, Pl. I, fig. 1.	
Cast in 4 parts, 12 feet long, of the best specimen ever discovered, found in the Lias-slates of Boll, Würtemberg,	26 00
The original belongs to Mr. Krantz.	
7. Mystriosaurus longipes, Pl. II, fig. 5.	
Perfect skeleton from the same locality,	9 00
The original in the Imperial Museum at Vienna.	
8. Mystriosaurus, species. Pl. II, fig. 8.	
Head of a small sized specimen from the same place,	1 50
The original is in the Royal Museum at Berlin.	
9. Mystriosaurus, species.	
Vertebral spine with extremities (?), same locality,	6 00
10. Ichthyosaurus platyodon. Pl. II, fig. 2.	
Perfect head of a skeleton 60 feet long,	9 00
11. Perfect fin of the same specimen. Pl. II, fig. 3,	5 00
12. Ichthyosaurus intermedius. Pl. II, fig. 4.	
Head, —— ——? and fins perfect,	7 00
13. Ichthyosaurus tenuirostris. Pl. II, fig. 9.	
Perfect head,	1 25
Originals of Nos. 10–13 in A. Krantz's cabinet.	
14. Ichthyosaurus communis. Pl. II, fig. 10.	
Fin perfect,	0 75
The original is in the Imperial Museum at Vienna.	
15. Plesiosaurus dolichodeirus, Conyb. Pl. I, fig. 2.	
Skeleton perfect, 6 feet long, from the Lias slates of Glastonbury in Somersetshire,	25 00
The original is in the British Museum.	
16. Pelagosaurus, new sp. Pl. II, fig. 14.	
Head, perfect, from Boll, Würtemberg,	1 00
The original in A. Krantz's cabinet.	

This then constitutes a most convenient and economical battery. The first expense of the plates, without the connecting wire is about two shillings. The battery requires no attention from day to day—involves no expenditure for acids—is permanent in its action—and appears to possess every desirable quality for a telegraph for short distances.

In none of the preceding experiments was the wire which formed the circuit wound into a coil, but was stretched out into a long line.

Exp. 13. On the 1st of June, 1849, the galvanometer on the long circuit, Exp. 7, settled at 61°; on the short circuit, Exp. No. 2, it settled at 66°. This is the same as was observed May 15th, the day on which the zinc plate was first buried; although in one instance after a rainy day, an observation of 70° had been recorded. The current during these seventeen days had been remarkably uniform.

I now buried a second zinc plate twenty inches square by the side of the former one, at the depth of two feet beneath the surface of the earth, and connected the two plates by a short wire. The galvanometer on the long circuit settled at 66½°; on the short circuit it settled at 72°. Thus it appeared that by the addition of the second zinc plate which was considerably larger than the first, the strength of the electric current had been increased about one-third.

The following experiments were performed to determine the influence of the size of the copper plate upon the intensity of the current.

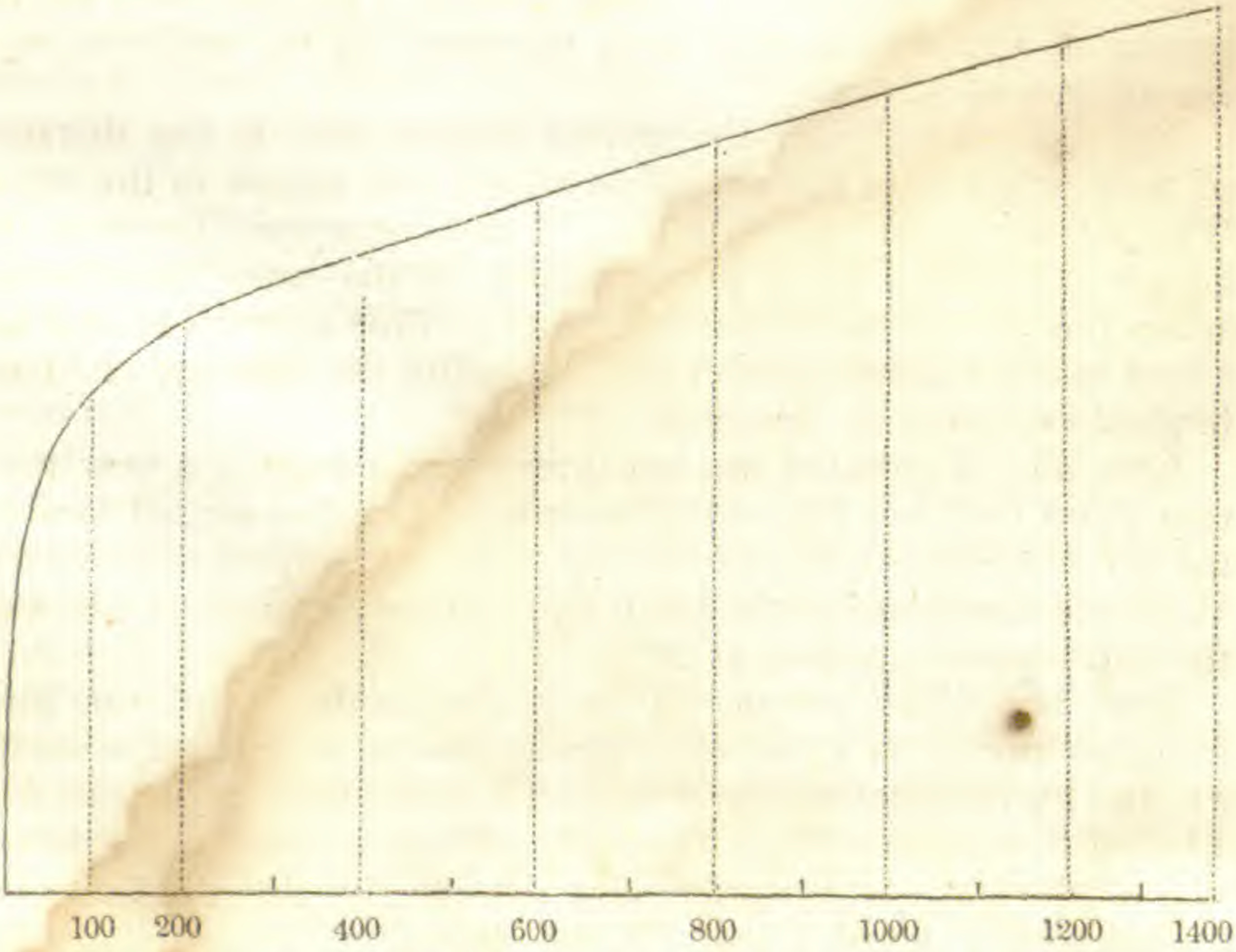
Exps. 14 to 29. I detached copper plates Nos. 2 and 3 from the long wire, and substituted for them a single copper plate forty-eight inches by fourteen immersed in the well. The galvanometer stood at 74¾°.

I now divided the copper plate in the middle leaving a plate twenty-four inches by fourteen immersed in the well. The galvanometer stood at 71½°.

I thus proceeded to divide the copper plate until I had reduced it to three inches by a half inch; after which the plate was entirely removed. I then withdrew the zinc gradually from the well until only three inches of it remained immersed in the water, and noticed at each step the effect upon the needle. The copper wire was $\frac{1}{21}$ of an inch in diameter, and while the copper plate was attached, it was immersed five and a half feet in the water. In the following table, column second shows the dimensions of the copper plate employed; column third shows the entire surface of copper immersed, including both sides of the plate and also the immersed wire; column fourth shows the observed deviation of the galvanometer needle; and column fifth shows the natural tangent of the angle of deviation.

No. of Experiment.	Size of the Copper Plate.	Copper surface immersed.	Deviation of Galvanometer.	Tangent of deviation
14	48 inches by 14	1354 square inches.	74¾°	3·668
15	24 " 14	682 "	71½	2·989
16	12 " 14	346 "	68¼	2·507
17	6 " 14	178 "	66½	2·300
18	6 " 7	94 "	64¾	2·120
19	3 " 7	52 "	62½	1·921
20	3 " 3½	31 "	60¾	1·786
21	3 " 2	22 "	59	1·664
22	3 " 1	16 "	57	1·540
23	3 " ½	13 "	56½	1·511
	Length of wire immersed			
24	6 feet.	10·8 "	56	1·483
25	5½ "	9·9 "	55¼	1·442
26	3 "	5·4 "	46¾	1·063
27	1 "	1·8 "	32¾	·643
28	6 inches.	0·9 "	19	·344
29	3 "	0·45 "	11	·194

The law which these numbers follow is exhibited by the following curve, in which the abscissas represent the amount of copper surface immersed in the water, and the ordinates represent the intensity of the electric current, assuming the intensity to be proportioned to the tangent of the angle of deviation of the galvanometer.



The numbers below the horizontal line represent the square inches of copper surface immersed: the dotted vertical lines represent the corresponding intensity of the electric current.

Thus it appears that for plates less than one square inch, the intensity of the current as measured by its effect upon a magnetic needle, is nearly proportioned to the surface of the plates; but in order to double the intensity of the current yielded by a copper plate of three and one-third square inches, counting both sides, the surface of the plate must be increased fourteen fold; and in order to increase the current fourfold, the surface of the plate must be increased four hundred and twenty fold. In order to double the current again would probably require a copper plate more than sixteen feet square.

The following experiments were performed to determine how far the intensity of the current could be increased by multiplying the number of galvanic elements.

Exp. 30. I buried a plate of zinc six inches square in the earth at a distance of twelve feet from the well used in the preceding experiments. The depth to the surface of the water in the well was also twelve feet. A plate of copper six inches square being attached to a wire and dropped into the well, the galvanometer settled at 45°.

Exp. 31. I then buried a second copper plate of the same dimensions in the earth at a distance of one inch from the first zinc plate, and connected it by a wire with a second zinc plate which was immersed in the well by the side of the copper plate and separated from it to the distance of half an inch by interposed cork. The galvanometer settled at 58°. The tangents of 45° and 58° are in the ratio of ten to sixteen. In this ratio the intensity of the current had been increased by the addition of a second pair of plates.

Exp. 32. I removed the second copper plate to the distance of five inches from the zinc plate which was buried in the earth. The galvanometer settled at 50°. I then interposed between the copper and zinc a third pair of plates of the same dimensions, when the galvanometer settled at 58°. This experiment did not afford much encouragement for increasing the number of plates beyond two pairs of elements.

Exp. 33. I repeated the last three experiments in a new position about four feet from the former one. In this second locality the soil was only eight inches deep, a flat stone lying underneath. With one zinc plate in the earth and one copper plate in the well the galvanometer settled at 26°.

Exp. 34. With a copper plate in the earth distant one inch from the zinc, and a pair of plates in the well, as in experiment 31, the galvanometer settled at 44°. The tangents of 26° and 44° are almost exactly in the ratio of one to two. The intensity of the current was therefore doubled by the addition of a second pair of plates.

Exp. 35. I removed the second copper plate to the distance of twelve inches from the zinc which was buried in the earth. The galvanometer settled at 28½°. I placed the copper plate six inches from the zinc, when the galvanometer settled at 30°. I placed the copper plate five inches from the zinc when the galvanometer settled at 33°. I then interposed a third pair of plates when the galvanometer settled at 40½°. In this experiment the three pairs of plates did not furnish the same intensity as two pairs in Exp. 34. By bringing the plates a little closer together some increase of effect would have been obtained; but although the experiment was several times repeated, nearly the same advantage appeared to be lost in every instance by the separation of the second copper plate from the first zinc, as was gained by the interposition of the third pair of plates.

Exp. 36. I took three pairs of plates six inches by seven, all well secured at distances of one-third of an inch from each other. The outer copper plate was connected by a wire with the zinc plate buried in the earth, as in Exp. 30. The outer zinc plate was connected with the copper plate buried one inch from the zinc, as in Exp. 31. Upon lowering the battery into the well the galvanometer stood at 62°.

Exp. 37. I removed one pair of plates from the battery, the interval between the remaining ones being still one-third of an inch, when the galvanometer stood at 60¾°.

Exp. 38. I removed a second pair of plates from the battery, leaving only one pair separated by a distance of one-third of an inch in the well; and one pair separated by an inch buried in the earth, when the galvanometer stood at 70°.

Thus it appears that one pair of plates immersed in the water affords a stronger current than two or three pairs. The difference between two and three pairs is altogether trifling.

Exp. 39. I removed the copper plate from the ground and the zinc plate from the well, when the galvanometer settled at 53°. The tangents of 53° and 70° are almost exactly as one to two. This experiment therefore leads to the same conclusion as Exp. 34, that with one pair of elements buried in the earth and one immersed in the well, the intensity of the current is double of that furnished by a single pair.

Exp. 40–54. The following experiments were made to determine the influence of the size of the zinc plate upon the intensity of the current. I buried a plate of sheet zinc twelve inches square on the spot employed in Exp. 30. A plate of copper twelve inches by fourteen was attached to a wire and immersed in the well. Upon connecting the two plates by a wire the galvanometer stood at 65½°. I then removed one-half of the zinc plate when the galvanometer stood at 64½°. I continued thus to divide the zinc plate and record the indications of the needle until the plate was reduced to as small dimensions as could well be used. The following table contains the observations. Column second shows the dimensions of the zinc plate employed; column third shows the entire surface of zinc buried in the earth, counting both sides of the plate; column fourth shows the observed deviation of the galvanometer needle; and column fifth shews the natural tangent of the angle of deviation.

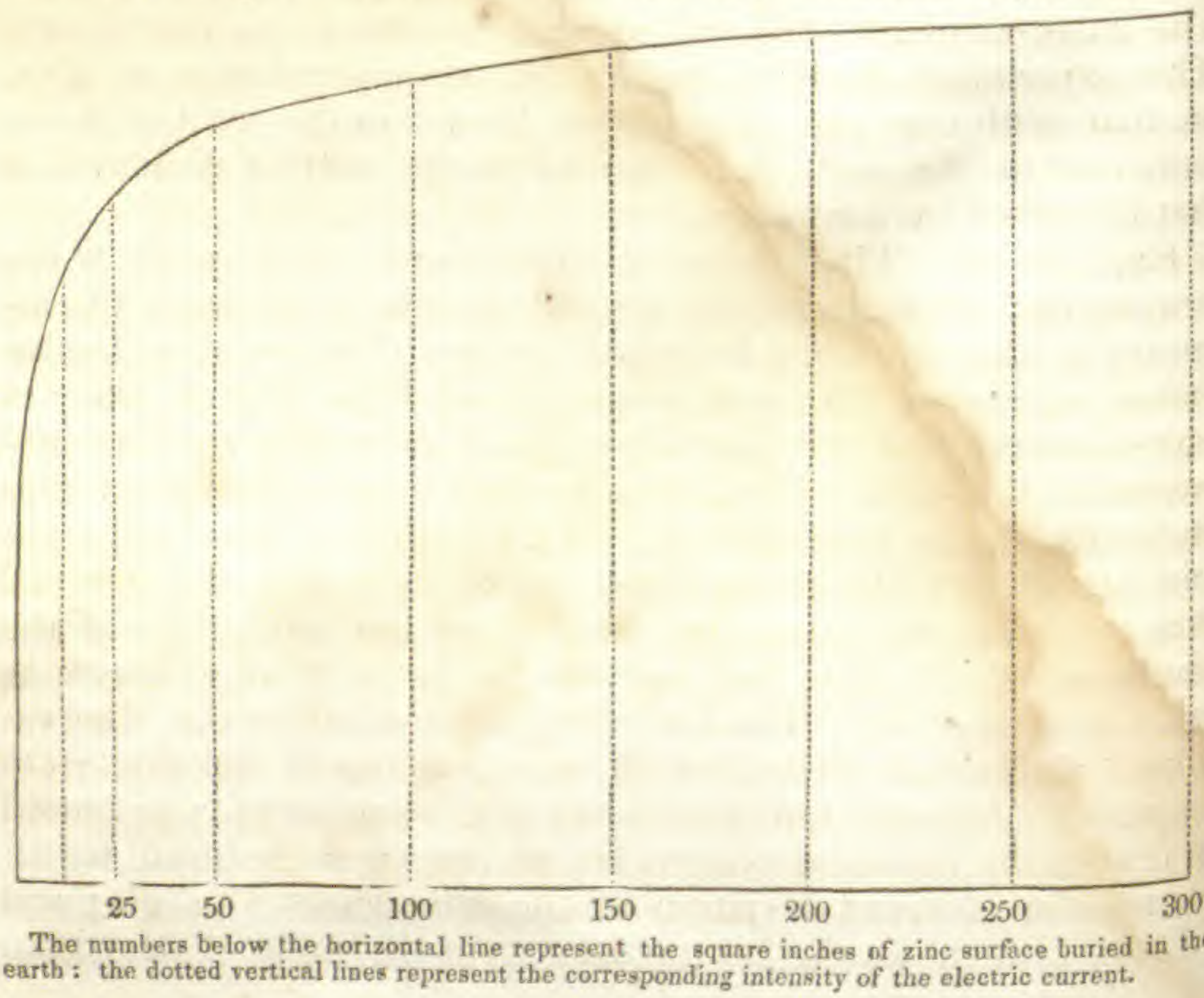
No. of Experiment.	Size of the Zinc Plate.	Zinc surface buried.	Deviation of Galvanometer.	Tangent of deviation.
40	12 inches by 12	288 square inches.	65½°	2·194
41	12 " 6	144 "	64½	2·097
42	6 " 6	72 "	63¼	1·984
43	6 " 3	36 "	61¾	1·861
44	3 " 3	18 "	58¾	1·648
45	3 " 2	12 "	57	1·540
46	3 " 1	6 "	53½	1·351
47	2 " 1	4 "	52¼	1·292
48	1 " 1	2 "	49½	1·171
49	1 " ½	1 "	45	1·000
50	1 " ¼	½ "	42½	0·916
51	½ " ¼	⅛ "	37½	0·767
52	¼ " ¼	⅛ "	31½	0·613
53	¼ " ⅛	$\frac{1}{16}$ "	26¾	0·504
54	⅛ " ⅛	$\frac{1}{32}$ "	24	0·445

Exp. 55. In several of the last experiments the solder with which the copper wire was attached to the zinc plate covered a considerable portion of the zinc surface and impaired the effect of the plate. I therefore cut a strip one-tenth of an inch wide from thin sheet zinc and soldered it to the end of a copper wire. When this was inserted two inches in the ground and connected with the copper plate in the well, the galvanometer settled at 46¼°.

Exp. 56. When the same zinc wire was inserted half an inch in the ground, the galvanometer settled at 36¼°.

Exp. 57. When the end of the zinc barely pressed upon the ground by its own weight, the galvanometer settled at 17½°.

The law which the preceding numbers follow is exhibited by the following curve line, in which the abscissas represent the



The numbers below the horizontal line represent the square inches of zinc surface buried in the earth: the dotted vertical lines represent the corresponding intensity of the electric current.

amount of zinc surface buried in the earth, and the ordinates represent the intensity of the electric current, assuming the intensity to be proportioned to the tangent of the angle of deviation of the galvanometer.

From these experiments it appears that a small wire of zinc inserted half an inch in the ground affords a current half as strong as a plate an inch square; and a plate one inch square affords a current more than half as strong as a plate one foot square; so that even less advantage is gained by increasing the surface of the zinc plate than the surface of the copper plate.

Exp. 58. I took a strip of sheet zinc one-tenth of an inch wide and twenty inches long, and having soldered to it a copper wire sixty feet long, inserted it vertically in the ground near the Philosophical Hall. Upon dropping the end of the copper wire, Exp. 7, seven hundred and sixty feet in length, into the well without any plate attached, the needle settled at $38\frac{3}{4}^{\circ}$. This current worked the telegraph with promptness and efficiency.

The following experiments, No. 59 to 65, were tried with the electricity of the common machine.

Exp. 59. A Leyden jar having a capacity of one quart was charged with the electricity of a common machine, and the charge passed through the long circuit used in Exp. 7. The jar rested upon a table with a wire attached to the zinc plate underneath it. Upon bringing the wire attached to the copper plate near to the knob of the jar the charge passed apparently without difficulty.

Exp. 60. I applied my left hand to the outside of the jar which rested upon the zinc wire as before. On bringing the other wire which I held in my right hand near the knob, the jar was discharged and I received a severe shock.

Exp. 61. The same experiment was repeated with the short circuit No. 2. I again received a shock, but much feebler than before.

It appeared that the circuit through which the jar was discharged in the last two experiments, offered so much resistance to the passage of the fluid, that at least a portion of the charge preferred the shorter route through my body. In order to determine whether this resistance arose from the wire or the interposed earth, the following experiments were tried.

Exp. 62. I took a copper wire $\frac{1}{21}$ of an inch in diameter and one hundred and twenty feet long, and arranged it round the Philosophical Hall so that I could discharge a jar through the entire length or any portion of it at pleasure. When I discharged the jar through thirty feet of wire, I perceived not the slightest shock, although I held one end of the wire in my right hand, and with my left hand clasped the outside of the jar.

Exp. 63. When forty feet of wire were introduced, the shock would not probably have been noticed, if it had not been a particular object of attention. With sixty feet of wire the shock was so slight that it might have escaped notice under ordinary circumstances, but when I clasped the wire very firmly in my hand, the shock was quite decided. With one hundred and twenty feet of wire the shock was felt in both my wrists and slightly up to my elbows.

Exp. 64. In order to obtain some measure of the amount of resistance which this current was capable of overcoming, I took two cat-skins prepared for electric experiments with their fur upon them. One of them was lined with cotton cloth, cotton batting and silk. I doubled each of the skins and laid them together so as to make four layers of fur, the whole being nearly an inch thick when well compressed. When I discharged the jar through the short circuit, as in Exp. 61, my right hand being protected by four thicknesses of fur, I perceived no shock.

Exp. 65. When the jar was discharged through one hundred and twenty feet of wire as in Exp. 63, my hand being protected by four thicknesses of fur, I received a sensible shock. With six thicknesses of fur I perceived no shock, except when some part of my hand or wrist was allowed to come within an inch of the unprotected wire, in which case I received a severe shock, although I held eight or more thicknesses of fur in my hand.

Similar experiments were tried with from one to two hundred folds of silk and with similar results.

The length of wire employed in Exp. 65 was but slightly greater than the wire employed in Exp. 64; and was considerably less than the entire circuit employed in that experiment including the earth. Hence we must conclude that the twenty-seven feet of earth included in the circuit of Exp. 64, offered no appreciable resistance to the passage of the electric fluid. It is inferred, therefore, that the resistance detected in Exps. 60 and 61, was due mainly if not entirely to the length of wire in the circuit.

It is remarkable that the electricity of a single zinc plate should traverse this long circuit so freely, while the electricity of a charged jar seeks in preference the circuit through the human body, although protected by a considerable thickness of the poorest conductors known.

The following experiments were made to determine the influence of the length of the conducting wire upon the intensity of the current.

Exp. 66. I attached a copper plate fourteen inches by twenty-four to the end of the wire which was immersed in the well. I then added six hundred and thirty feet more of wire, making the length of wire in the circuit fourteen hundred and fifty feet, so that the entire circuit, including the four hundred and seventy-five feet of earth, was one thousand nine hundred and twenty-five feet. The galvanometer settled at 69¼°.

Exp. 67. I united the zinc wire, Exp. No. 58, instead of the zinc plates, to the long copper wire, making the length of circuit the same as in the last experiment; when the galvanometer settled at 47¼°.

Exp. 68. I detached five hundred and ten feet of wire, leaving the length of wire in the circuit nine hundred and forty feet. When this was connected with the zinc plates, the galvanometer settled at 69½°.

Exp. 69. I detached three hundred and seventy more feet of wire, leaving the length of wire in the circuit five hundred and seventy feet; when the galvanometer settled at 70°.

Thus it appears that when the length of the circuit was doubled, the intensity of the current was but slightly impaired, which favors the conclusion that the current thus generated might be employed for telegraphing to considerable distances. Mr. Vail succeeded in telegraphing from Washington to Baltimore with such a battery. The size of the plates employed in his experiment was five feet by two and a half.

Exp. 70. I substituted the zinc wire for the zinc plates on the same circuit as in Exp. 69, when the galvanometer settled at 48¼°.

Exp. 71. I connected the zinc plates with copper plate No. 1, on the short circuit, Exp. No. 2, when the galvanometer settled at 72¼°.

Exp. 72. I substituted the zinc wire for the zinc plates on the same circuit, when the galvanometer settled at 48½°.

The preceding experiments were all completed by the 25th of June, and no further experiments were made until September.

Exp. 73. On the 11th of September, I repeated Exp. No. 71, when the galvanometer settled at 71½°.

Exp. 74. On the 3d of October, I repeated the last experiment, when the galvanometer settled at 75°.

Thus for nearly five months, a plate of zinc buried in the earth furnished a current of electricity of an intensity well nigh constant. The entire range of the galvanometer needle was only four degrees. These variations were ascribed to changes in the moisture of the earth, as the intensity of the current was generally observed to increase after a long rain. It does not appear however that on the whole the intensity has diminished during these five months, and it is remarkable that the last observation was the highest made during the entire period, but the ground was at this time unusually wet in consequence of a recent rain.

ART. II.—*Geology of Canada.*

From the Proceedings of the Association for the Advancement of Science, at Cambridge, August, 1849.

MR. T. S. HUNT, of the Geological Commission of Canada, made an oral communication upon the results of the geological exploration of that country, and showed by the aid of a map, the general distribution of the formations and their relation to the rocks of New England. The following is a summary of his remarks.

In presenting the report made by W. E. LOGAN, Esq. to the Provincial government, embracing the results of the survey of 1847–8, I beg leave to offer a brief sketch of the results which have been developed by himself and his assistants. The feature which first claims our attention in looking at the geological structure of this country, is a formation of syenitic gneiss, often passing into mica schist, and interstratified with crystalline limestone, which forms a ridge of high land extending from the coast of Labrador along the north side of the St. Lawrence, at a distance of from twelve to twenty miles from the shore, until it crosses the Ottawa, near Bytown, whence it is traced across lake Simcoe to the shores of Lake Huron, where its northern limit is observed near the mouth of the French river, while it again appears at the southeastern extremity upon Matchedash Bay. Resting upon this are a series of rocks forming the whole north coast of the lake and numerous small islands. It is made up of sandstones, often coarse-grained, and sometimes becoming conglomerate from the presence of red jasper pebbles. These beds are associated with slates, and one or more bands of limestone. The slates are greenish, and highly chloritic, often containing epidote; sometimes they assume the character of conglomerates, from the presence of pebbles of syenite. The formation is much cut by greenstone dykes, and exhibits very frequently interstratified beds of greenstone often of great thickness. Both these and the sedimentary beds contain metalliferous quartz veins, of which the copper mines of this region are examples. Resting unconformably upon the tilted edges of this formation, and in other places directly upon the southern limit of the syenitic gneiss, appear the silurian rocks, identical with those which are found in New York, and cover the peninsula between Lake Huron and Lake Ontario. Beginning with the rock designated in the New York nomenclature the Potsdam sandstone, we have upon the Manatoulin Islands and the coast between the Matchedash Bay and Sarnia, a complete exposure of those formations known as the Trenton limestone, Utica slates, Loraine Shales, Medina sandstones, and the Niagara limestones, with the rocks of the Clinton group. All of these are well characterized by their respective fossils, and are spread out quite undisturbed at a very gentle dip of about thirty-five feet in a mile. The thickness of these rocks, as exhibited in a section across the Grand Manitoulin and La Cloche Islands, was found to be from the base of the Potsdam sandstone to the top of the Niagara limestone, 1,273 feet.

Passing to the east, we find that the syenitic rocks have divided near where they cross the Ottawa, and taking a southward course, are spread over a considerable extent of country between the Ottawa and the St. Lawrence. Crossing this river below Kingston, they constitute the greater part of the Thousand Isles, and are extensively developed in the northern counties of New York.

The country thus bounded on the west and north consists of a broad valley of twelve to twenty miles on the north, and thirty to forty miles on the south side of the St. Lawrence, which at its southwestern extreme, includes the valley of the Richelieu and the northern part of lake Champlain. On the southeastern side of this is a mountain belt of from twenty-five to thirty miles in width; this is the prolongation of the Green Mountains of Vermont, which further north constitute the Shickshock and Notre Dame mountains of Gaspé. This mountain range, coincident with the course of the river, is bounded at its southeastern base by a valley of gently undulating land, from twenty to thirty miles in width, which may be traced from the upper part of the Connecticut river to the upper portion of the St. Francis; thence by the eastern branch of the Chaudière to the Rivière de Famine, a tributary of the Chaudière, the valley is continued in the course of the St. John's until further on, it falls into the valley of the Ristigouche, and is thence traced quite into the Baie des Chaleurs. The general strike of the rocks is coincident with the direction of the St. Lawrence and the mountain range, and the same geological formations appear continuous without.

If a line be drawn from St. Scholastique, upon the north shore of the Ottawa, passing forty miles S. E. to Montreal, and thence to Canaan, on the Connecticut river, in the north of Vermont, we shall have a section nearly at right angles to the general course of the formations. Commencing at the northwest, the first rock which presents itself resting upon and skirting the bases of the hills of the syenitic gneiss and crystalline limestone, is a fine sandstone, which is seen on both shores of the Ottawa at its mouth, constituting there a considerable island, and is thence traced south into the county of Beauharnois, where it spreads out to a considerable width, and passing into the state of New York, divides against the syenitic formation. Sweeping around its base, one portion passes up the valley of the St. Lawrence, and the other is developed in that of Lake Champlain, where it is recognized as the Potsdam sandstone. To the northeast it probably skirts the base of the syenitic rocks, and has indeed been observed at the Falls of the St. Maurice, but owing to the great depth of tertiary deposit which fills the valley, the opportunities of examining it are but few. The next rock upon the line of section is a limestone, very silicious at the base, but pure and thick-bedded in the middle, gradually becoming bituminous and shaly toward the top. This formation, exposed at a very moderate dip, constitutes the greater portion of the island ot Montreal, and crossing below to the north side of the river, is lost beneath the tertiary sands and clays. To the south, it sweeps around the extremity of a trough, until it reaches St. John, where either turning over an anticlinal or affected by a dislocation, it turns up the west side of the Richelieu and runs into New York.

This formation is shown by its fossils to be referable in its lower part to the calciferous sandstone, while the upper beds are the Trenton limestone. It contains interstratified greenstone trap, sometimes amygdaloidal, which constitutes the mountain of Montreal. Resting upon this limestone is a set of black shales which appear on both shores of the river before Montreal, and constitute some islands in its bed. To the south, these shales, which are the Utica slates, follow the course of the limestone, keeping the east shore of the Richelieu, and spreading out to a considerable breadth, constitute the region of country between the mouth of Lake Champlain and Missisquoi Bay. To these succeed a series of shales, bluish and grayish, arenacious, and more or less calcareous, which are evidently from their fossils the Loraine shales. These are seen upon the Richelieu at Chambly, upon the Yamaska near St. Hyacinthe, and in several other points along the line of strike. They present a considerable breadth, and are not improbably kept at the surface by some little undulations. Succeeding these, after two or three miles, covered by tertiary sands, appears a repetition of the Trenton limestones, which have been traced from Philipsburg, upon the line of Vermont, through the Seigniory of St. Hyacinthe, to Deschaillons, where they cross the St. Lawrence, and are exposed again upon the northern shore. These are followed by a repetition of the Utica slates and Loraine shales, which flank the limestones upon the St. Lawrence, and are exposed at various points along the strike. Upon the Barbue river, in the Seigniory of St. Hyacinthe, occurs what appears to be a small trough of higher rocks, consisting of heavy greenish sandstones, interstratified with red and chocolate-colored slates, sometimes mixed with green bands. These red slates are highly ferruginous, and sometimes contain traces of oxyd of titanium. Near the line of Vermont, appears, succeeding the Trenton limestone, the extremity of a similar trough of slates and sandstones, more or less calcareous, which is prolonged into Vermont. In Yamaska mountain a mass of trap lies in the line of the St. Hyacinthe sandstones and red slates, and brings up on its flanks similar sandstones and bluish and greenish slates, with a crystalline yellow-weathering limestone. The sandstones near the trap contain mica and plumbago.

These rocks, however, are not seen upon the line of section, but in their strike occur the bluish and grayish calcareous and arenaceous shales, which are followed by light greenish and ash-gray slates, interstratified with gray sandstones. Following these appear the red slates with green bands and their accompanying sandstones, which are sometimes finely conglomerate and more or less calcareous, often containing mica and graphite. These are associated with bands of a greenish chloritic limestone, holding small portions of oxyd of chromium in some form, and near the base, with one or two beds of greyish limestones. South of this section line, the strata on each side of this deposit converge, but northwardly the breadth gradually increases, and seems to show that these rocks form a trough more or less disturbed by undulations. Following the western side of the trough, the slates with their accompanying sandstones, crossing the St. Francis, are seen at St. Nicholas on the St. Lawrence, and in the rear of Point Levi near Quebec. On the eastern side, the slates are followed to Roxton, where affected by an undulation, they sweep round towards Shefford Mountain, and thence are traced to Inverness on the Becancour, accompanied by the beds of limestone, already mentioned as associated with them at the base. Beyond these, on the line of section, are a set of gray and black clay slates, with thin-bedded sandstones and limestones, which although presenting no fossils, appear in their general characters identical with those on the other side of the trough and with the fossiliferous beds of the Richelieu and Yamaska. These rocks appear to run upon an anticlinal to Shefford, where an undulation has been described as carrying the sandstones to the east; thence upon another anticlinal across the Nicolet, where the dark slates and limestones are traced around into a narrow anticlinal valley which runs parallel with the other anticlinals, and is continued to the province line in the township of Sutton.

This double trough contains two great masses of trap, which constitute Broome and Shefford mountains, and appear to have disturbed and altered the rocks to a considerable extent. South of these intrusive rocks we have first upon the section, greenish and gray clay slates, followed by a belt of silicious and calcareous rocks, which vary from a somewhat arenaceous limestone to a feebly calcareous sandstone. These are seen in some places divided into three bands by the intervention of clay state, probably by undulations, which produce repetitions.

The limestone is dolomitic, and is cut in all directions by great numbers of quartz veins; it sometimes contains garnets, and is associated with iron and copper pyrites. At the distance of about a mile is another band of limestone precisely similar, and accompanied, like it, with slates and quartzose beds, which seem to be altered sandstones, and make the first high lands of the mountain district. This ridge, with its two bands of dolomite, appears to be synclinal, and it is traced about ten miles from the province line, where it dies out. Here another hill about half a mile to the S. E., apparently an anticlinal, takes up the same measures.

To these succeed a series of more or less quartzose chloritic rocks, with an imperfect slaty cleavage. They seem to be altered sandstones, which upon their western border, where the alteration has been less profound, still present their original structure. Following these, appears a band of limestone resembling the last, and often divided into two or three belts by green chloritic or gray talcose slates, interstratified with beds of an impure specular iron ore, more or less mixed with chlorite and often titaniferous. The limestones sometimes contain green and purplish talc and occasional crystals of chromic iron; they are marked by the same quartz veins as before. About two miles farther on, a precisely similar belt occurs, and the interval is filled with talcose, chloritic and epidotic slates, associated with bands of magnetic and specular iron. The epidote forms little nodules, and is often associated with quartz; rutile with specular iron is sometimes found crystallized in quartz veins. From this, extending to the Sutton valley, which is the supposed prolongation of the anticlinal, is about a mile of hard quartzose rocks slightly chloritic.

Another section is presented upon the St. Francis, which cuts the rocks nearly at right angles; it shows the dark colored slates and limestone supporting greenish silicious slates, followed by a belt of brown-weathering dolomite, interstratified and accompanied with purple sandstones and red slates, to which succeeds at a distance of about a mile, another belt of limestone, with quartzose bands. The intermediate rocks are sandstones, and conglomerates, often almost pure quartz; southeast of the limestone are seen two or three miles of chloritic rocks, with nodules of epidote and quartz, followed by a band of dolomitic limestone, with veins of magnetic and specular iron ore, and associated with talcose slate. To this succeeds an extent of heavy quartz rock, slightly talcose, and another band of dolomite interstratified with talcose slate, which is followed by the same fine greenish silicious slates as were observed on the western side. Beyond these are found the dark slates with their thin limestone beds, which, as has been already remarked, have been traced around to the opposite anticlinal. The fact that the dolomites and sandstones within, are traced around in the same manner, and the similarity in their lithological characters, shows that they are on opposite sides of a synclinal.

On the line of section, about a mile beyond where the Sutton dolomites would cross, occurs another belt of dolomite associated with soapstone and green chromiferous talc. In its strike we find in one place a band of soapstone filled with bitter-spar, and passing on the northwest into a dolomite of the usual character, while on the southeast is a narrow band of green serpentine. Another dolomitic band occurs a little farther, associated with green talc, serpentine and soapstone. It has been followed for a considerable distance, and in one place consists of soapstone with patches of dolomite, which in the distance of about three hundred yards on the strike, passes into a band of dark green serpentine with soapstone. At other places in the strike, the soapstone is associated with chromic iron, and in one place a bed of magnesite with chromiferous talc. These appear to constitute a trough, and the interval is filled with coarse quartzose chloritic slates, occasionally epidotic, with imbedded crystals of magnetic and specular iron; mica and feldspar are not unfrequently met with.

Following this, the rocks for the next five miles are coarse chloritic micaceous schists, often feldspathic, passing into gneiss, and in some places, very quartzose. About three miles on the line of section, is a band containing talc and calcareous spar, the latter making a considerable portion of the rock, which is stained green with oxyd of chrome. East of this the rock is more feldspathic and contains small crystals of tourmaline. These measures as they go south expand into a wide mountain tract, the summit of which, Sutton mountain, is more than four thousand feet above the St. Lawrence. A valley in the line of the chromiferous calcareous rocks divides the mass into two ridges, one of which dies down very soon, while the other crosses the line of section and is lost a few miles farther north; this region still requires further examination, to determine accurately the relations of the western portion.

On the eastern side of this range occurs a belt of soapstone and serpentine, which has been traced at intervals a distance of twenty miles along the west borders of the Missisquoi. On the west it is bounded by a quartzose chloritic band, associated with a translucent silicious rock of a corneous lustre and fracture. In the strike of the serpentine further north, dolomite is found. On the east side of the river, at the distance of a mile and a half from the former, another serpentine band occurs; the interval is filled with slates and gray quartz rock, with some beds of chloritic and epidotic rocks and a curious jaspery quartz rock containing epidote. This band of serpentine has been traced one hundred and thirty-five miles from the province line across the Chaudière, to the township of Cranbourne. In some parts, it seems to pass into or is associated with a diallage rock, and in others to be a mixture of quartz and serpentine. Like the western band, it is accompanied with soapstone and contains veins and disseminated grains of chromic iron.

Beyond this occur clay slates with beds of white, compact quartz of a scaly fracture and horny lustre, containing often imbedded diallage, hornblende, pyroxene or feldspar; sometimes the rock is nearly homogeneous, but at other times grains of angular, transparent quartz show clearly its conglomerate character. This rock accompanies the serpentine throughout, and constitutes a range of mountain peaks, one of which, Orford Mountain, is more than four thousand feet above the sea. Beyond this still, on the line of section is a band of impure dolomite, which farther north in the strike is replaced by soapstone, magnesite, and serpentine; a similar band is seen again after an interval of a mile, filled with gray slate and the corneous rock.

To these rocks follow gray fossiliferous limestones interstratified with calcareous slates, which form apparently two narrow parallel troughs, one on each side of Lake Memphremagog. On the east side, at Georgeville, they are followed by gray and black glossy slates, and then by talcose and chloritic slates, often micaceous and associated with quartzose beds, and others very talcose; in the strike of these upon the lake appears a band of serpentine, followed by fine silicious talcose slates. From the position of these rocks, there appears evidence of a great dislocation which has divided the fossiliferous troughs and brought up the corneous rock in a mountain mass on the west side of the lake. Evidence of an anticlinal in this line is found in the dip of the fossiliferous limestones near the quartzose rocks farther on in the strike. Beyond these rocks, east of Georgeville, highly crystalline limestones appear, which however still display fossils that admit of identification.

The remaining twenty miles of the section to the Connecticut exhibit these crystalline micaceous limestones, interstratified with soft micaceous slates; the calcareous beds predominate for a few miles, but the calcareous matter finally gives place to silicious, and the slates become stronger. Some of the prior argillaceous beds contain chiastolite, and others exhibit hornblende and garnets. The limestones are more or less micaceous, and often very crystalline; some are quite white, while others are grayish or blackish. Even the most crystalline present on their weathered surfaces the forms of encrinal discs and corals; and in several the characteristic *Favosites gothlandica*, with various species of *Cyathophyllum* and *Porites* are observed. At Dudswell in the line of the strike, the fossiliferous beds are finely exposed, and upon the Rivière de Famine, the rock, which is here less crystalline, exhibits, besides these and other fossils, the *Atrypa affinis*. The fossiliferous beds appear to be near the base of the formation. The rocks of this valley, southeast of the corneous range, are often pierced with masses of a fine-grained, beautiful granite, which forms large dykes and often considerable areas, displacing the calcareous formation. A range of granite-topped hills bounds the valley on the southeast, to the sources of the Chaudière, and constitutes the height of land.

The facts which we have stated seem to show that the sandstones and red slates with their chromiferous chloritic bands, are identical with the dolomitic, chloritic and quartzose rocks of Sutton valley, and these with the serpentines and quartzose rocks of the valley of the Missisquoi; so "that the whole of the Green Mountain rocks, including those containing the auriferous quartz veins, belong to the Hudson River group, with the possible addition of a part of the Shawangunk conglomerates." The fossiliferous rocks of the St. Francis valley are evidently Upper Silurian and referable to the Niagara limestones; a similar formation has been met with at Gaspé and traced one hundred and fifty miles S.W.; and from the similarity of the Notre Dame to the Green Mountains and the fact that the Hudson River rocks are continuous along the St. Lawrence to Cape Rosier, we may conclude that the Upper Silurian rocks will be found continuous, or nearly so, throughout. They constitute the calcareo-micaceous formation of Prof. Adams, which he has traced nearly to the southern line of Vermont. Resting upon this formation in Gaspé is a body of arenaceous rocks, seven thousand feet thick, which apparently correspond to the Chemung and Portage group of New York, with the old red sandstones. As this formation is found extending quite to the Mississippi, it is probable that it will accompany the Silurian rocks through New England and surround the coal fields of New Brunswick, of Eastern Massachusetts and Rhode Island. To this may perhaps be referred in part the rocks of the White Mountains, which may sweep around the Western border of the Massachusetts anthracite formation until lost under the super-carboniferous rocks of the Connecticut River. The limestones of Western New England seem to be no other than the metamorphic Trenton limestones of Phillipsburg, while the chlorito-epidotic rocks and serpentines of Sutton valley appear again in the rocks of southern Connecticut between these limestones and the new red sandstone. With such a key to the structure of the metamorphic rocks of New England and of the great Appalachian chain of which these form a part, we may regard the difficulties that have long environed the subject as in a great degree removed, and the bold conjectures as to their metamorphic origin which have been from time to time put forth, fully vindicated.

ART. III.—*Ash Analyses;* by JNO. A. PORTER.

[Read before the Cambridge Scientific Association, Sept. 27, 1849.]

THE following analyses of the ashes of hay, oats and the refuse of the whiskey distillation from potatoes, were intended as the starting point of an investigation which had for its object the consideration of the proportions and relations of the salts contained in the food, and in the liquid and solid excrements of animals. This investigation was interrupted by circumstances, but as the analyses have a certain value independent of the special object for which they were intended, they are here made public. The method employed was, without material variation, that of Fresenius and Will, (see Fresenius's quantitative analysis). The alkalies were determined by the indirect method, that is, weighed together either as sulphates or as chlorids, and the quantity of each calculated from that of the sulphuric acid in chlorine found in the mass.

	Potato refuse.	Oats.	Hay.
SiO_2	2·84	53·97	30·01
SO_3	6·10	0·49	2·11
PO_5	16·78	17·35	15·43
CO_2	12·27	——	0·68
KO	38·52	12·94	20·80
NaO	4·47	2·02	10·85
CaO	5·19	3·00	8·24
MgO	7·33	7·08	4·01
Fe_2O_3	1·50	0·60	1·83
$NaCl$	4·00	——	5·09
	99·00	97·45	99·05

The hay was from the grass commonly known as bluetop.

ART. IV.—*A Product of the action of Nitric Acid on Woody Fibre;* by JNO. A. PORTER.

[Read before the Cambridge Scientific Association, Sept. 27, 1849.]

THE occasion of the investigation, the results of which are here given, was the appearance in the Annales de Chimie et de Physique,* of an article by Prof. Sacc of Neufchatel, Switzerland, on the functions of pectic acid in the vegetable kingdom. He supposes that woody fibre is a product of its transformation, and that the retransformation of woody fibre into pectic acid takes place in plants, under certain circumstances. That the latter transformation is

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* Ann. de Chim. et de Phys., [3], xxv, 219–230.

possible he conceives himself to have proved, by subjecting woody fibre to the action of nitric acid, the product of such action being a substance which he regards as pectic acid. From this in connection with other circumstances, he infers the probability of the same change under the influence of certain agencies in the living plant. The grounds presented by Prof. Sacc for believing that the substance above mentioned was pectic acid, are scarcely sufficient. The object of the present investigation, undertaken at the suggestion of Prof. Liebig, was to decide this point.

Prof. Sacc's process was repeated, and the reactions of the substance obtained were compared with those of the substance acknowledged as pectic acid, obtained from turnips. The latter was prepared according to the method of Chodnew.*

200 grammes shavings of white pine were heated some hours with 2 kilogrammes nitric acid of commerce and 400 grammes distilled water, and the white pasty mass that resulted washed out with water, likewise distilled. Prof. Sacc found a sample of the mass thus obtained, perfectly soluble in dilute ammonia, and it was this substance dried at 212° F. that he subjected to analysis. The mass obtained by myself was not perfectly soluble in water containing ammonia. A substance of syrupy consistence remained in small quantity upon the filter. The whole quantity was therefore treated with ammonia and the solution filtered and afterwards precipitated by hydrochloric acid. The precipitate was washed out, at first with slightly acidified water, then with pure water and finally with alcohol. After thoroughly drying at 212°, this substance was of a reddish gray color.

A difference in its behavior and that of the pectic acid from turnips is observable on washing out with alcohol—the latter becomes fibrous on being pressed with the hand; the former retains its slimy consistence.

The following are the results of the comparison of the two substances dried at 212°.

The pectic acid is slightly soluble in boiling water and its solution coagulable by sugar or alcohol. The substance from wood is on the contrary insoluble in water.

The pectic acid is easily soluble in alkalies and reprecipitable by acids as a perfectly transparent jelly. The substance from wood is difficult of solution in alkalies, and the precipitate, at first transparent, contracts rapidly to white translucent flocks. From a solution more strongly alkaline it is precipitated as a light white powder; this was not the case with the pectic acid.

The alkaline solutions of both substances are precipitable by alcohol. Either substance boiled with excess of potash loses after a time its property of being precipitated by acids.

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* Annalen der Pharmacie, li, 355.

The behavior of alkaline solutions of both substances toward bases is, as far as observed, similar. The silver, lead and copper salts, for instance, possess a similar appearance.

Either substance treated with hydrochloric acid, imparts a red color to the liquid. Sulphuric acid acts similarly, at the same time blackening the substance and giving off the color of caramel. With moderately dilute nitric acid their action is different. The pectic acid is partially transformed into mucic acid, which separates on cooling as a white crystalline powder, and is further recognizable by its insolubility in alcohol and its difficult solubility in water. This action was observed by Frémy. Chodnew obtained no mucic acid, probably because too concentrated acid was employed. The substance from wood, boiled with acid of the same concentration, is gradually transformed into oxalic acid; the solution yields no precipitate on cooling.

The substance employed in the following analyses was dried at 212°, then pulverized and afterward dried again at 212°, until there was no farther loss of weight. It contained no trace of nitrogen.

Its per-centage of ash was determined in two portions.

I. 0·5390 grm. yielded ash, 0·0020 grm. =00·37 per cent.
II. 0·4768 " " " 0·0018 " =00·38 per cent.
Mean, - - - - - 00·375 per cent.

Three combustions of the substance were made with chromate of lead. The results were as follows:

I. 0·5583 grm. yielded 0·8847, CO_2 and 0·2925, HO.
II. 0·3531 " " 0·5630, " " 0·1892, "
III. 0·4602 " " 0·7256, " " 0·2383, "

The composition in hundred parts, calculated from these analyses, taking the ash into account, is as follows:

	I.	II.	III.
C .	43·38 .	43·64 .	43·16
H .	5·84 .	5·97 .	5·78
O .	50·78 .	50·39 .	51·06

The formula $C_{16}H_{13}O_{14}$ expresses very accurately this composition:

	Mean of analyses.	Calculated from formula.
C . .	43·393 . .	43·44
H . .	5·863 . .	5·88
O . .	50·744 . .	50·68

The only grounds presented in Prof. Sacc's paper for believing that the substance analyzed by him was pectic acid, are its appearance, its ready solubility while yet moist in ammonia, and its property of being precipitated from this solution by acids. Its composition is not such, for the quantity of hydrogen it contains is much greater than that found by any investigator in the substance acknowledged as pectic acid. The mean results of Chodnew's analyses of this acid, to which those of Prof. Sacc most nearly approach, are as follows—for convenience of comparison, Prof. Sacc's results are given in the second column, my own in the third:

C	42·22	41·93	43·39
H	5·21	5·93	5·86
O	52·55	52·14	50·75

Chadnew's formula is $C_{28}H_{20}O_{26}=C_{14}H_{10}O_{13}$.
Prof. Sacc's " " $C_{14}H_{12}O_{13}$.

The results of my own analyses of the substance from wood differ from those expressed by the latter formula, principally in the larger amount of carbon found; they differ also as widely from those obtained in any analysis of pectic acid. My further reasons for believing that the substance is not such, are, first, its different behavior on washing with alcohol; second, its insolubility in boiling water; third, the form of the precipitate obtained from a solution in excess of alkali; and finally, the fact that while pectic acid is partially transformed into mucic acid on being boiled with nitric acid, this is not the case with the substance under consideration.

My further conclusion from the investigation is that the real formula of the new acid is $C_{16}H_{13}O_{14}$.

ART. V.—*On the Navicula Spencerii;* by WARREN DE LA RUE.

(In a letter to the Editors, dated London, August 28, 1849.)

SOME time since, my attention was called to an article, in your Journal, for March, 1849, from the pen of Prof. J. W. Bailey, entitled, "Some remarks on the Navicula Spencerii, and on a still more difficult test object;" as this article contains some strictures on the description* of the markings on this Navicula observed by Mr. Marshall and myself, I trust, you will allow me an opportunity of replying to Prof. Bailey, in your valuable Journal.

I avail myself of this opportunity to correct Mr. Quekett, with respect to the nature of the markings observed by us;—he says, "Mr. De la Rue has further made out that the dots are not projections from the surface, but are either perforations or depressions;"—now this is precisely the reverse of what I wished, but apparently failed, to convey to Mr. Quekett, in a conversation I had with him, respecting this and some others of the Navicula-

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* See Quekett on the use of the Microscope, page 440 and plate ix.

ceæ; the markings of some I hold to be depressions, but those of N. Spencerii to be wart-like prominences.

With this correction, I proceed to answer Prof. Bailey, first premising, that I bear most willing testimony to the strong feeling of justice and absence of national prejudice, which pervades all the letters written by that gentleman to my friend, Mr. Marshall, whenever he speaks of the labors of English opticians; likewise the absence of any wish to eulogize Mr. Spencer's productions, at the expense of others. It is not, perhaps now, an unfitting occasion, to state that English microscopists have, during a long period, been much indebted to the kindness and zeal of Prof. Bailey, furnishing them, through the medium of the gentlemen favored by his correspondence, with any new objects, his investigations might have brought to light. I mention this, in order to show that the highest esteem is entertained by the English microscopist for Prof. Bailey, and that it is unlikely that he would be charged directly or indirectly, "with underrating the English microscopes," or with any *wish* to "overrate the merits of Mr. Spencer's, or the difficulties of N. Spencerii as a test object;" more especially by those who have, like myself, had an opportunity of seeing portions of his correspondence relating to the subject.

As I hold, that the difficulty of the N. Spencerii has been unwillingly overrated, if the exhibition of its markings, as mere lines, be the only test of the powers of an object glass, I should be wanting in candor, if I did not record my opinion.

Not having taken part in the correspondence quoted by Prof. Bailey, I do not, in any way, hold myself answerable for the opposite impressions, it may tend to convey; it is not however a question, of what this or that observer is capable of showing with a given object glass, but what the glass can really be made to do. With one exception, I believe that none of the object glasses, spoken of by Prof. Bailey's London correspondent, were incapable of resolving the Navicula; the fairness of which reference I hope to establish. The exception I allude to, is Mr. Marshall's own glass, which, on careful examination, we found to be defective; and, in consequence, it was placed in the hands of the maker.

I will now as briefly as possible, state my acquaintance with the N. Spencerii, in order to show that any difficulty in resolving its markings, was not due to the object glasses possessed by the "Londoners."

It was only subsequently to the letter, dated 2nd June, 1848, quoted by Prof. Bailey, that I heard of the Spencerii, when Mr. Marshall mentioned to me, that he had received a most difficult object from America, which he would be glad of an opportunity of examining with me, as he could make nothing of it; an opportunity soon presented itself and we met at my house.

The object alluded to, was a slide of the N. Spencerii mounted in balsam, and sent over to Mr. Marshall by Prof. Bailey; two rings marked with a diamond, indicated two objects to be examined. The test having been illuminated with oblique light, from a lamp with and without the use of the mirror, was examined with a Ross's $\frac{1}{12}$th having only an aperture of 90°; this objective had been in my possession for some years, and was far inferior to those Ross was furnishing, with an aperture from 115° to 120°.*

Very little difficulty was now experienced in bringing out separately both sets of lines most distinctly, by illuminating in two different directions. We now attempted to examine the object with a Ross's $\frac{1}{12}$th, of 110°; but, owing to the thickness of the covering-glass, we could not get it on the object; as it was an only specimen we did not deem it advisable to change the covering-glass.

In consequence, Mr. Marshall undertook to write to Prof. Bailey, to request the favor of a little of the deposit, in order to mount fresh specimens, both dry and in balsam; the former with the view of studying the nature of the markings under the most favorable circumstances.

I believe I am right in saying that the first parcel which arrived was lost by an accident; at all events, it was not until the 14th of August. 1848, that Mr. Marshall had prepared specimens with covering-glass sufficiently thin for our large aperture $\frac{1}{12}$ths. On that day he wrote to me, "I have prepared two sides for you, one in balsam and the other dry, they have been both evaporated on the covering-glass which is exceedingly thin. * * * * I should like to go over the slides I have prepared, and particularly the dry mounted one, for the purpose of resolving it, if we can, by direct light. The Bank is so disturbed by the heavy omnibuses that your own quiet room is the best place, and if you should be disengaged some evening, I will go to your house, taking with me the slides and two or three others which I have for your cabinet."

Previously to his writing the above, we had succeeded in showing the markings with a large aperture $\frac{1}{4}$th inch objective of Ross's make, having an aperture of 80°. This fact was communicated verbally to the Microscopical Society, on one of the ordinary meetings, by Mr. Marshall.

Having again met at my house, we examined the dry and balsamed specimens; as we were well acquainted with the N. angulata, we at once proceeded with the view of ascertaining

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* Mr. Ross, some time back, succeeded in making a twelfth with an aperture of 135°, in which the aberrations were well corrected. It is now in the possession of Dr. Leeson.

whether the N. Spencerii had similar dot-like markings; to determine this was a matter of greater difficulty than to resolve them into cross lines; but, after working for about an hour, the dry specimen was most satisfactorily resolved; and the dots exhibited on that occasion we did not succeed so well in showing, in the markings of the balsamed specimen. Direct illumination was used on this occasion, the illuminator being a $\frac{1}{4}$th inch object glass of 60°.

It appears that Mr. Marshall communicated in his letter of the 18th August, 1849, quoted by Prof. Bailey, that the dry specimen had been resolved into dots, and that ere long, he hoped to report the resolution of the balsamed specimen; this has been since repeatedly accomplished, but, whether recorded or not by Mr. Marshall, I cannot say.

I feel I am warranted in pronouncing *the markings of the Navicula Spencerii shown as lines, not to have been a difficult test for the object glasses of the* "*Londoners*" at the time of its arrival. It appears it was so, however, for some observers, and Prof. Bailey drew from his correspondents' letters the very fair inference, that the instrument was at fault and not themselves; he supports, however, my conclusion, when he states that the microscopes which, in the hands of their possessors, had failed to show the markings, readily resolved them in his.

With regard to the measurements of the distance of the markings, fixed by Prof. Bailey at values so widely different from my own, I have to remark, that I delayed answering his communication, in order to repeat my measurements with every possible precaution.

Prof. Bailey states the distances of the markings to be from $\frac{1}{120000}$th to $\frac{1}{200000}$th of an inch, whilst I assign to them a value of from $\frac{1}{45000}$th to $\frac{1}{50000}$th of an inch, (from centre to centre of the spots.) That the measurement given by me was not very wide of the truth, I will proceed to show, and I believe that Prof. Bailey, on reference to his notes or on repeating the measurement, will trace out the cause of the error he has fallen into.

My previous measurements were made with a ruled micrometer, used with a positive eye-piece, the value of whose divisions had been rigorously estimated by comparison with a micrometer of $\frac{1}{5000}$th of an inch, placed on the stage of the microscope. I have now repeated the estimation by a different, and I believe a preferable, method to that I employed before, viz., by illuminating the object to show alternately the markings as cross and longitudinal lines, and then drawing them, by the aid of a small steel reflector, shown at page 129 of Mr. Quekett's work. Retaining the microscope in exactly the same position, I removed the object, and placed on the stage of the microscope first a micrometer of $\frac{1}{5000}$th of an inch which I sketched on the paper; having by comparison roughly estimated the value of the markings, I then selected two sets of lines from Nobert's test slide, according, as nearly as possible, with this estimate; the lines of the two selected were the $\frac{1}{45045}$th and the $\frac{1}{36056}$th of an inch apart from centre to centre, these were set off in the same way.

The drawing of the markings, that of the micrometer of $\frac{1}{5000}$th of an inch, and those of Nobert's series, were compared together by taking a sufficient number of lines in a pair of dividers, and the distance of the markings thus ascertained. This operation was repeated, first with an eye-piece, magnifying 1200 diameters, then with one magnifying 1900 diameters. The distances of the cross markings from two different sides of the shell, estimated with the first eye-piece, was $\frac{1}{45000}$th and $\frac{1}{47000}$th respectively, with the second eye-piece, the distances for the same part of the shell, were $\frac{1}{45667}$th and $\frac{1}{46000}$th respectively. The longitudinal markings in both cases I found to be $\frac{1}{50000}$th of an inch. All these values are from centre to centre, and are sufficiently concordant, amongst themselves and with those previously given, to establish my measurements beyond doubt. The difference in distance between the cross and longitudinal lines, accounts for the greater difficulty one experiences in resolving the latter.

Measurements of the markings of the hippocampus gave the following values: for the distance of the centres of the cross markings $\frac{1}{37000}$th of an inch and for the longitudinal $\frac{1}{32000}$th of an inch; these were fully confirmed by comparison with Nobert's lines of $\frac{1}{32175}$th and $\frac{1}{37537}$th of an inch.

In order that others may be able to judge of the reliance to be placed on the values here given, I subjoin the following measurements of some of Nobert's lines, and the real values assigned by himself; these were made without knowing at the time Nobert's values:

Lines to the inch (*English*).

De la Rue.	Nobert.	De la Rue.	Nobert.
11111	11261	32000	32175
13043	13056	37037	37537
15200	15426	40816	40950
17647	18163	43103	42982
20454	20475	45045	45016
23666	23461	47468	47619
27272	28153	50000	50000

I would wish here to record my admiration of the skill of Mr. Nobert, who has ruled at my request a series of progressive lines, fifteen in number, running from 11260 lines to 56300 lines to an inch, and a separate band on the same slide of 112613 lines to the inch, besides other series very useful to me in comparing with

Naviculaceæ; these have some of the finer series crossed at angles of 90° and 120° respectively, and afford a good control of the value of one's conclusions respecting the nature of their markings. All the straight bands, with the exception of the last, can be made out by oblique light with my quarter of 80° before alluded to. The last series of $\frac{1}{112613}$th of an inch I can see to be lined, on using a $\frac{1}{12}$th object glass of 110°, but up to the present moment, I have not satisfied myself that the lines I see do not comprise two of the real lines. It is, at all events, worthy of experimental inquiry, to ascertain whether the physical properties of light do not put a natural limit to our resolving lines so close as the $\frac{1}{120000}$th and the $\frac{1}{200000}$th of an inch, quoted by Prof. Bailey; the celebrated Fraunhofer maintained that this was the case.

After what I have said, in the commencement of this communication, it is hardly necessary for me to state that I quite agree with Prof. Bailey, that the markings on the Spencerii are due to the allinement of prominences; I moreover concur in his views respecting the difficulty of deciding on the real nature of the markings, on objects so minute as the Naviculaceæ. One thing is however quite certain, that a much inferior glass, provided it have a sufficient angle of aperture, will suffice to show even both sets of lines at one time, than that required to bring them out as distinct dots without any blue or fuzziness. Bringing out both sets of lines at once is to me a well know phenomenon and quite different from the exhibition of markings by the image of a luminous object brought to focus in the plane of the object.

I must not be understood to affirm positively that Mr. Spencer's glasses will not do this, for I have never had an opportunity of examining one. On a late occasion a recent objective of Spencer's was however tried in my presence by the possessor on the N. angulata, but, though very excellent, it did not equal our English twelfths. Judging from Mr. Spencer's production, I feel assured that he is a man of too much merit to feel hurt at this criticism.

As I am unacquainted with Mr. Spencer's new test, I cannot speak as to its difficulty.

I would recommend* Natchet's condensing prism to the attention of all microscopists engaged in the examination of lined objects; it brings out the dot-like markings of the N. Spencerii with remarkable force, even in balsamed specimens. It consists of a prism, which, by two internal reflections and the inclined convex surface of its summit, condenses light at an angle of 35° on to the object. By mounting it in such a way that it may be rotated as well as brought to a focus, it answers all the purpose of a Legg's stage.

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* Mr. Natchet is an optician resident in Paris.

The feat with the hand tube mentioned by Dr. Bailey is surely rather a *tour de force* for the observer, than for the objective of the "Yankee Backwoodsman;" who, if report speaks truly, is a highly educated American gentleman, with talents and acquirements sufficient to remove any obstacles to the attainment of a position amongst the first opticians of his day.

Art. VI.—*Caricography;* by Prof. C. Dewey.

(Continued from vol. viii, p. 350.)

No. 241. *C. lupuliformis*, Sartwell, *lupulina*, Muh., var. *polystachya*, Schw. and Tor. in Mon. Cyp. Tor., No. 132, p. 420.

Spicis staminiferis 1–3 oblongis, suprema longo-pedunculata squamas lanceolatas acutas habente, inferis perbrevibus sessilibus subbracteatis: pistilliferis 3–5 longo-cylindraceis superne aggregatis subsessilibus, infima nunc subdistante nunc remota exserte longo-pedunculata, folioso-bracteatis sublaxifloris; fructibus *tristigmaticis* globoso-ovatis inflatis teretibus scabrostratis sessilibus striatis glabris bicornibus, squama ovata cuspidata plusquam duplo longioribus.

Culm 2–3 feet high, erect, large, smooth on its angles, with long leafy bracts and with the lanceolate rough-edged and reticulate leaves surpassing the culm; staminate spikes 1–3, cylindric, slightly bracteate, with long lanceolate scales, the upper spike 2–4 inches long and pedunculate, the lower short and sessile and rarely androgynous; pistillate spikes 3–5, cylindric, 2–3 inches long, clustered above and nearly sessile, erect or slightly diverging, the lowest often quite remote and long exsertly pedunculate, all with leafy bracts and the lower sheathing; stigmas three; fruit globose-ovate, tapering into a long and serrulate and two forked beak, quite sessile; pistillate scale *ovate*, cuspidate, scarcely half as long as the fruit; achenium rhomboid *with a prominent node on the angles.*

Differs from *C. lupulina*, Muh., in its much longer and more numerous spikes, its globose ovate fruit, closely sessile, with its *serrulate* beak, its *ovate* scale, its rhomboid and *nodose* achenium, its nearly bractless staminate spikes, its general and glabrous appearance, and its coming to maturity near a month later. It seems not to be *C. gigantea*, Rudge, which has been considered another form of *C. lupulina.* In several respects the plant now described differs from these two like *C. Grayii*, Carey, from *C. intumescens*, Rudge.

Found about lakes, ponds and marshes in the northern states and Canada—not very common.

No. 242. *C. torta*, Boott. *C. acuta*, Schk. Tab. Ff, fig. 92 *b.*

Spica staminifera unica, interdum binis, cylindracea; pistilliferis ternis vel pluribus longo-cylindraceis sublaxifloris, basin parvis et sparsifloris, apice substaminiferis, superne sessilibus, inferne pedunculatis, divergentibus vel recurvatis; fructibus *distigmaticis* ovatis utrinque convexis, superne teretibus acuminatis et interdum recurvatis, squamam lanceolatam subobtusam interdum superantibus sæpe subæquantibus.

Culm near two feet high, erect, rather slender, triquetrous, scarcely rough on the edges, leafy towards the base; leaves lanceolate, smooth or soft, shorter than the culm; lower bract long as the culm, the upper shorter or nearly wanting; pistillate spikes usually three, sometimes four, long, slender, sometimes enlarging upwards, very sparse-fruited towards the base of lower spikes, recurved in maturity, and the lower pedunculate, the upper sessile; stigmas two; fruit ovate, convex on both sides, short or long tapering upwards to a point and some recurved; pistillate scale lanceolate, obtusish, narrower than the fruit, black with a green keel, sometimes longer, but more commonly a little shorter than the fruit; culm and leaves light green.

Grows in wet places over the United States. This plant differs much from the European and American form of *C. acuta*, L., and was properly described as a distinct species by Dr. Boott, the distinguished secretary of the Linnæan Society. It is probable that Schk. derived his figure, No. 92 *b*, from American specimens, and in his time he might reasonably consider the plant to be a variety of *C. acuta*, L. It is not *C. acuta* var. *sparsiflora*, D.

ART. VII.—*On the Nitrates of Iron and some other Nitrates;*

by JOHN M. ORDWAY,[*] of the Roxbury Laboratory, Mass.

SESQUINITRATE of iron may be easily obtained in the form of crystals by taking advantage of the fact, that this salt is almost insoluble in cold nitric acid.

When metallic iron is gradually added to nitric acid of sp. gr. 1·29, copious red fumes are given off, and the liquid assumes a greenish hue, till nearly ten per cent. of iron has been taken up.

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[*] The author observes as follows in a letter relating to his investigations:—

Those who have occasion to prepare liquid nitrate of iron in the large way, are often troubled, in cold weather, by the deposition of crystals before the requisite quantity of iron has been dissolved. Concerning the true nature of these crystals, I have been unable to gather any definite information from all the works of chemistry within my reach. Indeed, respecting the compounds of nitric acid and peroxyd of iron, though of some importance in the arts, the books give but vague accounts, and those not altogether correct. Thus "azotate ferrique" is described in Hoeffer's Dictionaire de Chimie et de Physique, as "d'un brun rouge, *incrystallisable*, deliquescent, soluble dans

A farther addition changes the color to a dark red, and if the action be continued still longer, a rusty precipitate forms. If we stop short of this last point, and add to the product its own bulk of nitric acid of sp. gr. 1·43, an abundant crop of crystals will be deposited on cooling below 60° F. The same result may be attained by evaporating the greenish liquid, and adding acid enough to insure a considerable excess, before setting the solution aside to cool. If the first crystals are brown, they may be purified by redissolving in nitric acid, with the aid of a gentle heat, and allowing again to crystallize.

The crystals thus obtained, have the form of oblique rhombic prisms, which are either colorless or of a delicate lavender color, but when dissolved in water, yield a yellowish brown solution. They are somewhat deliquescent and very soluble in water; while at a temperature below 60° F., a weighed quantity was not wholly taken up by over twenty parts of nitric acid of sp. gr. 1·37.

At about 117° F., this salt melts into a clear, deep red liquid, which in one trial remained fluid till cooled to 83° F., when the heat developed by solidification, quickly raised the thermometer to 116½°.

The composition of this substance, as indicated below, affords reasons for supposing that by its admixture with a bicarbonate, an intense cold might be produced. Such proved to be the case, for when two ounces of the bruised crystals were stirred up with one ounce of pulverulent bicarbonate of ammonia, the thermometer introduced fell from 58° to −5° F. Previous cooling is attended with an increase of effect.

These experiments, being very tangible, would furnish excellent illustrations of the principles of latent heat.

A small quantity of the melted nitrate kept hot for several hours by means of a water bath, yielded a perfectly dry, dark brown, deliquescent powder, containing some water and one half the original amount of acid. More acid may be expelled by a moderate heat, but to drive off the last portions, requires a temperature approaching to redness.

The well drained crystals afforded by precipitation with ammonia 19·8 p. c. of peroxyd of iron, and 100 grs. boiled with carbonate of baryta, gave a liquor which with sulphuric acid

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l'eau et dans l'alcool." While Berzelius incidentally mentions that "*Vauquelin* ayant laissé de l'acide nitrique en contact avec de la battiture de fer, trouva, au bout de plusieurs mois, des *cristaux incolores*, qui affectaient la forme de prismes rectangulaires à quatre pans." Perhaps the *rectangulaire* was a mistake, for in several experiments, I have obtained forms variously modified but all referable to the oblique rhombic system. In one huge crystal which had been many months in forming, the angles included between the long lateral faces of the prism, were found to be 101° and 79° nearly.

Numerous experiments made with a view to obtain more light on the subject, have afforded some results which may not be altogether uninteresting, and are, I trust, partly new and singular.

yielded 86·5 grs. of sulphate of baryta, indicating 40·104 p. c. of dry nitric acid. Hence the formula is probably $\overset{\cdot\cdot\cdot\cdot\cdot}{N}_3\overset{\cdot\cdot\cdot}{\mathbf{F}}\mathrm{e}+18\dot{H}$, which would give in 100 parts;—nitric acid 40·095, peroxyd of iron 19·819, water 40·086.

Basic nitrates.—A liquid is used in cotton dyeing, which is prepared by adding iron turnings to aquafortis till the solution assumes a very dark red color. A fair sample of this solution, of sp. gr. 1·478, was found by analysis to contain five equivalents of nitric acid to two equivalents of sesquioxyd of iron. A portion of the same placed in contact with metallic iron, remained clear until nearly enough iron had been taken up to form a sesquibasic nitrate, ($\overset{\cdot\cdot\cdot\cdot\cdot}{N}_2\overset{\cdot\cdot\cdot}{\mathbf{F}}\mathrm{e}$,) when a rusty precipitate began to appear, whose exact nature it is difficult to determine.

A full sesquibasic nitrate was formed by adding crystals of the nitrate to the proper quantity of freshly precipitated oxyd of iron. And proceeding by the same means, but with slow and cautious steps, as into an unknown region, I was successively astonished by the discovery of soluble basic nitrates containing to three equivalents of acid, two, three, six, eight, twelve, fifteen, eighteen and twenty-four equivalents of base, respectively; and then, from the slowness with which the union took place in the last, I supposed the limit reached. Yet this liquid was found to bear the addition of a small quantity of lime water, without change.

On arriving at these remarkable results, the question naturally came up, whether there were any chances of error. But on examination, no foreign substance was detected, and the analyses of the six, twelve, fifteen, and twenty-four basic compounds, agreed so nearly with the syntheses as to remove all doubts.

Which of these bodies have claims to be regarded as true atomic compounds, there seems to be no clue but analogy to determine. They all form intensely deep red liquids, which are not altered by dilution, nor by brisk boiling, provided the evaporation be not carried too far. By spontaneous evaporation they leave a very dark red powder, perfectly soluble in water. That left by the dodecabasic nitrate, was not deliquescent, and lost 30 p. c. of its weight by ignition. Hence its empirical composition would be $\overset{\cdot\cdot\cdot\cdot\cdot}{N}\overset{\cdot\cdot\cdot}{\mathbf{F}}\mathrm{e}_4+9\dot{H}$.

When cotton cloth is dipped in any of these solutions, and dried, the oxyd of iron becomes permanently attached. Indeed the adhesion of the base to cotton fibre, renders filtration through paper exceedingly slow.

Since spring and river water, and the solutions of most salts, are incompatible with the twenty-four basic nitrate, it was found necessary to use an abundance of distilled water for washing the oxyd used in its preparation. So intense was the color of this liquid that, though containing only 3·4 p. c. of oxyd of iron, two drops imparted a perceptible tinge to a pint of distilled water. In trying the reactions of various subtances with it, all the iron appeared to be immediately thrown down by muriate of ammonia, chlorid of sodium, iodid of potassium, chlorate of potash, sulphates of soda, lime, zinc and copper, nitrates of potash and soda, and the acetates of baryta and zinc. Precipitates formed more slowly with the nitrates of ammonia, magnesia, baryta and lead. Tartrate of soda furnished a precipitate soluble in ammonia. Ferrocyanid of potassium gave a dark peat-brown precipitate without the least tinge of blue. Ferrocyanid of potassium gave likewise a rich peat-brown precipitate. Tincture of galls afforded dark brown flocks, and on standing some time, the supernatant liquor turned black. Alcohol, acetate of lead, acetate of copper, cyanid of mercury, nitrate of silver, and arsenious acid caused no change.

With the tribasic nitrate, muriate of ammonia, chlorid of sodium and nitrate of soda produced no effect; while the sulphates threw down all the iron, prussiate of potash struck a blue color, and tincture of galls gave a black.

Nitrate of Alumina.—Nitrate of alumina crystallizes from a concentrated and somewhat acid solution, in colorless oblique rhombic prisms, whose height is generally small in proportion to their width. They are deliquescent, and very soluble both in water and in nitric acid. The crystals, like those of the other sesquinitrates, can be best dried by spreading them on an absorbent surface, and placing the whole under a bell glass, along with a shallow vessel containing sulphuric acid.

The salt was found to melt at 163° F., into a clear colorless liquid, which began to crystallize when cooled down to 147½°, the thermometer rapidly rising, at the same time, to 102°. The melted mass parts with its acid much less rapidly than the nitrate of iron. One ounce of the powdered salt mixed with one-half ounce of bicarbonate of ammonia, lowered the thermometer from 51° to $-10°$ F.

100 grs. of pretty dry crystals, yielded by ignition 13·7 grs. of alumina. Distillation with sulphuric acid gave 42 p. c. of nitric acid, and by boiling with carbonate of baryta, 42·42 p. c. was separated. The numbers corresponding to $\overset{\cdot\cdot\cdot\cdot\cdot}{N}_3\,\overset{\cdot\cdot\cdot}{\mathbf{Al}}+18\,\dot{H}$, would be in 100 parts:—nitric acid 43·17, alumina 13·68, water 43·25.

Nitrate of alumina appears to form with the hydrate, a series of salts similar to the basic nitrates of iron. But they have not as yet been fully examined.

Nitrate of Chrome.—Nitrate of chrome crystallizes with difficulty in warm weather, but I have succeeded in obtaining two crops, one of them presenting the form of the oblique rhombic prism, and the other a very deeply modified variety of the same. These crystals have the changeable purple color peculiar to the salts of chrome, and their solution in water is of the same hue while cold, but becomes green when heated.

This salt fused at about 98° F. into a deep green fluid, which began to assume the solid state when cooled to 75°, the thermometer rising thereupon to 96°. If heated to redness, it undergoes complete decomposition, leaving a bulky oxyd of a beautiful green color.

The composition of nitrate of chrome was found by analysis to be: nitric acid 39·7 p. c., oxyd of chrome 19 p. c. Calculation from the formula $\overset{:\cdot:}{N}_3\,\overset{\cdots}{\mathrm{Cl}}+18\dot{H}$, gives: nitric acid 40·44, sesquioxyd of chrome 19·13, water 40·43.

No experiments have been made on the basic salts.

Roxbury, Mass., Oct. 1st, 1849.

ART. VIII.—*A description of two additional Crania of the Engé-ena, (Troglodytes gorilla, Savage,) from Gaboon, Africa;* by JEFFRIES WYMAN, M.D.

Read before the Boston Society of Natural History, Oct. 3d, 1849.

THE evidence now existing of a second and gigantic African species of man-like ape, as appears from published reports, consists of the following remains:—1. Four crania in the United States, two males and two females, of a large portion of a male skeleton, and of the pelvis and of some of the bones of a female. These were the first remains of this animal which had been brought to the notice of naturalists, and were described in the Boston Journal of Natural History.*—2. Three other crania subsequently discovered exist in England and have been made the subject of an elaborate memoir by Prof. Owen, in the Transactions of the Zoological Society of London.†—3. Quite recently, Dr. George A. Perkins, for many years an able and devoted laborer in the Missionary enterprise at Cape Palmas, W. Africa, has brought to the United States, two additional crania, one of which is deposited in the Museum of this Society, and the other in that of the

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* See Proceedings of the Boston Soc. Nat. Hist., Aug. 18, 1847; also a description of characters and habits of Troglodytes gorilla, by Thomas S. Savage, M.D., Corresp. Memb. Bost. Soc. Nat. Hist., and of the Osteology of the same by Jeffries Wyman, M.D., Boston Journ. Nat. Hist., Vol. v, p. 417, 1847.

† Osteological Contributions to the Natural History of the Chimpanzées, (*Troglodytes*, Geoff.,) including the description of the skull of a large species, (*T. gorilla*, Savage,) discovered by Thomas S. Savage, M.D., in the Gaboon country, West Africa, by Prof. Owen, F.R.S., F.Z.S., &c. Read Feb. 22, 1848. Trans. Zoolog. Society of London, Vol. iii, p. 381, 1849.

Essex Institute in Salem. Both of these have been referred to me for the purposes of description, and it is the object of this communication to notice the more important anatomical features of this the largest of African Quadrumana, with regard to which additional information is desired.

Cranium I. Male.—This belonged to an adult Engé-ena,* as is evident from the fact that the teeth are all perfectly developed; yet not to an old one, as appears from the circumstances that the points of the molars are but very slightly worn, and the crests on the top of the head and occiput are but imperfectly formed. Its size as well as that of all the other crania of this species which have been measured, when compared with that of *T. niger* (Chimpanzée) and a well marked Negro head, may be learned from an inspection of the following table.

Table I.—Measurements of the crania of *T. gorilla*, of *T. niger* and of the cranium of a native African in inches and tenths.—Nos. 2, 6, 7 and 8 are in inches and lines.

	Troglodytes gorilla.						T. niger.		Man
	Males.				Females.		Male	Female.	
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Length of head from occiput to edge of incisive alveolus,	11·2	11·4	11·0	10·2	9·10	9·0	8·0	7·9	9·6
Greatest breadth across post-auditory ridges,	6·1	6·10	6·4	5·9	5·2	5·6	5·0	4·6	5·4
Smallest diameter behind orbits,	2·5	3·3	2·9	2·7	2·5	2·4	2·6	2·8	3·4
Diameter of face across zygomatic arches,	6·5	6·6	7·0	6·4	5·5	5·3	5·0	4·8	5·7
Diameter of face outside the middle of the orbits,	4·9	6·0	5·8	5·7	4·3	4·8	4·3	4·0	4·9
From occiput to most prominent part of supra-orbitar ridge,	7·3	..	7·6	6·5	6·5	6·1	5·4	5·3	7·2
From sup. orb. ridge to edge of incisive alveolus,	4·8	..	5·7	6·0	..	..	4·0	4·4	3·5
Breadth of zygomatic fossa,	1·7	1·8	1·9	1·8	1·4	1·5	1·3	1·1½	1·1
Inter-orbitar space,	1·1	1·3	1·2	1·1	1·0	1·1	0·8	0·7	1·2
Transverse diameter of orbits,	1·5	1·9	1·8	1·6	1·4	1·6	1·5	1·6	1·6
Vertical " "	1·6	1·7	1·6	1·6	1·4	1·7	1·3	1·3	1·3
Length of bony palate from outer edge of incisive alveolus,	3·7	4·1	..	4·3	3·4	3·3	..	..	1·7
From anterior edge of foramen magnum to outer edge of incisive alveolus,	7·2	..	..	7·4	3·5	..	..	..	..

(Crania I. and V. were the ones brought by Dr. Savage to this country—II, VI, VII. and VIII. are the crania described by Prof. Owen; III. and IV. are the crania which were obtained by Dr. Perkins—IX. the cranium of a Negro born in Africa in whom the characteristics of the race were well marked, and which belongs to the Cabinet of the Boston Soc. for Med. Improvement. See Catalogue of Society's Cabinet, Specimen No. 61.)

This cranium does not agree with that figured by Prof. Owen in his memoir (Pl. lxi.) in the exclusion of the orbits from view

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* Prof. Owen designates *T. gorilla* as the "Great Chimpanzée." The Mpongwes (natives inhabiting the banks of the Gaboon) call this species the Engé-ena, a more desirable name, as the term Chimpanzée has been always associated with the black or smaller species.

by the prominent malar bones when the skull is seen in profile, but as was the case in those discovered by Dr. Savage, the nasal bones are wholly, and the orbit in part brought into view. In none of them is it more excluded than in the first figures of our memoir. The great ridges above the orbits, which are so widely developed in *T. niger*, are still more so in the present species, and in the specimen now under consideration sustain the former statements with regard to them. Prof. Owen remarks in connection with them, "the prominence of the whole supra-orbitar ridge reaches its maximum in the present species and forms the most marked distinction in the comparison of its skull with that of man." (Memoir, p. 405.)

Sutures.—I have shown in a former communication from an examination of several crania of the Chimpanzée, that nearly all the sutures are completely obliterated early during the adult period.* From a careful examination of the six crania of the Engéena to which I have had access, there is every reason to believe that an early coösification takes place in them also. In the skull now under consideration, which it is to be remembered, has not long passed the adult period, the frontal, the sagittal, the coronal, the squamous portion of the temporal sutures, all those in the temporal fossa as well as the transverse portion of the lambdoidal are no longer persistent. The crania which have been examined by Prof. Owen, or some of them at least, indicate an opposite state of things. To ascertain, therefore, the value of cranial sutures as specific signs, it is quite obvious, that a large number of crania of different ages must be critically examined.

Inter-maxillaries.—These bones so important as zoological indications are completely coössified with the maxillaries and with each other. No indication of a suture exists between them and the last mentioned bones either on the external surface below the nasal openings, or in the roof of the mouth. I was not able to find any indications of the ascending portion of the intermaxillary bone which articulates with the nasals, until led by Prof. Owen's description to make a more careful search. Although externally there was no mark which would lead an anatomist to infer its existence, yet within the nasal cavity at a short distance from its margin, the edge of the process was easily detected, it not having become coössified in that region with the adjoining bone.

The extension of the intermaxillary upwards as far as the ossa nasi, so as to form the lateral walls of the external nasal orifice, as was indicated in a specimen of Chimpanzée, examined by Prof. Owen, is still obvious in a young skull of the same species in my possession, where it reaches the nasals by a slender and

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* Boston Journal of Natural History, April, 1843.

pointed process. The enlargement of this process in the Engé-ena,* so as to form an extensive articulation with the nasal bones, inasmuch as it is a repetition of what exists in the lower quadrumana and nearly all the mammalia, must be regarded as an index of degradation.

Ossa Nasi.—Prof. Owen, in his memoir† on the Engé-ena, in speaking of the sutures between the nasal maxillary and intermaxillary bones, says, "it is remarkable indeed since these sutures remain so distinct in the adult female skull and the two adult male skulls, in the Bristol Museum, that no trace of them should have been detected in either of the four skulls taken to America by Dr. Savage, in which the ossa nasi are described as being firmly coössified with each other and the surrounding bones," (the concluding words of the above sentence he does not quote, viz., "but their outline is sufficiently distinct.") In the cranium brought by Dr. Perkins, the consolidation of these bones is equally complete and their outline is but indistinctly traceable.

In the crania formerly described, the ossa nasi form, on the median line, a sharp elevation or crest; in the specimen figured by Prof. Owen, (Pl. lxii,) this is represented by a more rounded and convex ridge, "and thus offering a feature of approximation to the human structure which is very faintly indicated, if at all, in the skull of the *T. niger*."‡ In the cranium now under consideration, when compared with the Plate above referred to, the convexity is still more remarkable, and will bear a more favorable comparison with the "bridge" of the nose in some of the human races.

The expansion of the nasals above, where they are interposed between the frontals, as described by Prof. Owen, was overlooked in my former description, only very faint indications of sutures remaining. On a more careful examination, the outline of the portion of bone interposed between the orbitar process of the frontals is indistinctly traceable in the male skull discovered by Dr. Savage, and in both of the crania brought to this country by Dr. Perkins; and in all of them, on a line with the upper extremity of the ascending process of the superior maxillary bone, at the point where the nasal bones become the most contracted, there exists an equally strong indication of a transverse suture, which separates the portion marked 15′ in Prof. Owen's figure from the true nasals, and equally distinct indications of this suture exist in his figure just referred to. Thus we have strong ground for the supposition that the part marked 15′ by Prof. O. may not be the expanded portion of the nasals but an additional osseous element intercalated between the frontals. In this event my orig-

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* This is very distinctly shown in Pl. lxii. of Prof. Owen's Memoir.

† Op. cit., p. 420.

‡ Op. cit., p. 393.

inal description of the ossa nasi, "as having a more triangular form than in the Chimpanzée, the apex being more acute," still holds good. If, however, the bone referred to prove to be a portion of the nasals, we shall have in this another index of inferiority to the Chimpanzée, as it is a repetition of what is met with in the lower quadrumana.

Teeth.—The molars alone remain, the incisors and canines having been lost. The length of the grinding surface of the molar teeth is 2·9 inches, the two rows being nearly parallel to each other. This is true of the alveoli, though the crowns slightly diverge from each other posteriorly in consequence of an inclinatiom outwards. Nearly all of the cusps of the teeth are perfect, those of the first molar being the most worn, as would naturally be expected, it being the first which is protruded. The inner cusps of this tooth are worn nearly to the base; the outer are but slightly abraded, and the same is the case with the inner cusps of the second molar; with these exceptions the points of the different crowns of the molars and premolars are entire.

In comparing their grinding surface with that of the human jaw, one cannot but be struck with its greater extent, with the much greater development of the outer row of cusps, and the high ridge which on all three of the molars connects the outer row of cusps with the anterior inner cusp. In these respects as well as in having the third molar, or the "dens sapientiæ," of equal size with the others, the Engé-ena recedes from the Chimpanzée and still farther from man.

In the left upper jaw and on the level with the lower extremity or the pterygoid process, a supernumerary molar existed, still buried in its bony cavity, the roots not having as yet been developed. In the configuration of its grinding surface it did not conform with either of the other teeth.

Bony Palate.—By reference to the table of measurements, it will be seen that the space between the incisive alveoli and the edge of the hard palate is much greater proportionally than in the Chimpanzée. The median suture has disappeared and only slight indications remain of a former suture between the maxillaries and the ossa palati. The emargination on the middle of the edge of the palate is much less distinct than in either of the other specimens which I have examined, or than in that figured by Prof. Owen.

The *Vomer* has the same thin and delicate structure as in the other crania and does not meet the ossa palati at the posterior edge.

Cranial capacity.—In studying the anatomical characters of this and the allied quadrumana with reference to their zoological position, nothing can be more desirable than to have accurate knowledge with regard to the structure and dimensions of the brain, for this may be regarded as one of the most important of all the tests of elevation or degradation. The bodies of the adult anthropoid animals so seldom fall into the hands of the anatomist, that it becomes extremely difficult to accumulate observations on the actual condition of this organ. In the comparative study of human crania with reference to national peculiarities, much light has been derived from accurate measurements of their internal capacity. These may be readily obtained and form a very important substitute for the actual dimensions of the brain itself. In the subjoined tables I have given the results of the measurements of all the crania both of Engé-enas and Chimpanzées to which I have had access while writing these remarks, and as they have been repeated in each case several times over, they may be regarded as nearly accurate. The capacity of the third cranium is alone doubtful; a portion of the occiput having been destroyed, rendered exact measurement impracticable, though it is believed that the result can differ but little from the truth.

TABLE II.—Cranial capacity of adult Engé-enas.

		Cubic inches.
I.	Male from Dr. Perkins,	34·5
II.	Male from Dr. Savage,	28·3
III.	Male from Dr. Perkins,	28·0?
IV.	Female from Dr. Savage,	25·0
	Mean of the four crania,	28·9½

TABLE III.—Cranial capacity of adult Chimpanzées.

		Cubic inches.
I.	Female,	26·0
II.	Female,	24·0
III.	Female,	22·0
	Mean capacity of three skulls,	24·0
	Cranial capacity of young Chimpanzées.	
IV.	First dentition complete,	20·0
V.	First dentition complete but the sutures obliterated to a less extent than in the preceding,	18·0

The above results clearly indicate that there exists a wide range in the cranial capacity of the Engé-enas, amounting to nine cubic inches, when both sexes are included in the observation. While it would be desirable to have the measurements of a much larger number, we still have evidence for concluding, that in the Engé-ena, as in man,* the capacity of the cranium of the male is

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* "Although many female brains exceed in weight particular male brains, the general fact is sufficiently shown, that the adult male encephalon is heavier than that of the female, the average difference being from 5 to 6 oz." From the examination of 278 male brains and of 191 females, "an average weight is deduced of 49½ oz. for the male and of 44 oz. for the female." Quain and Sharpey's, Quain's Anatomy; edited by Joseph Leidy, M.D., vol. ii, p. 185. Philadelphia, 1849.

larger than that of the female; the smallest male skull of the Engé-ena measuring twenty-eight cubic inches, and the female only twenty-five cubic inches.

In Table III, the three adults are females, and it is quite worthy of notice, that the internal capacity of these differs so little from that of the female Engé-ena, while at the same time the body of the Chimpanzée is so much smaller than that of the other species. By comparing the measurements given of the corresponding portions of the skeleton of the Engé-ena and Chimpanzée, it will be seen that a much wider difference exists between them, than exists between the dimensions of their respective brains.*

It is interesting to contrast the measurements of the cranial capacity of these members of the Quadrumanous group with that of some of the more prominent of the human races. The following table which is extracted from the general summary of the measurements of a vast number of crania, by Dr. S. G. Morton of Philadelphia, gives in cubic inches the average cranial capacity of the different races or groups there mentioned.†

TABLE IV.

RACES.	No. of skulls measured.	Largest capacity.	Smallest capacity.	Mean.	Mean.
Teutonic Race of CAUCASIANS.					
Germans,	18	114	70	90	90
English,	5	105	91	96	
Anglo-Americans,	7	97	82	90	
MALAY GROUP.					
Malayan family,	20	97	68	86	85
Polynesian family,	3	84	82	83	
AMERICAN GROUP.					
Toltecan Family.					
Peruvians,	155	101	58	75	81
Mexicans,	22	92	67	79	
Barbarous Tribes,	159	104	70	87	
NEGRO GROUP.					
Native African Family,	62	99	65	83	
Hottentots,	3	83	68	75	
Australians,	8	83	63	75	

These results are derived from a table which Dr. Morton has based upon the actual measurements of over 600 skulls. The smallest mean capacity is that derived from the Hottentots and Australians, which equals only seventy-five cubic inches, while that of the Teutonic races amounts to ninety cubic inches. The maximum capacity of the Engé-ena, is therefore considerably less than one half of the mean of the Hottentots and Australians, who give us the minimum average for the human races.

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* See Table of comparative measurements. Boston Journal of Natural History, vol. v, p. 417.

† Catalogue of Skulls of Man and the Inferior animals in the collection of Samuel George Morton, M.D., &c. 3d edition. Philadelphia, 1849.

Cranium II. Male.—This cranium belonged to an individual much older than the one described in the preceding pages, the inner row of cusps of all the molars having been worn to their bases. The same obliteration of the sutures had taken place, the malar bones are more tumid, rendering the edge of the lower and outer part of the orbit more rounded. The floor of the nasal orifice slopes gradually from the anterior extremity of the vomer to the edge of the incisive alveoli, and presenting a groove on the median line. In man, the intermaxillary bones form a projecting ridge on the median line both in and below the nasal orifice and at the middle of the border of this opening form the projecting "nasal spine," which is not met with in any of the lower animals, and is therefore *an anatomical character peculiar to man.* With regard to this conformation of the intermaxillary bones, the Engé-ena recedes farther from man than the Chimpanzée. Two infra orbitar foramina exist on each side. The crests are not so well developed as in the cranium just described. The occiput having been in part destroyed, the cavity of the cranium is completely exposed. A groove for the lodgment of the longitudinal sinus is well defined; "digital impressions," formed by the cerebral convolutions, exist, but not well marked, the *crista galli* is merely rudimentary and is represented by a very slight median ridge, the olfactory fossa is quite deep, the cribriform plate being on a level with the middle of the orbit. About five parallel groves for the lodgment of the branches of the dura matral artery exist on each side.

Zoological position of the Engé-ena.

With the knowledge of the anthropoid animals of Asia and Africa which now exist, derived from the critical examinations of their osteology, their dentition, and the comparative size of their brains by various observers, especially Geoffroy, Tiedemann, Vrolik, Cuvier, and Owen, it becomes quite easy to measure with an approximation to accuracy, the hiatus which separates them from the lowest of the human race. The existence of four hands instead of two, the inability to stand erect, consequent on the structure of a skeleton adapted almost exclusively to an arboreal life, the excessive length of the arms, the comparatively short and permanently flexed legs, the protruding face, the position of the occipital condyles in the posterior third of the base of the skull and the consequent preponderance of the head forwards, the small comparative size of the brain, the largely developed canines, the interval between these last and the incisors, the three roots to the bicuspid teeth, the laryngeal pouches, the elongated pelvis and its larger antero-posterior diameter, the flattened and pointed coccyx, the small glutæi, the smaller size of the lower compared with the upper portion of the vertebral column, the long and straight spinous processes of the neck, these and many other subordinate characters, are peculiarities of the anthropoid animals, and constitute a wide gap between these and the most degraded of the human races, so wide that the greatest difference between these last and the noblest specimen of a Caucasian is inconsiderable in comparison.

Whilst it is thus easy to demonstrate the wide separation between the anthropoid and the human races, to assign a true position to the former among themselves is a more difficult task. Mr. Owen in his earlier memoir, regarded the *T. niger* as making the nearest approach to man, but the more recently discovered T. gorilla, he is now induced to believe approaches still nearer, and regards it as "the most anthropoid of the known brutes."* This inference is derived from the study of crania alone, without any reference to the rest of the skeleton.

After a careful examination of the memoir just referred to, I am forced to the conclusion, that the preponderance of evidence is unequivocally opposed to the opinion there recorded; and after placing side by side the different anatomical peculiarities of the two species, there seems to be no alternative but to regard the Chimpanzée as holding the highest place in the brute creation. The more anthropoid characters of the *T. gorilla* which are rereferred to by Prof. O., are the following.

1. "The coalesced central margins of the nasals are projected forwards, thus offering a feature of approximation to the human structure, which is very faintly indicated, if at all in *T. niger*."† This statement is applicable to all the crania which I have seen, and especially to the two crania described in this paper. Nevertheless the extension of the nasals between the frontals, or the existence of an additional osseous element, is a mark of greater deviation from man.

2. "The inferior or alveolar part of the premaxillaries, on the other hand, is shorter and less prominent in *T. gorilla* than in *T. niger*, and in that respect the larger species deviates less from man."‡ The statement in the first portion of this sentence is certainly correct, but a question may be fairly raised on that in the second. The lower portion of the nasal opening in the Engé-ena is so much depressed, especially in the median line, that the intermaxillary bone becomes almost horizontal, and the sloping of the alveolar portion takes place so gradually that it is difficult to determine where the latter commences and the nasal opening terminates, and in this respect it deviates much farther from man than *T. niger*.

3. "The next character which is also a more anthropoid one, though explicable in relation to the greater weight of the skull

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* Op. cit., vol. iii, p. 414.

† p. 393.

‡ p. 393.

to be poised on the altas, is the greater prominence of the mastoid processes in the *T. gorilla*, which are represented only by a rough ridge in the *T. niger*."*

4. The ridge which extends from the ecto-pterygoid along the inner border of the foramen ovale, terminates in *T. gorilla* by an angle or process answering to that called "styliform" or "spinous" in man, but of which there is no trace in *T. niger*.†

5. "The palate is narrower in proportion to the length in the *T. gorilla*, but the premaxillary portion is relatively longer in *T. niger*."‡

These constitute the most important if not the only characters given in Prof. Owen's memoir, which would seem to indicate that the Engé-ena is more anthropoid than the Chimpanzée, and some of these it is seen must be received with some qualification.

If on the other hand we enumerate those conditions in which the Engé-ena recedes farther from the human type than the Chimpanzée, they will be found far more numerous, and by no means less important. The larger ridge over the eyes and the crest on the top of the head and occiput, with the corresponding development of the temporal muscles, form the most striking features. The intermaxillary bones articulating with the nasals, as in the other Quadrumana and most brutes, the expanded portion of the nasals between the frontals,—or an additional osseous element if this prove an independent bone,—the vertically broader and more arched zygomata, contrasting with the more slender and horizontal ones of the Chimpanzée, the more quadrate foramen lacerum of the orbit, the less perfect infra-orbitar canal, the orbits less distinctly defined, the larger and more tumid cheek bones, the more quadrangular orifice with its depressed floor, the greater length of the ossa palati, the more widely expanded tympanic cells, extending not only to the mastoid process, but to the squamous portion of the temporal bones, these would of themselves be sufficient to counterbalance all the anatomical characters stated by Prof. Owen in support of the more anthropoid character of the Engé-ena.

When, however, we add to them the more quadrate outline of the upper jaws, the existence of much larger and more deeply grooved canines, molars with cusps on the outer side longer and more sharply pointed, the dentes sapientiæ of equal size with the other molars, the prominent ridge between the outer posterior, and the anterior inner cusps, the absence of a crista-galli, a cranial cavity almost wholly behind the orbits of the eyes, the less perfectly marked depressions for the cerebral convolutions, and above all, the small cranial capacity in proportion to the size of the body, no reasonable ground for doubt remains, that the Engé-ena occupies a lower position and consequently recedes further from man than the Chimpanzée.

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* Op. cit., p. 394. † p. 395. ‡ p. 395.

It does not appear that any other bones of the skeleton have as yet fallen into the hands of any European naturalist. A description of some of the more important of them will be found in the memoir above referred to,* in which it will be seen that there are two anthropoid features of some importance, which go to support the view advanced by Prof. Owen, and these are the comparative length of the humerus and ulna, the former being seventeen and the latter only fourteen inches, and in the proportions of the pelvis. This last is of gigantic size, and is a little shorter in proportion to its breadth than in *T. niger*.

While the proportions of the humerus and the ulna are more nearly human than in the Chimpanzée, those of the humerus and femur recede much farther from the human proportions than they do in the Chimpanzée, as will be seen by the following measurements:

	Humerus.	Femur.
Man, . . .	15·0	18·5
Chimpanzée, . .	10·9	11·0
Engé-ena, . .	17·0	14·0

Thus in man the femur is three inches longer than the humerus, in the Chimpanzée, these bones are nearly of the same length, and in the Engé-ena the humerus is three inches longer than the femur, indicating on the part of the Engé-ena a less perfect adaptation to locomotion in the erect position than in the Chimpanzée.

Canine tooth of the Engé-ena—natural size.

Description of a canine tooth of a male Engé-ena.—In only one of the crania of the male Engé-enas which I have seen were the canines remaining; and these were so much abraded that they had lost to a great extent, their natural outline, and consequently their most striking and distinctive marks. In the females, as in the Chimpanzée and the Quadrumana, generally the canines are much less elongated than in the males. Among the bones first sent to this country by Dr. Savage, was the canine tooth represented in the annexed figure, which I was not able to identify, until an opportunity occurred of comparing it with Prof. Owen's descriptions of more perfect teeth. The crown is laterally compressed, the posterior edge being trenchant and its base provided with a prominent tubercle, which is doubtless rendered more conspicuous by the wearing of the edge beneath it. On its inner surface the crown is impressed with two strongly marked grooves, which extend from the base nearly to

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* Boston Journal of Nat. History, vol. v, p. 417.

its apex; and include between them a prominent rounded ridge. The following table gives the comparative measurements of two canines from the upper jaw of the Engé-ena, and one from that of the Chimpanzée. The figures in the first column relate to the tooth described above; those in the second and third to the measurements given by Prof. Owen,* the measurements being in inches and lines.

	T. gorilla.		T. niger.
Length,	2·8	2·8	2·0
Length of crown,	1·3½	1·3	0·10½
Breadth of base,	1·0	0·10	0·7
Thickness of do.	0·7½	0·7½	0·5½

The following note from Dr. G. A. Perkins to the author, dated Salem, Oct. 15, 1849, confirms the statements made by Dr. Savage, in his description of the habits of the Engé-ena, as to its ferocity and the fact of its attacking human beings.

"The two crania were received from a person on board a vessel trading in the Gaboon and Danger Rivers, W. Africa. They were obtained from the natives on the banks of the latter, by whom they had been preserved as trophies. From the gentleman who gave them to me, I learned that the killing of one of these animals was by no means a common occurrence. He describes the animal as being remarkably ferocious, even attacking the natives when found alone in the forests, and in one instance which fell under his observation, horribly mutilating a man who was out in the woods felling trees to burn. His shouts brought to his aid several other natives, who after a severe contest, succeeded in killing the Engé-ena. The man was afterwards in the habit of exhibiting himself to foreigners who visited the river and of receiving charity from them."

ART. IX.—*Notice of the cranium of the Ne-hoo-le, a new species of Manatee (Manatus nasutus) from W. Africa;* by JEFFRIES WYMAN, M.D.

Read before the Boston Society of Natural History, November 7th, 1849.

THE species of the genus Manatus, Cuv. which have been heretofore generally recognized, are only two in number, viz., 1, M. AMERICANUS, Cuv. and Desm.; *Trichechus manatus*, Linn.; *le grand Lamantin des Antilles*, Buff. 2, the M. SENEGALENSIS, G. Cuvier; *M. Africanus*, F. Cuvier; *Trichechus australis*, Shaw.† The late Dr. Richard Harlan of Philadelphia, has indi-

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* Trans. Zoolog. Soc. London, vol. iii, p. 395.

† Fred. Cuvier. Hist. Nat. des Cetacées. 8vo. Paris: 1836. Also Cyclopedia Anat. and Physiology, Article Cetacea. Lond.: May, 1836.

cated a third species from E. Florida, to which he has given the name of M. LATIROSTRIS.* This species is recognized by Lesson and Fischer, but has been more recently denied by Blainville, who in referring to it in connection with two other species of the same group, (MANATUS, *Lamantin*, Blainville,) L. du tabernacle and L. de l'Orinoque, expresses himself, "ne regardant nullement comme suffisamment distinct."†

The existence of this third species has been within a short time conclusively demonstrated by Prof. Agassiz, and the evidence on which this conclusion rests will soon be published in a memoir on those genera of Cetaceans whose remains have been found in the United States.

In the Proceedings of the Boston Society of Natural History, vol. ii, p. 198, is a notice by Dr. George A. Perkins of an animal captured in the Cavalla River, W. Africa, known to the natives as Ne-hoo-le, and which Dr. Perkins referred to the genus Manatus. In a note to that communication I stated, that this animal differed from all known species of Manatee, both in the *number of the teeth* which was for the molars $\frac{9}{9}\ \frac{9}{9}$, and in *the absence of nails on the paddles*, as well as in other characters of subordinate value. In the sequel it will be seen however that the formula for the teeth was not correctly stated. The provisional name of *Manatus nasutus* was given to this supposed species.

Quite recently, Dr. Perkins, on his return from Cape Palmas, brought with him and presented to the Boston Society of Natural History, an imperfect cranium of the same species, the lower jaw, the intermaxillary, nasal and temporal bones having been broken off by the natives as they divided the carcass amongst themselves for food. A sufficient number of characteristic parts, however, remain to demonstrate that the species, as formerly suspected, is a new one. In establishing the following characters, the cranium in question has been compared with that of the *Manatus senegalensis, M. Americanus and M. latirostris:* the first belonging to the Boston Society of Natural History and the others to the Academy of Natural Sciences of Philadelphia.

I. *Teeth.—Molars* $\frac{10}{10}\ \frac{10}{10}$; the first and second of the series have been dropped and their alveoli are partly filled up; the five following ones on each side, remain in use, but the last three still remain in their alveolar cavities, the roots not having as yet been developed. The enamel on all the teeth, on those which are retained in their sockets as well as on those which are in use, is perfectly smooth. The internal root of each molar has a distinct

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* On a species of Lamantin resembling the M. senegalensis, (Cuvier,) inhabiting the coast of E. Florida. By Richard Harlan, M.D. Journal Acad. Nat. Sciences, Philadelphia. Vol. iii, p. 390.

† Osteographie, Fascic. xv. Genus Manatus, p. 123.

groove on its inner surface and all the roots are quite divergent. The transverse diameters of the anterior and posterior ridges are more nearly equal than in the other species.

M. Senegalensis.—Molars $\frac{9}{9}\,\frac{9}{9}$; the enamel is rugous; the inner root is not grooved, all of the roots nearly vertical, and the teeth in use not more than four. *M. latirostris.* Molars $\frac{10}{10}\,\frac{10}{10}$, teeth in use four or five; enamel rugous. *M. Americanus,* Molars $\frac{11}{11}\,\frac{11}{11}$. Teeth much smaller than in the preceding species; the number in action six. The crowns are higher, but the inner root as in M. nasutus is grooved on its internal surface.

II. *Palate.*—The median ridge is flattened on its summit and the palatine foramina are of variable sizes; the most anterior is the largest and perforates the bone nearly vertically and with rounded edges. In the *M. latirostris* they are all more minute; in the *M. Senegalensis* and *M. Americanus,* the anterior are the largest, but perforate the bone obliquely and are protected for some distance after they assume the horizontal direction by a thin sharp edge or shelf of bone. The palatine foramina are subject to so great variety in most animals, that the characters just enumerated must be regarded as of doubtful value unless verified on a large number of crania.

III. *Malar bones.*—These are readily distinguished from the corresponding bones of all the other species in being very broad in their zygomatic portion, measuring nearly an inch in breadth at their free extremity. In *M. Senegalensis,* the zygomatic portion is slender, style-shaped, and terminated by a knob. This is also the case in *M. Americanus* and *latirostris,* except that in the last the part in question has no enlargement at its end, is a little broader than in the preceding, but forms a much closer union with the zygomatic portion of the temporal bone, approaching a suture of the kind called "harmonia."

IV. *Frontal region.*—In this as well as in *M. Americanus* the frontal region is quite narrow, but in the latter it is rounded, "bombée," while in the former it is depressed. The forehead of the *M. latirostris* and *Senegalensis* is proportionally much broader.

V. *Occipital foramen.*—In all the species this foramen is more or less triangular, the angles being rounded; but in *M. Americanus, Senegalensis,* and *latirostris* the apex is directed downwards, while in that from the Cavalla river it is directed upwards.

The number of known species of the genus Manatus now amounts to four, two from Africa, viz.: *M. Senegalensis and M. nasutus,* and two from the New World, viz.: *M. Americanus and M. latirostris.*

ART. X.—*On Denudation in the Pacific;* by JAMES D. DANA.

THE following pages are extracted from different chapters in the Geological Report of the Exploring Expedition under Capt. Wilkes.*

The valleys of the Pacific Islands have usually a course from the interior of the island towards the shores; or when the island consists of two or more distinct summits or heights (like Maui) they extend nearly radiately from the centre of each division of the island. They are of three kinds:

I. A narrow gorge, with barely a pathway for a streamlet at bottom, the enclosing sides diverging upward at an angle of thirty to sixty degrees. Such valleys have a rapid descent, and are bounded by declivities from one hundred to two thousand feet or more in elevation, which are covered with vegetation, though striped nearly horizontally by parallel lines of black rock. There are frequent cascades along their course; and at head, they often abut against the sides of the central inaccessible heights of the island. The streamlet has frequently its source in one or more thready cascades that make an unbroken descent of one or two thousand feet down the precipitous yet verdant walls of the amphitheatre around.

II. A narrow gorge, having the walls vertical or nearly so, and a flat strip of land at bottom more or less uneven, with a streamlet sporting along, first on this side, and then on that, now in rapids, and now with smoother and deeper waters. The walls may be from one hundred to one thousand feet or more in height; they are richly overgrown, yet the rocks are often exposed, though every where more than half concealed by the green drapery.

These gorges vary in character according to their position on the island. Where they cut through the lower plains, (as the dividing plain of Oahu,) they are deep channels with a somewhat even character to the nearly vertical walls, and an open riband of land at bottom. The depth is from one to three hundred feet, and the breadth as many yards. Farther towards the interior, where the mountain slopes and vegetation have begun, the walls are deeply fluted or furrowed, the verdure is more varied and abundant, and cascades are numerous.

This second kind of gorge, still farther towards the interior, changes in character, and becomes a gorge of the first kind, narrowing at bottom to a torrent's course, along which are occasional precipices which only a torrent could descend.

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* U. S. Exploring Expedition during the years 1838–1842, under the command of C. WILKES, U. S. N.—Geology by JAMES D. DANA, A.M., Geologist of the Expedition. 750 pp. 4to, with a folio Atlas of 21 plates of fossils. Philadelphia: 1849.

III. Valleys of the *third* kind have an extensive plain at bottom quite unlike the strip of land just described. They sometimes abut at head against vertical walls, but oftener terminate in a wide break in the mountains.

The ridges of land which intervene between the valleys, have a flat or barely undulated surface, where these valleys intersect the lower plains or slopes; but in the mountains, they are narrow at top, and sometimes scarcely passable along their knife-edge summits. Some of them as they extend inward, become more and more narrow, and terminate in a thin wall, which runs up to the central peaks. Others stop short of these central peaks, and the valleys either side consequently coalesce at their head, or are separated only by a low wall, into which the before lofty ridge had dwindled. The crest is often jagged, or rises in sharp serratures.

The main valleys, which we have more particularly alluded to above, have their subordinate branches; and so the ridges in necessary correspondence, have their subordinate spurs.

As examples of the valleys and ridges here described, we introduce a brief account of an excursion in the Hanapepe valley on Kauai, one of the Hawaiian Islands, and a second up the mountains of Tahiti.

Hanapepe Valley, Kauai.—We reached its enclosing walls, about four miles from the sea, where the sloping plain of the coast was just losing its smooth, undulating surface, and changing into the broken and wooded declivities of the interior. The valley, which had been a channel through the grassy plain, a few hundred feet in depth, was becoming a narrow defile through the mountains. A strip of land lay below, between the rocky walls, covered with deep-green garden-like patches of taro, through which a small stream was hastening on to the sea.

We found a place of descent, and three hundred feet down, reached the banks of the stream, along which we pursued our course. The mountains, as we proceeded, closed rapidly upon us, and we were soon in a narrow gorge, between walls one thousand feet in height, and with a mere line of sky over head. The stream dashed along by us, now on this side of the green strip of land, and then on that; occasionally compelling us to climb up, and cling among the crevices of the walls to avoid its waters, where too deep or rapid to be conveniently forded. Its bed was often rocky, but there was no slope of debris at the base of the walls on either side, and for the greater part of the distance it was bordered by plantations of taro. The style of mountain architecture, observed on the island of Oahu, was exhibited in this shaded defile on a still grander scale. The mural surfaces enclosing it had been wrought, in some places, into a series of semicircular alcoves or recesses, which extended to the distant summits over head: more commonly, the walls were formed of a series of semicircular columns of vast size, collected together like the clustered shafts of a Gothic structure, and terminating several hundred feet above, in low conical summits. Although the sides were erect or nearly so, there was a profuse decoration of vines and flowers, ferns, and shrubbery; and where more inclined, forests covered densely the slopes.

These peculiar architectural features proceed from the wear of rills of waters, streaming down the bold sides of the gorge; they channel the surface, leaving the intermediate parts prominent. The rock is uniformly stratified, and the layers consist of gray basalt or basaltic lava, alternating with basaltic conglomerate.

Cascades were frequently met with; at one place, a dozen were playing around us at the same time, pouring down the high walls, appearing and disappearing, at intervals, amid the foliage, some in white foamy threads, and others in parted strands imperfectly concealing the black surface of rock beneath.

A rough ramble of four miles brought us to the *falls* of the Hanapepe. The precipice, sweeping around with a curve, abruptly closed the defile, and all farther progress was therefore intercepted. We were in an amphitheatre of surpassing grandeur, to which the long defile, with its fluted or Gothic walls, decorated with leaves and flowers and living cascades, seemed a fit porch or entrance-way. The sides around were lofty, and the profuse vegetation was almost as varied in its tints of green as in its forms. On the left stood apart from the walls an inclined columnar peak or leaning tower, overhanging the valley. Its abrupt sides were bare, excepting some tufts of ferns and mosses, while the top was crowned with a clump of bushes. To complete the decorations of the place,—from a gorge on the right, in the verdant mountains above, where the basaltic rocks stood out in curved ascending columns on either side, as if about to meet in a Gothic arch, a stream leaped the precipice and fell in dripping foam to the depths below; where, gathering its strength again, it went on its shaded way down the gorge.

The *mountains of Tahiti* commence their slopes from the sea or a narrow sea-shore plain, and gradually rise on all sides towards the central peaks, the ridges of the north and west terminating in the towering summits of Orohena and Aorai, while the eastern and southern, though reaching towards the same peaks, are partly intercepted by the valley of Papenoo. Aorai is seven thousand feet in height and Orohena not less than eight thousand feet.

We commenced the ascent of Mount Aorai by the ridge on the west side of the Matavai Valley, and, by the skillfulness of our guide, were generally, able to keep the elevated parts of the ridge without descending into the deep valleys which bordered our path. An occasional descent, and a climb on the opposite side of the valley were undertaken; and although the sides were nearly perpendicular, it was accomplished, without much difficulty, by clinging from tree to tree, with the assistance of ropes, at times, where the mural front was otherwise impassable. By noon of the second day, we had reached an elevation of five thousand feet and stood on an area twelve feet square, the summit of an isolated crest in the ridge on which we were travelling. To the east, we looked down two thousand feet into the Matavai Valley; to the west a thousand feet into a branch of the Papaua Valley, the slopes either way, being from sixty to eighty degrees, or within thirty degrees of perpendicular. On the side of our ascent, and beyond, on the opposite side, our peak was united with the adjoining summit by a thin ridge, reached by a steep descent of three hundred feet. This ridge was described, by our natives, as no wider at top than a man's arm, and a fog coming on, they refused to attempt it that day. The next morning being clear, we pursued our course. For a hundred rods, the ridge on which we walked was two to four feet wide, and from it, we looked down, on either side a thousand feet or more, of almost perpendicular descent. . Beyond this the ridge continued narrow, though less dangerous, until we approached the high peak of Aorai. This peak had appeared to be conical and equally accessible on different sides, but it proved to have but one place of approach, and that along a wall with precipices of two to three thousand feet, and seldom exceeding two feet in width at top. In one place we sat on it as on the back of a horse, for it was no wider, and pushed ourselves along till we reached a spot where its width was doubled to two feet, and numerous bushes again affording us some security, we dared to walk erect. We at last stood perched on the summit edge, not six feet broad. The ridge continued beyond for a short distance, with the same sharp, knife-edge character, and was then broken off by the Punaavia Valley. Our height afforded a near view of Orohena; it was separated from us only by the Valley of Matavai, from whose profound depths it rose with nearly erect sides. The peak has a saddle shape, and the northern of the two points is called Pitohiti. These summits, and the ridge which stretches from them toward Matavai, intercept the view to the southward. In other directions, the rapid succession of gorge and ridge that characterizes Tahitian scenery, was open before us. At the western foot of Aorai, appeared the Crown. Beyond it extended the Punaavia Valley, the only level spot in sight; and far away, in the same direction, steep ridges, rising behind one another with jagged outline, stood against the western horizon. To the north, deep valleys gorge the country, with narrow precipitous ridges between; and these melt away into ridgy hills and valleys, and finally into the palm-covered plains bordering the sea.

On our descent, we followed the western side of the Papaua Valley, along a narrow ridge such as we have described, but two or three feet wide at top, and enclosed by precipices of not less than a thousand feet. Proceeding thus for two hours, holding to the bushes which served as a kind of balustrade, though occasionally startled by a slip of the foot one side or the other—our path suddenly narrowed to a mere edge of naked rock, and, moreover, the ridge was inclined a little to the east, like a tottering wall. Taking the upper side of the sloping wall, and trusting our feet to the bushes while clinging to the rocks above, carefully dividing our weight lest we should precipitate the rocks and ourselves to the depths below, we continued on till we came to an abrupt break in the ridge of twenty feet, half of which was perpendicular. By means of ropes doubled around the rocks above, we in turn let ourselves down, and soon reached again a width of three feet, where we could walk in safety. Two hours more at last brought us to slopes and ridges where we could breathe freely.

The peculiarities here described characterize all parts of the island. Towards the high peaks of the interior, the ridges which radiate from, or connect with them, become mere mountain walls with inaccessible slopes, and the valleys are from one to three thousand feet in depth. The central peaks themselves have the same wall-like character. It is thus with Orohena and Pitohiti, as well as Aorai; and owing to the sharpness of the summit edge, rather than the steepness of the ascent, Orohena is said to be quite inaccessible. Dr. Pickering and Mr. Couthouy, in an excursion to a height of five thousand feet on this ridge, met with difficulties of the same character we have described.

Without citing other examples, we continue with the author's remarks on the origin of these valleys.

The causes operating in the Pacific, which may have contributed to valley-making, are the following:

1. Convulsions from internal forces, or volcanic action.
2. Degradation from the action of the sea.
3. Gradual wear from running water derived from the rains.
4. Gradual decomposition through the agency of the elements and growing vegetation.

The *action of volcanic forces* in the formation of valleys, is finely illustrated in the great rupture in the summit of Hale-a-kala on Maui. The two valleys formed by the eruption are as extensive as any in the Hawaiian Group, being two thousand feet deep at their highest part, and one to two miles wide. They extend from the interior outward towards the sea. Above, they open into a common amphitheatre, the remains of the former crater, the walls of which are two thousand feet high.

As other examples of volcanic action, we may refer to the pit craters of Mount Loa, among which Kilauea stands preëminent. This great corral, if we may use a Madeira word, is a thousand feet deep, one to two miles wide, and over three long, so that it forms a cavity which may compare advantageously with many valleys; and were the walls on one side removed, it might become the head of a valley like that of Hale-a-kala on Maui.

As an example of this kind of valley upon islands which have lost their original volcanic form, we venture to refer to the wide Nuuanu, back of Honolulu, (island of Oahu,) which has at its head on either side, a peak rising above it to a height of two thousand four hundred feet, or four thousand feet above the sea.

The immense amphitheatre to the west of the lofty Orohena and Aorai, on the island of Tahiti, is remarkable for its great breadth, and the towering summits which overhang it; and if not a parallel case to that of Maui, that is, if the head was not originally the great crater, there must have been a subsidence or removal of a large tract by internal forces.

The precipice of the eastern mountain of Oahu, is another example of the effect of convulsion in altering the features of islands, causing either a removal or subsidence.

The many fissures which are opened by the action of Kilauea, might be looked upon as valleys on a smaller scale, and the germs of more extensive ones. But with few exceptions, these fissures as soon as made are closed by the ejected lava, and the mountain is here no weaker than before. Those which remain open, may be the means of determining the direction of valleys afterwards formed.

Action of the sea.—The action of the sea in valley-making, is supposed to have been exerted during the rise of the land; and as such changes of level have taken place in the Pacific, this cause it would seem, must have had as extensive operation in this vast ocean as any where in the world, especially as the lands are small and encircled by the sea, and there is, therefore, a large amount of coast exposed, in proportion to the whole area.

But in order to apprehend the full effect of this mode of degradation, we should refer to its action on existing shores.* At the outset we are surprised at finding little evidence of any such action now in progress along lines of coast. The islands, and the shores of continents have occasional bays, but none that are deepening by the action of the sea. The waves tend rather to fill up the bays and remove by degradation the prominent capes, thus rendering the coast more even, and at the same time, accu-

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* The view here presented is sustained in De la Beche's Geological Researches, page 192.

mulating beaches that protect it from wear. If this is the case on shores where there are deep bays, what should it be on submarine slopes successively becoming the shores, in which the surface is quite even compared with the present outline of the islands? Instead of making bays and channels, it can only give greater regularity to the line of coast.

Upon the North American coast, from Long Island to Florida there are no valleys in progress from the action of the sea. On the contrary, we ascertain by soundings that the bottom is singularly even; and the bays, as that of New York, are so acted upon by the sea, that were it not, in the case mentioned, for the action of the current of the Hudson River, its limits would continue gradually to contract. Around Tahiti there are no submarine valleys. The valleys of the land are often two thousand feet deep; but they die out towards the shores. Thus over the world, scarcely an instance can be pointed out of valley making from the action of the sea. During the slow rise of a country, the condition would not be more favorable for this effect than in a time of perfect quiet. If America were to be elevated, would the action make valleys in the shores just referred to? If England were slowly to rise, would this favor the scooping of valleys through its beaches? Would not beach formations continue to be the legitimate production of the sea along its line of wave action; and where the rocks should favor the opening of a deep cove, would not the same action go on as now, causing a wear of the headlands and a filling up of the cove at its head? Were Tahiti now to continue rising, could the waves make valleys on the coast? The increasing height of the mountains would give the streams of the land greater eroding force, and more copious waters; but the levelling waves would continue to act as at the present time. The effects of the sea in making valleys have been much exaggerated, as is obvious from this appeal to existing operations, the appropriate test of truth in geology.

The action of a rush of waters in a few great waves over the land, such as might attend a convulsive elevation, though generally having a levelling effect, might produce some excavations, as is readily conceived; yet it is obvious on a moment's consideration, that such waves could not make the deep valleys, miles in length, that intersect the rocks and mountains of our globe.

But it is supposed that there may be fissures about volcanic islands in which the sea could ply its force. Yet even in these cases, unless the fissures were large, the seashore accumulations would be most likely to fill and obstruct them. To try this hypothesis by facts, we remark that there are no such shore fissures around Mount Loa, nor any of the other Hawaiian Islands. The fissures formed by volcanic action immediately about a volcano, are generally filled at once with lavas as we have stated, and the vent is mended by the force which made it. It is, therefore, a gratuitous assumption that such fissures have been common. The existence, however, of large valleys such as have been attributed above to convulsions cannot be doubted; but the sea would exert its power in such places, nearly as now in Fangaloa Bay, Tutuila, and other bays in continents;—a beach forms, and a shore plain, and afterwards there is a little action from the sea in these confined areas of water.

In the Illawarra district, New South Wales, there are several places where dikes of basalt have been removed by the sea, and channels one hundred yards in depth, of the width of the dike (six feet), now exist, cutting straight into the rocky land. This is an example of the action of the sea where everything is most favorable for it. And we observe that there is little resemblance in this narrow channel with but a trifling wear of the inclosing rocks, to the valleys which are to be accounted for in the Pacific; and little authority to be derived from it for attributing much efficacy to the sea in wearing out valleys. The reason of this is apparent in the fact that the sea rolls up a coast in great swells, and cannot parcel itself off, and act like a set of gouges: this latter effect it leaves for the streams and streamlets of the shores which are gouges of all dimensions.

Although the sea can accomplish little along coasts towards excavating valleys, yet when the land is wholly submerged, or only the mountain summits peer out as islands, the great oceanic currents sweeping over the surface and through channels between the islands, would wear away the rocks or earth beneath. From the breadth and character of such marine sweepings, we learn that the excavations formed would be very broad rounded valleys; and their courses would correspond in some degree with the probable direction which the currents of the ocean would have, over the region in case of a submergence. Moreover where there are different open channels for the ingress of the sea, having free intercommunication, there are often strong currents connected with the tides, and consequently much erosion. It is obvious that the valleys of the Pacific islands have nothing in their features or positions attributable to such a cause.

Running water of the land, and gradual decomposition.—Of the causes of valleys mentioned in the outset we are forced to rely for explanations principally upon running streams: and they are not only gouges of all dimensions, but of great power, and in constant action. There are several classes of facts which support us in this conclusion.

a. We observe that Mount Loa, whose sides are still flooded with lavas at intervals, has but one or two streamlets over all its slopes, and the surface has none of the deep valleys common about other summits. Here volcanic action has had a smoothing effect, and by its continuation to this time, the waters have had scarcely a chance to make a beginning in denudation.

Mount Kea, which has been extinct for a long period, has a succession of valleys on its windward or rainy side, which are several hundred feet deep at the coast and gradually diminish upward, extending in general about half or two-thirds of the way to the summit. But to the westward it has dry declivities, which are comparatively even at base, with little running water. A direct connection is thus evinced between a windward exposure, and the existence of valleys: and we observe also that the time since volcanic action ceased is approximately or relatively indicated, for it has been long enough for the valleys to have advanced only part way to the summit. Degradation from running water would of course commence at the foot of the mountain, where the waters are necessarily more abundant and more powerful in denuding action, in consequence of their gradual accumulation on their descent. Mount Kea, like Mount Loa, is nearly 14,000 feet high, and the average slope is 7 to 8 degrees.

Hale-a-kala on Maui offers the same facts as Mount Kea, indicating the same relation between the features of the surface and the climate of the different sides of the island. On Eastern Oahu the valleys are still more extensive; yet the slopes of the original mountains may be in part distinguished. And thus we are gradually led to Kauai, the westernmost of the Hawaiian Islands, where the valleys are very profound and the former slopes can hardly be made out. The facts are so progressive in character, that we must attribute all equally to the running waters of the land.

The valleys of Mount Kea alone, extending some thousands of feet up its sides, sustain us in saying, that time only is required for the formation of similar valleys elsewhere in the Pacific. As in Tahiti, so in other islands. these valleys take the direction of the former slopes; and though they may be of great depth and commence even under the central summits, they *terminate at the sea level, instead of continuing beneath it.*

The fluting of the walls of the Hanapepe Valley, a thousand feet or more in height, has been described on a preceding page. It cannot be doubted here that water was the agent; for the rills are seen at work. The contrast between the same valley near the sea, and in the mountains, (the walls in the former case being nearly unworn vertically,) is explained on the same principle: for the mountains are a region of frequent rains and almost constant clouds, and therefore abound in streams and streamlets and threads of water; while below, there are grassy plains instead of forest declivities, and but little rain. These furrowings vary from a few yards in width and depth to many furlongs.

The long and lofty precipice of Eastern Oahu, is an excellent place for studying farther this action. It is fluted in the same style as the Hanapepe Valley. In the distant view the vertical channels appear very narrow; but when closely examined they are found to be deep and often winding passages. The precipice faces to the windward, and is directly under the whole line of peaks in the mountain range, both of which facts account for an abundance of water. Going to the westward along the range, the precipice changes to a sloping declivity, and these passages become deeper and longer, and more winding, just in proportion to the increasing length of the slopes: moreover at the same time they decrease in number. Where there is no slope to collect the waters, the rills act independently, and their furrowings like themselves are small, narrow, and numerous; but as the declivity becomes gradual, the rills flow on and collect into larger streams, and the furrowings become deeper and more distant. Over this region, no distinction can be drawn as regards origin between these flutings and the gorges: and in respect to features, only this difference appears, that the size of the excavations is less and the number greater, the steeper the declivity. If a fissure be appealed to as the commencement of the longer valleys, it should also be admitted for each of the flutings. But this idea is wholly inadmissible.

A brief review of the action of flowing waters with reference to the different results described may place this subject in a clear light.

a. Suppose a mountain, sloping around like one of the volcanic domes of the Pacific.—The excavating power at work proceeds from the rains or condensed vapor, and depends upon the amount of water and rapidity of slope.

b. The transporting force of flowing water* increases as the sixth power of the velocity,—double the velocity giving sixty-four times the transporting power.—The eroding force will be greater than this on a mountain declivity, where the waters add their own gravity to the direct action of a progressive movement.

c. Hence, if the slopes are steep, the water gathering into rills excavates so rapidly, that every growing streamlet ploughs out a gorge or furrow; and consequently the number of separate gorges is very large, and their sizes comparatively small, though of great depth.

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* It has been shown by W. Hopkins, Esq., that the moving force of running water, (this force being estimated by the volume or weight of a mass of any given form which it is just capable of moving,) varies as the *sixth* power of the velocity. He says, "if a stream of ten miles an hour would just move a block of five tons weight, a current of fifteen miles an hour would move a block of similar form upwards of fifty-five tons; a current of twenty miles an hour would, according to the same law, move a block of three hundred and twenty tons: again, according to the same law, a current of two miles an hour would move a pebble of similar form of only a few ounces in weight."—*On the Transport of Erratic Blocks,* Trans. Camb. Phil. Soc., 1844, viii, 221, 233.

d. But if the slopes are gradual, the rills flow into one another from a broad area, and enlarge a central trunk, which continues on towards the sea, with frequent additions from either side. The excavation above, for a while, is small; for the greater abundance of water below, during the rainy seasons, causes the denudation to be greatest there, and in this part the gorge or valley most rapidly forms. In its progress, it enlarges from below upward, though also increasing above; at the same time, the many tributaries are making lateral branches.

e. Towards the foot of the mountain, the excavating power ceases whenever the stream has no longer in this part a rapid descent,—that is whenever the slope is not above one or two feet to the mile. The stream *then consists of two parts, the torrent of the mountains and the slower waters below*, and the latter is gradually lengthening at the expense of the former.

f. After the lower waters have nearly ceased excavation, a new process commences in this part,—that of widening the valley. The stream which here effects little change at low water, is flooded in certain seasons, and the abundant waters act *laterally* against the enclosing rocks. Gradually, through this undermining and denuding operation, the *narrow bed becomes a flat strip of land, between lofty precipices*, through which, in the rainy season, the streamlet flows in a winding course. The streamlet, as the flat bottom of the valley is made, deposits detritus on its banks, which in some places so accumulates as to prevent an overflow of the banks by any ordinary freshet. Such is the origin of the deep channels with a riband of land at bottom that cut through the "dividing plain" of Oahu, and which are common towards the shores of many of the Pacific islands.

g. The torrent part of the stream, as it goes on excavating, is gradually becoming more and more steep. The rock-material operated upon, consists of layers of unequal hardness, varying but little from horizontality and dipping towards the sea, and this occasions the formation of cascades. Whenever a softer layer wears more rapidly than one above, it causes an abrupt fall in the stream: it may be at first but a few feet in height; but the process begun, it goes on with accumulating power. The descending waters in this spot add their whole weight, as well as a greatly increased velocity, to their ordinary force, and the excavation below goes on rapidly, removing even the harder layers. The consequences are, a fall of increasing height, and a basin-like excavation directly beneath the fall. Often, for a short distance below, the stream moves quietly before rushing again on its torrent course, and when this result is attained by the action, the height of the fall has nearly reached its limit as far as excavation below is concerned;—though it may continue to increase from the gradual wear and removal of the rocks over which it descends.

h. As the gorge increases in steepness, the excavations above deepen rapidly,—the more rapid descent more than compensating, it may be, for any difference in the amount of water. Moreover, as the rains are generally most frequent at the very summits, the rills in this part are kept in almost constant action through the year, while a few miles nearer the sea they are often dried up or absorbed among the cavernous rocks. The denudation is consequently at all times great about the higher parts of the gorge, (especially after the slopes have become steep by previous degradation;) thus finally a steep precipice forms the head of the valley.

i. The waters descending the ridges either side of the valley or gorge, are also removing these barriers between adjacent valleys, and are producing as a *first* effect, a thinning of the ridge at summit to a mere edge; and as a *second*, its partial or entire removal, so that the two valleys may at last be separated only by a low wall, or even terminate in a common head,—a wide amphitheatre enclosed by the lofty mountains. In one case, the ridge between the two valleys, which towards the shores of the island has rather a broad back, high up in the region of mists and frequent rains becomes a narrow wall, and thus connects with the central summit. In the second, the ridge finally terminates abruptly, and a deep valley separates it from the main mountain.

The following sketch may assist the mind in conceiving of the action upon the Pacific mountains. It represents one of the valleys of Tahiti from the centre to the shore, excepting its irregularities of direction and descent, and the uneven character of its walls, arising from lateral valleys and minor denudations. The height of Tahiti is about eight thousand feet; its radius *c s* is ten geographical miles. The head of the valley at *a* is three thousand feet below the summit peak *p*. The descent along the air-line from *a* to *s*, averages five hundred feet to the mile. If *a* be four thousand feet below the summit, the exact depth was not ascertained,) it would still give four hundred feet to the mile.

This subject is beautifully illustrated in some of the tufa cones of Oahu, where, on a smaller scale, we have the same kind of gorge and valley; and in this case, there is no doubt that denudation was the cause by which they were produced. The valleys have the direction of the slopes, and are similar in form and winding character to those of the mountains. The intervening ridges are also similar. Many of them become very thin at summit as they rise towards the crest of the volcanic cone, and others have this upper part adjoining the crest wanting, owing to the extent of the degradation, so that two valleys have a common head against the vertical bluff. A better model of the mountain gorges could hardly be made, and it stands near by, convenient for comparison. Diamond Hill, one of these cones, is 800 feet high.

We need add little, in this place, on the capabilities of running water, after the statement, based on mathematics, that the transporting force varies as the sixth power of the velocity. If we remember that these mountain streams at times increase their violence a million fold when the rains swell the waters to a flood, all incredibility on this point must be removed.

A few thousand feet in depth, even in the solid rocks, is no great affair for an agent of such ceaseless activity, during the periods which have elapsed since the lands became exposed to their influence. And when we take into view the lofty heights of the Pacific islands, their rapid declivities giving speed to the waters and transported stones and earth, we must admit that of all lands, these are especially fitted for denudation by torrents.

The nature of the rocks also favors wear and removal. They are in successive layers, soft conglomerates or tufas frequently alternating with the harder basalt or basaltic lava. Moreover, the rock is commonly much fissured, owing to a tendency to a columnar structure; besides, they are often cellular. The waters thus find admission, promoting decomposition and also degradation. There are, also, frequent caverns between layers, which contribute to the same end.

There is every thing favorable for degradation which can exist in a land of perpetual summer: and there is a full balance against the frosts of colder regions in the exuberance of vegetable life, since it occasions rapid decomposition of the surface, covering even the face of a precipice with a thick layer of altered rock, and with spots of soil wherever there is a chink or shelf for its lodgment. The traveler on one of these islands ascending a valley on a summer day, when the streams are reduced to a mere creeping rill which half the time burrows out of sight, seeing the rich foliage around, vines and flowers in profusion covering the declivities and festooning the trees, and observing scarcely a bare rock or stone excepting a few it may be along the bottom of the gorge, might naturally inquire with some degree of wonder, where are the mighty agents which have channeled the lofty mountains to their base? But though silent, the agents are still on every side at work; decomposition is in slow, but constant progress; the percolating waters are acting internally, if not at the surface. Moreover, at another season, he would find the scene changed to one of noisy waters, careering along over rocks and plunging down heights with frightful velocity; and then the power of the stream would not be disputed.*

But if the waters have been thus efficient in causing denudation and opening valleys, may not fissures or dikes have determined their courses? The only test of truth, an appeal to facts, may answer the question. Mount Loa is a mountain yet unchanged. It has its dikes in great numbers: but over these dikes the country is more apt to be *raised* a little from the overflow of lavas than depressed, and this would turn off the water. Again, we see no instances of dikes yielding, and offering a course for a stream. As to unfilled fissures, there are few of them, and these, with rare exceptions, are immediately about the active vents. Is either supposition then sustained by the facts presented? We know the tendency of water to take the lowest parts of a surface, and will it not follow these parts, whether or not there be a dike or fissure? It is obvious that whatever ravines or depressions the floods of lava may have left, would be the courses of the waters; and these depressions would be followed to the sea, and ultimately become valleys. We may believe that the waters would not wait till there was a convenient fissure; they would go where *inclination* led, and make valleys with little difficulty, if there were no guiding or aiding fissures. Were the dikes filled by a rock more decomposable or more easily eroded than those enclosing it, as is the case in some granitic regions, we should expect that they would frequently become water courses: but this is seldom the fact in the Pacific islands.

The valleys in some of the Canary Islands, extend from the shores part way to the summit, as on Mount Kea and Hale-a-kala, and evidently for the reason already explained. We can detect

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* The rise of the streams, from the rains of the mountains, is often so rapid that in some instances, the native villages of the coast become flooded, before they have time even to move their property.—*Miss. Herald.* xxiii, 207.

Mr. Coan, who has often traversed the coast of Hawaii, north of Hilo, and during the drier seasons, (which, however, are of short duration on this, the windward coast,) fords the shallow streams without difficulty, gives the following account of his journey during a time of rains. "Great and continued rains fell during my absence, and the numerous rivers became so swollen and furious that the very sight of them was fearful. These raging streams crossed my path about *once in half a mile* for a distance of about thirty miles, and I was compelled to cross them to return home. Most of them run at a rate of twenty or thirty miles an hour, and in their course there are numerous cataracts from ten to a hundred and fifty feet in perpendicular descent. Though the torrents were so fearful as to make one almost quail at the thought of struggling with their fury, ropes were provided, and several men employed for the adventurous task. Great calmness and presence of mind, and great energy and muscular effort, were required to retain one's grasp of the rope, and buffet with the foaming flood. We at last succeeded, though at imminent peril. At one of the rivers, we spent three hours in finding a place where we might, with any degree of safety, extend our hawser across, and transfer our party to the opposite bank. The streams are at the bottom of narrow ravines, with the banks exceedingly precipitous, and often perpendicular bluffs of basaltic rock."—*Miss. Herald*, xxxviii, 157.

in regions of a similar kind, no evidence that the valleys have depended for their origin on the mountain's being a "crater of elevation," as von Buch urges.* The regular stratification of the sides of these valleys; the absence of all tiltings; their situation, as related to the rains; and the absence of fissures ready for making valleys on the leeward declivities, are points which favor no such theory: and, moreover, it is an unnecessary hypothesis.

We are thus led to conclude that between convulsions from subterranean forces, and degradation from waters supplied by the rains and attending decomposition, a lofty volcanic dome may be changed to a skeleton island like Tahiti. We have referred to Mount Loa as still unfurrowed; to Mount Kea and Hale-a-kala as having only the lower slopes deeply channeled with narrow gorges; and to other islands, as exemplifying all gradations in these effects to those in which the original features are no longer to be traced: we have pointed out the difference in the windward and leeward slopes, and have shown a relation between the quantity of rain and the amount of degradation:—we have exhibited a model of the mountains, an undeniable result of denudation, placed at their very base, as if for illustration:—and thus we have traced out and elucidated all the steps in the valley-making process, and have also shown them to be a necessary result from the action of running water.

Again, examples of convulsions from igneous forces have been pointed out in the great gorges of Hale-a-kala, and in Kilauea and other Hawaiian craters; in the mountain wall of Oahu, and similar scenes on other islands; in the wide amphitheatre of central Tahiti: and the importance of this means of change has thus been exhibited. Yet few such changes are apparent on any one island, and these are marked by decided characters not often to be mistaken. It has also been shown that although fissures made by volcanic forces, may in some cases have given the direction to valleys, yet they are by no means necessary in order that valleys should commence to form.

With literal truth may we speak of the valleys of the Pacific Islands, as the furrowings of time, and read in them marks of age. Our former conclusion with regard to the different periods which have passed over the several Hawaiian Islands since the fires ceased and wear begun, is fully substantiated. We also learn how completely the features of an island may be obliterated by this simple process, and even a cluster of peaks like Orohena, Pitohiti and Aorai of Tahiti, be derived from a simple volcanic dome or cone. Mount Loa, alone, contains within itself the material from which an island like Tahiti might be modeled, that should have near twice its height and four times its geographical extent.

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* See Iles Canaries, p. 285.

ART. XI.—*Remarks on the Constitution of Leucine, with critical observations upon the late Researches of M. Wutz;* by T. S. HUNT.

IN the American Journal for January, 1848, p. 123, I made some suggestions as to the true composition of leucine and proposed a correction of the formula which had been deduced by M. Mulder from his analyses. After noticing the sulphuretted alkaloid thialdine, lately discovered by Wöhler and Liebig, I remarked that it corresponded to a normal species whose formula is $C_{12}H_{13}NO_4$, which would be a homologue of glycocoll, "and very probably no other than leucine." This correction I ventured upon without having before me the analytical results of M. Mulder, because as I have stated, the formula deduced by that chemist, $C_{12}H_{12}NO_4$, was irreconcilable with the law which MM. Gerhardt and Laurent have announced as governing the composition of all azotized bodies. My proposed formula on the contrary, made this anomaly to disappear, and showing it a homologue of glycocoll, a substance formed at the same time with it, by the action of potash upon gelatine, at once explained the singular reactions of leucine with nitric acid, already described by M. Braconnot. Not having it in my power to verify any farther my view, I left the matter to the consideration of chemists.

In the Comptes Rendus de l'Acad. for Sept. 4th, 1848, there appears a communication from M. Cahours, who had submitted to analysis both leucine and aposepedine, (a product of the putrefaction of caseine which Mulder had supposed to be identical with leucine,) and found the two substances to agree in composition and to have precisely the formula which I had previously assigned. He has found that they form beautifully crystalline compounds with nitric and hydrochloric acids, and gives to the former the formula $C_{12}H_{13}NO_4, NO_5\,HO$. M. Cahours has also pointed out the relation between this body and thialdine and their homology with glycocoll. The *sarcosine* obtained by M. Liebig, by the action of barytic water upon creatine, has the formula $C_6H_7NO_4$ and belongs to the same homologous series.

The Annales de Chimie et de Physique for Nov., 1848, contains a memoir on the same subject by MM. Laurent and Gerhardt, from which it appears, that led by the same considerations as M. Cahours and myself, they have submitted leucine and its compound with nitric acid to analysis, and have arrived at the same conclusions as to its composition and homologous relations. None of these gentlemen however have alluded to my observations published ten months previous, which appear to have escaped their notice.

My formula requires C 54·9, H 9·9, N 10·7, O 24·5. The analyses of Mulder show on comparison with this, a little deficiency in the H and N, but those of M. Cahours are very close approximations. He obtained the following numbers:

	Aposepedine.			Leucine.	
Carbon, . . .	55·19	55·04	54·86	55·12	54·79
Hydrogen, . .	9·86	10·11	10·06	10·06	10·04
Azote, . . .	10·63	10·85	10·89	10·89	

The first analyses of MM. Laurent and Gerhardt made upon aposepedine, showed a deficiency in the carbon, but by solution in nitric acid and evaporation, the salt already described was obtained in beautiful crystalline needles, which, dried at 212° F., corresponded exactly with the numbers calculated from the formula $C_{12}H_{13}NO_4, NO_5 HO$, or in their notation, $C_6H_{13}NO_2, NHO_3$. This salt dissolved in a little water, mixed with alcohol, and precipitated while hot by ammonia, gave leucine in fine white scales, entirely inodorous; the analysis of this gave C 54·6, H 9·9. These results establish beyond all doubt the new formula.

The hydrochloric compound gave Cl 20·6, which corresponds to the formula $C_6H_{13}NO_2, HCl$. The nitrate, nitro-leucic acid of M. Bracconnot, forms, as that chemist had shown, crystallizable salts with lime and magnesia, and the authors have described a similar silver-salt. They remark moreover upon the fact that the three known alkaloids of this series appear to be derived from the same parent substance, for the sarcosine has been obtained from creatine which is without doubt a product of the transformation of the muscular tissues, and they suggest that sarcosine and the two homologues yet unknown, between this substance and leucine, may be detected in the products of these transformations of the animal matters, which yield glycocoll and leucine.

M. Laurent in a late memoir,* has shown that glycocoll may be regarded as the amid of an acid which is $C_4H_4O_6$, and differs from the acetate only by two equivalents of oxygen. For this acid he proposes the name of *glycocollic;* glycocoll will then be *glycolamic acid.* Mr. Horsford, by the action of chlorine upon a solution of glycocoll, obtained a substance which gave with chlorid of barium a crystallized salt, to which he ascribes the formula $C_3H_3O_6$, BaO,† but as M. Gerhardt has remarked, an equivalent of the carbon would be retained by the baryta as a carbonate, and that making a correction for this, the numbers obtained lead to $C_4H_3O_5, BaC = C_4H_3BaO_6$ which is that of the barytic salt of glycocollic acid.

This new genus is homologous with the carbonates, and sustains the same relation to the acetate, as the carbonic $C_2H_2O_6$ does to formic acid. Carbonic acid is the type of a series of

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* Annal. de Chim. et de Phys., May, 1848, p. 111.

† Am. Jour. Sci., Nov., 1847, p. 327

acids, including the glycocollic which are bibasic; the glycocolls are then monamids of bibasic acids, and while they possess the power of combining with acids, like alkaloids, have still an atom of saline hydrogen so that they may combine alike with nitric acid and nitrate of silver. The nitrate of glycocoll is indeed a copulate of two monobasic compounds, and thus in accordance with M. Gerhardt's law of saturation necessarily bibasic.

The glycocolls are isomeric with urethane and urethylane, those singular compounds discovered by M. Dumas by acting with ammonia and upon the chlorocarbonic ethers of ethylic and methylic alcohol.

Glycocoll is isomeric with urethylane, and sarcosine with urethane; leucine corresponds in the same manner to the unknown uramylane. The late researches of Wurtz upon the cyanic ethers* have made known some other new substances which sustain intimate relations to these bodies. I have shown some time since, that water is to be regarded as the homologue of the alcohols, and that consequently the ethers are homologous with their parent acids,† and M. Wurtz has found that as cyanic acid combines with ammonia and produces urea $C_2H_4N_2O_2$, a body pertaining to the formic series; the cyanic ethers give rise by the same action to two new compounds which have the formulas $C_4H_6N_2O_2$ and $C_6H_8N_2O_2$ and are the ureas of the acetic and metacetic series.

The action of water upon the cyanic ethers is not less remarkable; carbonic acid gas is disengaged and crystalline substances are formed which are soluble in alcohol and water. The reaction is dependent upon the assimilation of the elements of water and is thus represented,

$$2C_4H_3NO_2+2HO=2CO_2+C_6H_8N_2O_2$$

$$2C_6H_5NO_2+2HO=2CO_2+C_{10}H_{12}N_2O_2.$$

The first of these has the composition of metacetic urea, and the second that of valerianic urea, but the substance thus obtained from the cyanomethylic ether differs from the true metacetic urea in its properties, and M. Wurtz hence regards these new bodies as constituting an isomeric group.

We have then in the urethanes and the glycocolls, the ureas and the new compounds of Wurtz, two groups of isomeric bodies which present some interesting relations. If the glycocolls are the monamids of their peculiar acids, the new compounds of Wurtz are equally their binamids.

	Acids.	Glycocolls.	Comps. of Wurtz.	Urethanes.	Ureas.
Formic series,	$C_2H_2O_6$	unknown.	———	———	$C_2H_4N_2O_2$
Acetic "	$C_4H_4O_6$	$C_4H_5NO_4$	unknown.	$C_4H_5NO_4$	$C_4H_6N_2O_2$
Metacetic "	$C_6H_6O_6$	$C_6H_7NO_4$	$C_6H_8N_2O_2$	$C_6H_7NO_4$	$C_6H_8N_2O_2$
Butyric "	$C_8H_8O_6$	unknown.	unknown.	unknown.	unknown.
Valerianic "	$C_{10}H_{10}O_6$	"	$C_{10}H_{12}N_2O_2$	"	"
Caproic "	$C_{12}H_{12}O_6$	$C_{12}H_{13}NO_4$	unknown.	"	"

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* Chem. Gazette, Oct. 16th, from Comptes Rendus, Aug. 28th, 1848.

† This Jour., March, 1848, p. 265.

The farther researches of Wurtz upon the decomposition of the ureas will, I think, enable us to understand more clearly the nature of these bodies. The formic urea, by the action of a solution of potash, is resolved into carbonic acid and two equivalents of ammonia; acetic urea, which differs from it by $C_2 H_2$, is decomposed in a similar manner and yields one equivalent of ammonia and one of a new alkaloid homologous with it, which is represented by $C_2 H_5 N$. The transformation may be thus represented:

Formic urea, $C_2H_4N_2O_2+2KHO_2=C_2K_2O_6+NH_3+NH_3$.
Acetic urea, $C_4H_6N_2O_2+2KHO_2=C_2K_2O_6+NH_3+C_2H_5N$.

In the same way metacetic urea yields $C_4 H_7 N$; these alkaloids sustain to their respective alcohols the same relation that ammonia does to water. The action of potash upon the cyanic ethers has enabled M. Wurtz to obtain two new bodies in a state of purity; for as the ureas consist of these ethers with the addition of NH_3, we can easily see that the decomposition of the latter will give the alkaloids unmixed with ammonia. The discoverer has described them under the names of *methylamid* and *ethylamid*, but *methylamine* and *ethylamine* are more consonant with the nomenclature adopted for the alkaloids. The first is a permanent gas, and the second a very volatile liquid, both having a strong odor of ammonia, powerfully alkaline and caustic; they precipitate metallic solutions, and form with acids, crystallizable salts, which are distinguished by their ready solubility in hot absolute alcohol.* M. Dumas suggests that from their similarity of odor, they may often be mistaken for ammonia, when evolved in organic transformations.

It now becomes important to consider what will be the results of the action of alkalies upon the isomeres of the ureas, and the other bodies which we have placed beside them. M. Wurtz, at the time when he described the first, had not discovered these new alkaloids, and in his subsequent memoir does not appear to have submitted them to experiment. It will probably be found that their decomposition yields ammonia only and not the new alkaloids, and that the difference between metacetic urea and its isomere is that while the latter is the binamid of the acid $C_6 H_6 O_6$, the former (as appears from the results of its decomposition) is the amido-ethylamid of carbonic acid.

The urethanes will probably be found to yield methylamine and ethylamine by the action of potash, but it is otherwise with their isomeres, the glycocolls; Liebig has found that leucine evolves ammonia and hydrogen by the action of hydrate of potash and forms a *valerianile*. Horsford, on the other hand, observed the evolution

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* Chem. Gazette, March 15th, from Compt. Rend., Feb. 12th, 1849.

of ammonia and hydrogen by that agent from glycocoll, and found in the residue an oxalate; its analogy with leucine would lead us to expect formic acid, but Peligot has shown that a formiate when fused with excess of potash, is converted with the evolution of hydrogen into an oxalate, so that the product of Mr. Horsford's experiment was the result of a secondary action.

When thus regarded, the isomerism of these two classes of bodies is already explained; it is precisely that which exists between the acetic methylic ether and the formic ethylic ether, two bodies scarcely distinguishable but by the action of an alkali, which converts the one into an acetate and methol, and the other into a formiate and alcohol; the number of these isomeres is only limited by the want of the higher alcohols. It follows then that there does not exist a homologue of urea in the first family, for here in this primitive species the two groups are confounded, and farther it appears, that as we rise in the scale the number of possible isomeres is greatly increased. In the third family we have regarded the compound of Wurtz as the binamid of the acid of that family, while the new urea is an amido-ethylamid of the acid of the first family; there may equally exist a bimethylamid of carbonic acid or an amido-ethylamid of glycocollic acid, all of which will be isomeric with metacetic urea. The discovery of these new alkaloids enables us, by combining the elements ($C\,H$) in various ways, to increase the number of homologues and isomeric substances to an extent which is almost inconceivable.

The action of nitrous acid upon urea is well known to result in its conversion into nitrogen and carbonic acid, which is at once decomposed into water and an anhydrid, and a similar process has been adopted by Piria in his beautiful researches upon asparagine; he has demonstrated that in this way many amids are readily decomposed into nitrogen and a non-azotized body.

A similar process applied to glycocoll, sarcosine and leucine, would probably enable us to eliminate the acids of that series,* while the decomposition of the urethanes and higher ureas as well as the new alkaloids under its action, still presents a curious subject for investigation.

Montreal, May 22d, 1849.

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* M. Cahours has observed in the memoir above quoted, that when leucine is treated with oxydizing agents or exposed to the air in solution, it is decomposed with the evolution of a very disagreeable odor, and the formation of an acid which he supposes may be a homologue of the glycocollic, and he suggests that sarcosine by a similar process may afford the lactic acid. But here he appears to be in error, for the neutral lactates are represented by $C_{12}\,H_{10}\,M_2\,O_{12}$. ($C_6\,H_{10}\,M_2\,O_6$, Gerhardt,) while in the same notation, sarcosine is $C_6\,H_7\,NO_4$. The lactic is consequently polymeric of the *sarcosic* acid which in M. Gerhardt's notation will be $C_3\,H_6\,O_3$. Lactic acid has hitherto been described as monobasic, but Engelhardt and Maddsell in their late researches upon its salts, (Liebig's Annal., lxiii, p. 83,) arrive at the conclusion that it is bibasic, apparently ignorant that M. Gerhardt had long before announced the same thing, (Precis, tome 1er, p. 596.)

ART. XII.—*On Perfect Musical Intonation, and the fundamental Laws of Music on which it depends, with remarks showing the practicability of attaining this Perfect Intonation in the Organ;* by HENRY WARD POOLE, Worcester, Massachusetts.

1. THIS paper will treat only of one department of the science of music—the laws which fix the *tune* of all musical scales, and determine all musical intervals. Any one, who is at all conversant with the musical discussions of the last few centuries, will perceive that this is but partly explored and disputed territory, where eminent scientific writers have entertained different opinions, while *all* have agreed in admitting the fact, that there ever have been, and still are, difficulties and imperfections in the musical scale, as executed on organs, piano fortes, &c., which no one has yet shown how to overcome. It is with the belief that he has overcome these difficulties and is able to throw light on this abstruse and unsettled department of the science, in a *practical* point of view, that the writer proposes to discuss it. Very little on this subject reaches the eye of the theoretical and practical musician. In our elementary musical works it is either omitted, or if treated, is not understood; indeed the writer is not aware of a treatise in which it is fully or correctly discussed.

2. It is a singular fact, that while the human ear delights in pure harmony, (as performed by voices, violins and other instruments without *fixed scales*,) and while improvement has been made in every other science and mechanical art, the organ of the present day has all the imperfection of intonation which pertained to that instrument, four centuries since. For so long a period has this imperfection existed, that it has come to be considered as necessary, not only in this instrument, but by many it is believed to be inherent in *all music.* Instead of remedying the difficulty by introducing the sounds requisite to form the several scales (played in) perfect, and inventing such mechanism as would bring these sounds under the ready control of the organist, resort has been had to "temperament," which allows but one sound for G♯ and A♭, which makes the same note answer for A, the sixth of the key of C, and A, the key note of three sharps, which flats every fifth, sharps every major third, and leaves every musical interval (with the exception of the octave) more or less *out of tune.*

3. Various attempts have been made during the last three centuries to remedy the above difficulty, and to reduce the apparent imperfections of the musical scale to a scientific and mathematical basis. Salinas wrote on the subject as early as 1577, and the folio volume of Father Mersenne was published in French and Latin in 1648. These plans were to be effected by multiplying finger keys, which of course would augment fearfully the difficulty of

correct performance. In 1811, two patents were taken out in England for "improvements in instruments with fixed scales," an account of which, with drawings, will be found in Lond. Phil. Mag., vols. 37, 38 and 39. These were improvements in temperament only, without aiming at perfect intonation. Mr. Hawkes's system had seventeen sounds in the octave; Mr. Loeschman's had twenty-four sounds. There were mechanical as well as theoretical difficulties necessarily connected with these instruments, which were fatal to their ever coming into practical use. Rev. Henry Liston, the learned author of the article "Music" in the Edinburgh Encyclopædia, has done more in this department than any other writer. His "Essay on Perfect Intonation," in one volume quarto, was published in London in 1812. He also invented an organ designed to give the diatonic scales in perfect tune, which was built by the eminent organ-builders, Flight and Robson, of London. This was an instrument of great ingenuity, but as the inventor was a theorist rather than a mechanician, there were mechanical difficulties which alone would have been fatal to it as a practical instrument. To enable one pipe to give different sounds, Mr. Liston employed "shaders," which, arranged in classes and worked by pedals, were brought over the tops of the open, and mouths of the stopped, pipes, to alter their pitch. It is hardly necessary to remark that such mechanism was impracticable; as its correct performance required an accuracy of motion which was incompatible with the material and the nature of the instrument. There were also other mechanical difficulties in his instrument, as well as errors and omissions in his theory, (of which we shall hereafter speak,) that interfere with its claim of being an instrument of *perfect intonation*. Its harmony, however, was superior to that of the tempered organs, and is thus spoken of by John Farey, Sen., in the London Phil. Mag., vol. 37, p. 273.

"Sir: In your 27th vol., 206 p., I endeavored to call the attention of Lord Stanhope and other patrons of musical improvements, to the perfecting of an organ capable of performing in perfect tune. * * * It gives me great pleasure, therefore, to be able to state that the above is no longer a matter of doubtful speculation; but that myself and several others have heard an organ thus perfected by the Rev. Henry Liston; the exquisite effects of which, particularly in accompanying vocal music, far exceeded all that Maxwell and myself had written or perhaps conceived of the harmony of such an instrument."

Mr. Liston deserves great credit for what he *did* accomplish, and we feel much more inclined to praise him for this, than to speak of what he did *not* do. He himself frankly acknowledges the imperfections of his efforts, and concludes his essay as follows:

"After all, the subject is but just begun. I have been led to travel in some beautiful regions, unknown to such as had confined themselves to the highway. But larger discoveries remain yet to be made by those who shall, with more zeal and better qualifications, follow out the track in which it has fallen to my lot to go a little way before them."

4. The manner in which the subject of the musical scale and musical intervals is disposed of in our elementary treatises, is discreditable to music, as claiming to be a *science*. It is evident that the fundamental basis of music is not understood by those who attempt to teach the science. If it were necessary to corroborate this statement, we could refer to the blind and mysterious manner in which "temperament" is treated by modern theoretical writers. In this, which is simply an arbitrary substitution of a false note for two or more true notes, some writers have seen an "inexhaustible fountain of variety," "awful grandeur," and "exquisite beauty," while an English writer calls it an "inexplicable difficulty which no one has attempted to solve; the Deity seems to have left music in an unfinished state, to show his inscrutable power"![*] Temperament is an arrangement of economy by which a small number of sounds (usually twelve to the octave) are made to answer (imperfectly of course) for the much larger number which would be required to give music in tune in the usual number of keys. This arrangement was originally submitted to, merely for the accommodation of the *instrument-maker* and the *player*. So long as no mechanism had been invented by which more than twelve sounds could be managed by the organist, temperament was necessary in instruments of this class, but this reason no longer exists, as we shall show further on in this paper. Temperament has always been considered, by the great masters, as an evil attendant upon the "present imperfect state of instrumentation,"[†] and hence they preferred that their instrumental music should be performed by skillful artists on violins and other instruments which admit of perfect intonation; and these have held, to the present day, their rank as the leading and most important instruments in the orchestra. It would have instructed a composer like Beethoven, or an artist like Paganini, to have heard of the scale of a modern German theorist, Kollmann, which he calls the "scale of nature," consisting "of twelve sounds in the octave placed at equal distances," on which "wonderful compound of twelve diatonic, chromatic, enharmonic scales in one," he declares "all modern music depends." The somewhat voluminous treatise of Gottfried Weber, on "musical composition," has recently been translated in this country, and has been praised as a *scientific* work. The basis from which Weber attempts to

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[*] Gardiner's Music of Nature, p. 433, Bost. ed., 1837.

[†] Beethoven.

explain musical intervals is *the key-board of a piano forte!* An interval is the distance of one piano-key from another. He defines a fifth thus: "a fifth is an interval of five places." When we consider that a common piano, with twelve notes in the octave, is *never in tune*, and cannot by any possibility be put in tune, the value of such explanations is obvious. If he had defined his intervals by reference to the *horn* or *trumpet*, as thus—that the interval between the lowest and the second notes given by the horn is an octave—that the interval between the second and third notes is a perfect fifth, and so on—his definitions could have been depended on, as the horn will *always* (if properly blown) give its intervals *exactly* thus. But so far from attempting to establish his theory on any scientific or mathematical basis, he distinctly declares, "that it is not susceptible of such an establishment, or at least, has thus far failed of proving itself to be so."

5. The writer of this paper is of opinion that music is as susceptible of a systematic and mathematical basis as chemistry, astronomy, or any other science—that what are called the "mysteries" and "imperfections" of the musical scale contain in them nothing that is mysterious or imperfect—that temperament is no longer necessary, and would be as useful applied to a multiplication table as to a musical scale—that the same sound can no more correctly represent C♯ and D♭, than the number 62 can correctly represent the two products of 6 into 10, and 8 into 8—that music is much better given *in tune* than *out of tune*—that the fundamental principles in this department of the musical science are simple, and can be expressed in a moderately concise manner. The writer is also of opinion, that many theoretical and practical musicians will look with surprise and incredulity on these statements, but he can assure them that, if they will follow him patiently and candidly through this paper, their first impressions of his opinions will be essentially modified. It may be replied that the mechanism of the organ is already sufficiently complicated, without the addition of more sounds and more machinery; and that however true the writer's theory may be, there are mechanical difficulties which render the construction and playing of a perfect instrument impracticable. If the writer was not an organ-builder by profession, and had not already overcome all difficulties that have or *can* be suggested, he might be confounded by such an objection; but since he has not only perfected a theory, but constructed and patented an instrument on the basis of his theory, (which gives its chords in perfect tune; whose mechanism is simple and *practicable;* which has a common key-board and can be played by any organist sufficiently acquainted with his profession to know what *scale* or *key* his music is in:) he appeals with confidence to his instrument to justify him in the views which he has already, and shall express. Some further reference to this instrument will be made in the latter part of this paper.

6. The writer would remark as the conclusion of his introduction, that no one, in the present unsettled state of the musical science, can expect to become thoroughly acquainted with its fundamental principles, unless he will experiment and *think* for himself. He will constantly meet with the errors of the theorists, and if he cannot detect these for himself, he will find himself in perpetual darkness. Reasoning on musical science is not different from reasoning on any other science. We must interrogate nature, and follow where she leads us, notwithstanding the time-honored opinions of the theorists. As an illustration of this we may refer to the "chord of the seventh," which consists of a common chord with a certain seventh added. If we inquire what this seventh is, we are informed by all the theorists that it is *a fourth above the fourth*, and that its ratio is 9 : 16. Upon trial, this combination we find very *discordant* and disagreeable. If we ask a good natural singer to give the note, he gives it most readily and naturally 4 : 7, a little lower than the note laid down in the books, and this note (4 : 7) we find most natural and harmonious in the chord. A *theory* should be made from the *music* and not the music from the theory.

7. We find by experiment that *if two or more sounds heard together, are in the rapidity of their vibrations in a sufficiently simple ratio, their relations are perceived by the ear, producing an agreeable sensation, and this effect we call* HARMONY.

8. If we take a series of sounds, the ratios of whose vibrations are as the following numbers, 1 : 2 : 3 : 4 : 5 : 6 : 7 : 8 : 9 : 10, &c., we have the notes which will produce a series of *chords*, which commencing with the most simple, will gradually become more and more complicated, until the ear can no longer perceive their relations: when this point is reached they will *cease* to produce *chords* and *harmony*. Any ratio, neither of whose terms, (when reduced,) is larger than 10, will produce a chord appreciable by the ear. The extent to which the relations of chords can be perceived, will vary of course in different persons according to the delicacy of the ear, and hence it may not strictly be said that there is any absolute point where chords cease and discords commence, yet as our written music contains no chord whose ratio is expressed in higher terms than *ten*, and as this last ratio 9 : 10 is certainly *near* the farthest limits of our perception, we may properly consider that all chords must have the terms of their ratios within this limit. It may be added, that though one or both of the terms be larger than 10, yet if by dividing either or both by 2, the quotient is brought within the limit above mentioned, they will still produce harmony: e. g. the chord 5 : 12 is 5 : 6 or a *minor third*, the highest note of which is raised an octave.

9. We shall then consider any combination of sounds which are, each to every other of the combination, as the ratios ex-

pressed by the numbers above, (viz., 1 : 2 : 3, &c., to 10,) as *harmonious.* Here is the fountain head from which an abundant variety of harmonies may be drawn, which can be used by the composer at his pleasure. To all sounds used in combination, which do not come within the class just named, we give the name of *discordant.* Whether such combinations shall be used, is left entirely to the taste of the composer; we only insist on this, that we shall not call them *harmony.*

10. To the chords produced by the above ratios have been given names as follows:

1 : 2 — Octave.
2 : 3 — Perfect Fifth.
3 : 4 — Perfect Fourth.
4 : 5 — Major Third.
5 : 6 — Minor Third.
6 : 7 — } These two chords have
7 : 8 — } not been named.*
8 : 9 — Major Tone.
9 : 10 — Minor Tone.

By combining these numbers differently we obtain different chords, e. g.:

3 : 5 — Major Sixth.
5 : 8 — Minor Sixth.
4 : 9 — Major (or Perfect) Ninth.
4 : 7 — Perfect Seventh.
5 : 7 — } Chords derived from
7 : 9 — } the Perfect Seventh,
7 : 10 — } and not *named.*

11. All these chords are produced from four *prime numbers,* viz., 2, 3, 5, and 7. The prime 2 produces the *octave,* the prime 3, the *perfect fifth,* the prime 5, the *major third,* and the prime 7, the *perfect seventh.* As no *prime* number can be produced from others, by any multiplication or division, so no *chord,* produced by one prime number, can be obtained from another chord produced by a different prime—*e. g.,* we cannot by tuning a series of *fifths* ever obtain the *octave* of the original note, neither by tuning *fifths,* can we obtain a *major third,* nor from either or both of these chords (thirds and fifths) can we produce a *perfect seventh. Each are original, prime chords, not resolvable one into the other.* From the neglect of these simple mathematical principles result much of the mystery and fallacy connected with temperament. It is attempted in temperament to produce a *major third* from a series of *four fifths,* or what is the same thing, an alternate series of ascending fifths and descending fourths,

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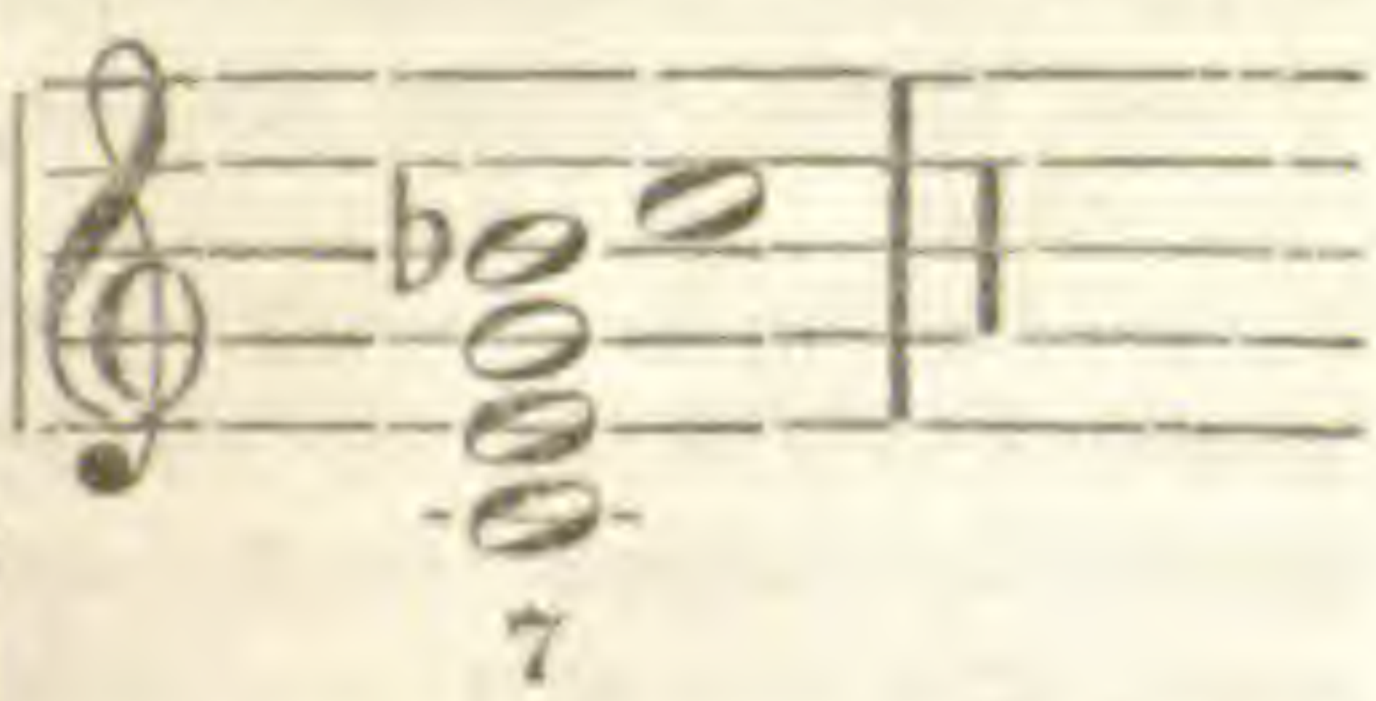

* It is remarkable that scarcely any mention has been made in musical treatises of these two beautiful and important chords. They are found in the chord of the Seventh. In this chord appear C, E, G, B♭, and C, whose vibrations are as these numbers, viz., $\overset{4}{\text{C}}$ $\overset{5}{\text{E}}$ $\overset{6}{\text{G}}$ $\overset{7}{\text{Bb}}$ $\overset{8}{\text{C}}$. Thus it will be seen that the ratios of G to Bb is as 6 : 7 and the ratio of Bb to C is as 7 to 8. The chord 4 : 7 we have called the *Perfect Seventh,* and for the same reason that the perfect fifth was so named. We have not called it the *minor* seventh, as the ratio of the minor seventh has always been stated so far as we have seen to be 9 : 16.

e. g. that $1\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}=\frac{4}{5}$ or $\frac{64}{81}=\frac{64}{80}$. Again it is supposed that a similar series of *twelve fifths* will end upon the *octave: e. g.*, that $1\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}=\frac{1}{2}$ or $\frac{262144}{531441}=\frac{1}{2}$ or $524288=531441$. But the mathematics cannot be tampered with in this manner with impunity, neither can the musical scale, which is founded upon them. The result of this mutilation is, (as might naturally be supposed,) the destruction of pure harmony and melody in the tempered music.

12. The question has been raised whether ratios which contain the *prime seven* should be considered *harmonic*. A standard elementary treatise before us contains the following: "Higher primes than 5 enter into no harmonic ratios: such combinations for instance as 1:7, 5:7, or 6:7, are altogether discordant. * * * * The ear will not endure them, and cannot rest upon them."*

The most certain method of determining the quality of any harmonic combination, is by an appeal to the ear. The combinations must first be *heard*, and the ear must decide upon them. Although combinations which contain the prime 7 are continually occurring in the performances of good singers and violin players, yet it might be difficult for one unfamiliar with them to know when they occur. If it be proposed to try them upon an *instrument*, it must be one of perfect intonation; *not* a common organ or piano-forte, which cannot give the chords referred to. It is probable that the writer quoted above, never heard (knowing *when* he heard them) the combinations he condemns. The writer of this paper has special facilities for the experiment in question, inasmuch as he has at hand an instrument of perfect intonation, upon which the effect of these, or any other combinations can be tried. On the evidence of his own ears and those of every musician who has heard them, he must pronounce them altogether *harmonious* and *pleasing*.†

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* Prof. Benj. Peirce, "On Sound," § 99.

† We have admitted in our system no prime *higher* than *seven*. The question may be asked, why the higher primes, as 11, 13, 17, 19, 23, &c., should be excluded? The only answer is, that they produce ratios too complicated for the ear to appreciate. These primes, and the combinations produced by them, are undoubtedly *natural*—they belong to the extended *science* of music—and would be useful were our ears sufficiently delicate to appreciate them. But although *nature's harmonies* are *illimitable*, there is a *limit* to *human perception* of them. If any one is curious to investigate this matter, he can satisfy himself by attempting to *tune* one of these remote primes, as the 11th, for instance, which will be the easiest of the whole. As this cannot be obtained from the other more simple chords, (octaves, fifths, thirds, or sevenths,) it must be tuned as an *eleventh* at once in a chord as follows, 8:11, 9:11 or 10:11, &c. If it be found impossible to *tune* it, it will certainly be impossible to use it in harmony or melody. If any one urge, however, that any of these primes, as the 11th for example, should be used in *practical* music for human ears, and find that he can appreciate it, (or in other words *tune* it, or know when it is *in tune*,) we will agree that it may be used by himself and those who possess equally delicate ears.

13. A *Scale* is a series of sounds, obtained from the above harmonic relations, arranged in the order of their acuteness, and it contains the notes required for the melodies and harmonies of the composition for which it is used.

14. The DIATONIC SCALE is composed of *seven* distinct notes, (the *eighth*, being the octave, is regarded as a repetition of the first.) It is formed by combining the chords of perfect fifth, (2:3,) and major third, (4:5,) and it contains all the intervals and chords which have been named, with the exception of those derived from the perfect seventh. Assuming C as a key-note, this scale, in the vibrations of its several notes, stands as follows:

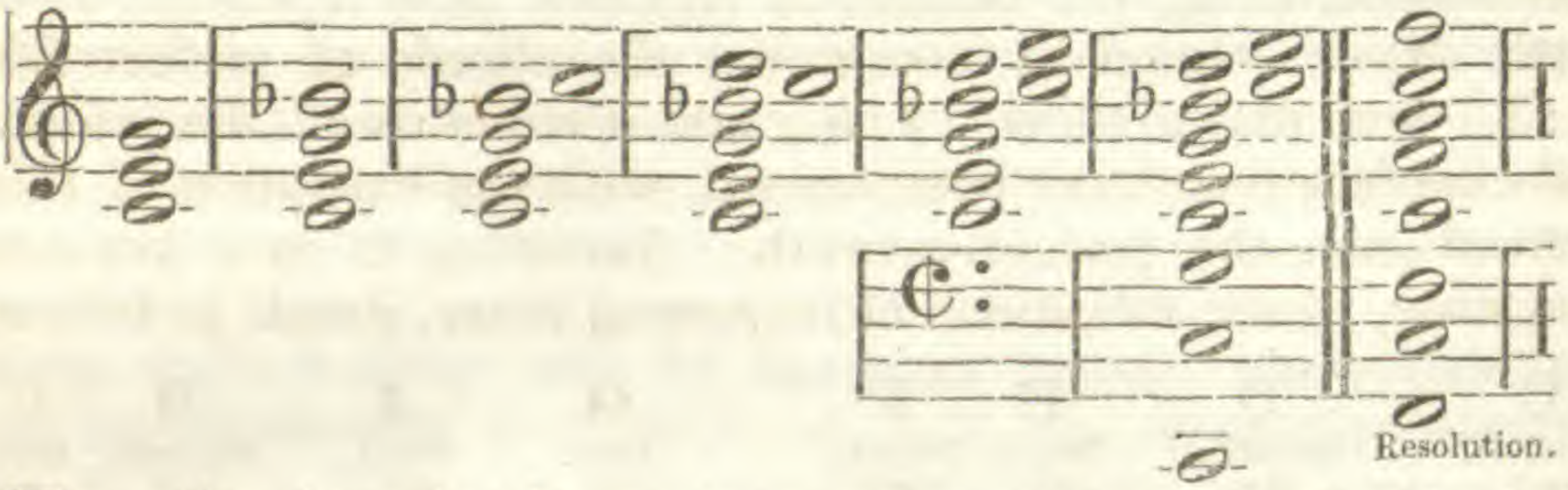
C		D		E		F		G		A		B		C
Key-note.		Second.		Third.		Fourth.		Fifth.		Sixth.		Seventh.		Octave.
24	:	27	:	30	:	32	:	36	:	40	:	45	:	48
	Maj. T.		Min. T.		S.		Maj. T.		Min. T.		Maj. T.		S.	

15. On examining the relations of these numbers, we find the intervals which separate the several notes of the scale. The ratio of 24:27 or 8:9, gives the interval between the first and second notes, which is called *major tone.* The ratio of 27:30 or 9:10, gives the interval between the second and third notes, which is called *minor tone.* The interval by which the major tone exceeds the minor is called *comma*, whose ratio is 80:81. The ratio of 30:32 or 15:16, expresses the interval between the third and fourth of the scale, and it is called *diatonic semitone* or simply *semitone*, *diatonic* being understood. From the fourth to the fifth, and from the sixth to the seventh, is the same as from the key-note to the second, i. e., major tone. From the fifth to the sixth is the same as from the second to the third, i. e., minor tone, and from the seventh to the eighth is the same as from the third to the fourth, i. e., diatonic semitone.

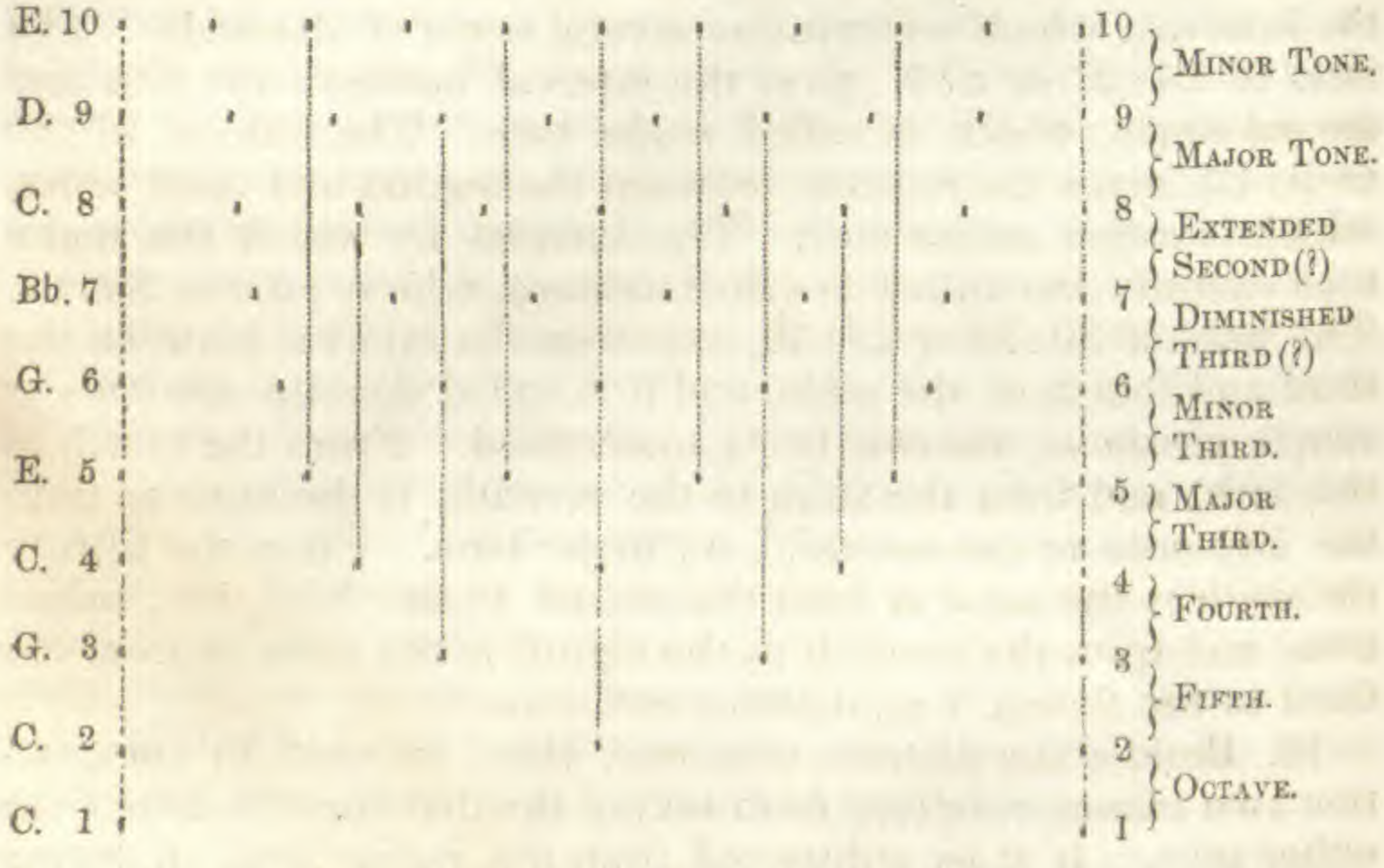
16. Besides the diatonic semitone, there are used in composition two others, resulting from taking the diatonic semitone from either tone. If it be subtracted from the *major* tone, it leaves what is called the *chromatic semitone*, and if taken from the *minor* tone, there remains the *grave chromatic semitone*, comma less than the chromatic.

17. If from any note, as key-note, there be taken a *perfect fifth* and *major third*, the three notes sounded together will produce a *common chord.* These notes are, in their vibrations, as these numbers, viz.: 4:5:6. If to this, the *perfect seventh* (4:7) be added, we have the *chord of the seventh*, expressed thus, 4:5:6:7. Adding the *octave*, the chord becomes 4:5:6:7:8. To this may be added the *major ninth* (4:9), producing this chord, viz.: 4:5:6:7:8:9. And finally, by adding the *tenth*, (or octave and major third), we obtain this chord, viz.: 4:5:6:7:8:9:10. By adding, below the key-note, the double-octave, its octave and twelfth, we have what may be called the *full chord of the tenth*,

viz.: 1:2:3:4:5:6:7:8:9:10. All of these chords are perfectly harmonious, and in all respects appreciable by the ear. The last contains within itself every musical chord and harmony, that can be obtained from ratios whose terms do not exceed ten. Examples of these chords, as written, we here exhibit.



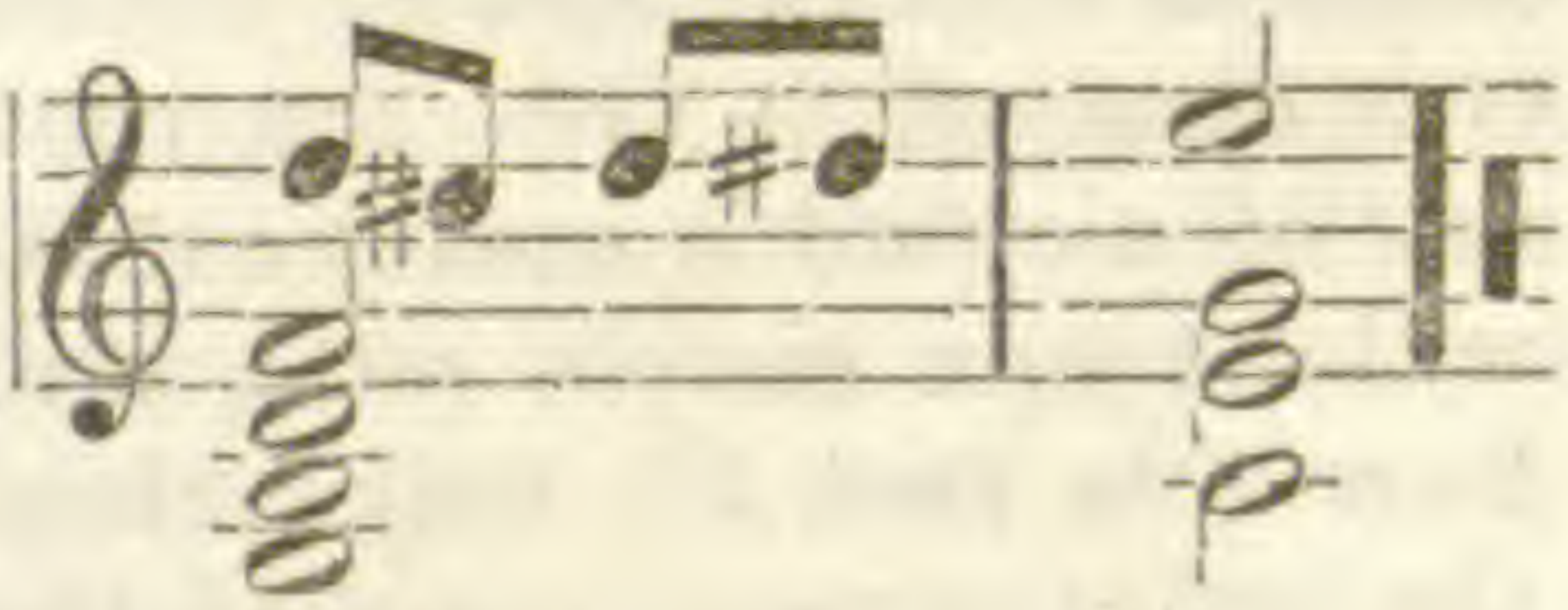
The vibrations in the various ratios of the full chord of the tenth may be represented to the eye by the following diagram.



Assuming any length of time, for a single vibration of the lowest note, it is evident that the other several notes of the chord will in the same time perform vibrations, equal in number to the numbers expressing their ratios respectively; and that at the expiration of this time, the vibrations of every note will coincide with each other. There are also points within this assumed time in which two, three, four or more of these notes will coincide in their vibrations. These coincidences are represented in the diagram by dotted lines. By means of the diagram, the vibrations of any other chord, as the common chord, the chord of the seventh, ninth, &c., may be examined, as they are all contained in the full chord of the tenth. The difference in the effect of the different chords is seen in the less frequent coincidences in the more complicated chords. Thus the octave is much more simple than the major tone, for the reason that every vibration of one of its notes, coincides with every second vibration of the other, while in the major tone it is necessary that that one note perform *eight*, and the other *nine* vibrations before there is any coincidence. And from this, will appear the increased difficulty in *tuning*, as the chords become more complicated.

18. From the introduction of the perfect seventh is obtained another interval, viz.: the difference between the *fourth* of the scale, and the *dominant seventh*, (i. e. the perfect seventh upon the fifth of the scale.) In this example, we have a melody in which these two notes appear. At *a*, B♭ is the fourth of the scale of F, while at *b*, it is the perfect seventh to C; and the last B♭ is lower than the first by about a comma and a quarter. Consequently in singing the melody with the accompaniment as written, the voice will give the second B♭ lower than the first by that interval. It will be found on experiment, that a good natural singer, if asked to sing the melody with this accompaniment, will naturally, and no doubt unconsciously, make the distinction referred to.

19. As it has been stated that musical ratios, in order to be harmonious, must not exceed a certain limit of simplicity, the question naturally arises, shall no other notes be heard together in music but those which have, each to every other, these simple ratios? Abundant examples can be selected from the best composers, in which notes are heard together, which make more complicated ratios, and which cannot be regarded as *harmonious*. To illustrate this we take the following example. With the chord of the dominant seventh as accompaniment, are heard at the same time the notes D, C♯, D and D♯. The melody in the first and third notes is in harmony with the accompaniment. But though C♯ and D♯ appear, while the chord is sounding, they can make no *harmony* with it. Neither are they *discordant*. The ear regards the progression of these notes as parts of the melody, and only requires that the melodic intervals (diatonic and chromatic semitones) be given truly, without regarding the *ratios* which the accidentals make with the accompanying chord. In other words, these are PASSING NOTES, which have nothing to do with the *harmony*, and are to be thrown out when we would find the notes which compose the



chord. Many apparently complicated combinations may be made simple, by attending to this department of *passing notes.*

20. There is a certain combination of sounds, which has occupied a separate department of most treatises. It is called the "chord of the diminished seventh," and is supposed to possess some peculiar and extraordinary qualities. It would, of course, not be treating this chord, which has received so much attention hitherto, with proper respect, to pass it over in silence. It is defined to be, and undoubtedly is, exactly like the chord of the seventh, with the exception that the lowest note (of the chord of the seventh) is in the "diminished seventh," raised a chromatic semitone. It is supposed that there exists in this combination a "*harmony*" which is peculiar* and altogether different from that found in the chord of the seventh. In the first example, the first chord is the common chord of G. It is intended to pass from this to the minor chord of A. Now, although we might pass from the chord of G, directly to that of A, it is judged expedient to have the melody of the lowest part, instead of ascending by a whole tone at once, ascend by two steps, viz., a chromatic and diatonic semitone. The G♯ introduced, does not belong to the harmony, but is merely a *passing note.* The matter is very easily understood in this first example. The second example is precisely like the first, with the exception that the seventh has been added to the chord, and it would have been equally easy to understand, had not the subject been darkened by the "words without knowledge," of the theorists who have written on the "diminished seventh." For if in the first example, G♯ is a passing note, why should its effect be changed by the addition of the *seventh* to the chord? It is stated by the theorists that the *root* of the chord at *a* is G, but that at *b* (when G is changed to G♯) the root changes to *E*. Now, as by the *root* of a chord is meant a note with which the remaining notes will be in a simple ratio, and will *harmonize*, we will inquire how this *root*, E, major third below G♯, will harmonize with the other several notes of the chord. The ratios of the vibrations of these several notes will be as follows:

Ex. 1. Ex. 2.

E	G♯	B	D	F
20	25	30	30	42

From these ratios we see that E will be discordant with F, (making the ratio 20:42, or 10:21), and G♯ will be discordant with D and F (25:36,

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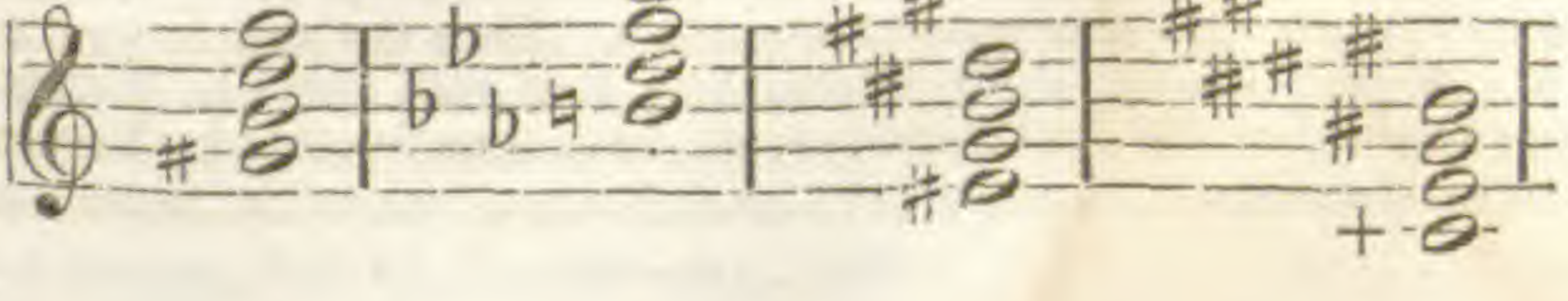
* Wm. Gardiner, in his "Music of Nature," gives the following as his idea of this chord. "If four minor thirds (!) be combined, they form the chord of the extreme flat seventh, which excites in us fear and alarm, because it is a clatter of sounds indicating rage and ferocity. These tones escape us in the ebullitions of our worst passions, and are heard in the savage murmurs of wild beasts."

and 25 : 42), making altogether not very *harmonious* "harmony." Indeed, the difficulty of treating the chord in this manner has caused considerable discussion, which some have endeavored to surmount, by calling it a "dissonant chord," or "dissonant *harmony!*" It is stated, (and with reason,) that "this root E must not be heard in the chord, as it is discordant." It is certainly remarkable if, in this chord alone, the *root* does not happen to be in harmony with the other members of the chord. But if G♯ be considered as a *passing note*, we shall at once be sure as to what the chord is. The root will be G, and every note (with the exception of G♯, the passing note, which must be thrown out when we reckon the harmony,) is in perfect tune with it, in a simple and harmonious chord, viz., 4 : 5 : 6 : 7. And this G♯ appears to us as plainly to be a passing note, through which the melody of the lowest part passes from G to A, (for after this note we always have A,) as that D♯ is a *passing note* from D to E, in the example given in (19.) In this example, in the chord at *a*, it would probably be admitted without dispute that G♯ was merely a passing note; and why it should be considered as any thing else, when it appears at *b*, could not, we think, easily be made manifest. We shall therefore consider that there is no different *harmony*, in what has been called the "chord of the diminished seventh," than exists in the "chord of the seventh;" and for this reason, that all the harmony it contains is derived from, and found in, the chord of the seventh.

21. Among the many mistakes and incongruities into which the theorists have been led by the temperament of the scale, and their constant habit of referring all combinations to the key-board of the piano-forte or organ, is the following idea in regard to this "diminished seventh." It is supposed that a chord of the diminished seventh contains the sounds which belong to *four* different and remote scales, and thus connects them together. Here are examples of four of these chords in the keys of C, E♭, A, and F♯; they are, as will be seen, the chords of the dominant sevenths of those keys, with the lowest notes raised a chromatic semitone.



It is supposed that each of these four chords contains the *same identical sounds:* and on the piano-forte, it is impossible to obtain any other than the same sounds, in the four different keys. These four chords have therefore been allowed to be one and the same thing. Mention is, indeed, made of the "*enharmonic change*" of G♯ to A♭, F to E♯, D to C+, &c.; but as on the piano forte it is impossible to make any change—that instrument having but one sound to answer for the two or more, which appear in the written music—the idea has prevailed that the change is merely *imaginary*, and that the alteration in the mode of writing the note, is made only to prevent one key from being mistaken for another, in the appearance of the written music to the eye. But the truth is, that in *perfect intonation*, an enharmonic change always means the *alteration* of a note by a small interval. And not only are enharmonic changes made when the written music shows a *sharp* changed to a *flat*, and *vice versâ*, but *changing the signature* will often produce an enharmonic change. This point will be more fully illustrated when we have spoken of transposition and modulation, and explained our *system of notation*.*

22. As musical composition would be very limited in variety, if confined to a single scale or key, other scales have been constructed on new key-notes, separated one from the other by intervals of perfect fifths, and from these key-notes, the remaining notes of each scale are placed at the same intervals which were adopted in the construction of the original. If we take the fifth of any scale as the key-note of a new scale, and complete it with the same intervals as the first, we shall find that *two sounds* will be introduced which were not found in the original scale. We take for example the diatonic scale of C, and assuming its fifth G as key-note, complete the scale of G. The second of this scale will be A, and from G to A, or the first to the second, must be a *major tone*, (15.) On examining the scale of C, (14) we find that the A of that scale is but a *minor tone*, from G. We must therefore introduce a *new A*, a comma higher than the first, and a major tone from G. Every other note of the C scale is correct for the G scale with the exception of F, which must be raised a *chromatic semitone* to F♯, to form the seventh of the scale of G. In general, the scale may be transposed to any extent by the following rules.

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* The writer has been led into this digression on the subject of the "diminished seventh," from the fact, that it has been treated, as he considers erroneously, in all the scientific musical works that have fallen under his observation, and it has been urged as an objection to a system of perfect intonation. Since the article was in type, a friend of extensive musical study informs him, that such views as Weber and others have expressed on the diminished seventh, have been rejected by Vogler and the best German theorists.

23. *To transpose the scale to the fifth above; the* SIXTH *must be raised a* COMMA, *and the* FOURTH *a* CHROMATIC SEMITONE *to form the* SECOND *and* SEVENTH *of the new scale.*

And to transpose it to the fifth below, the process must be reversed: i. e.: the SECOND *must be lowered a* COMMA, *and the* SEVENTH *a* CHROMATIC SEMITONE, *to form the* SIXTH *and* FOURTH *of the new scale.*

24. By this system of transposition we obtain two or more different notes expressed by the same letter—two A's for instance, as we have shown above. To make it obvious to the eye, which of several notes of the same letter belongs to any required scale, we have adopted the following *system of notation.* Every note of the diatonic scale of C, we mark with a figure 2; as thus: C^2, D^2, E^2, F^2, G^2, A^2, B^2, C^2. When in transposition one of these notes is raised a comma, enharmonically,* it is marked with the higher number 3; and when it is lowered a comma it is marked with 1. Thus A^3 will signify a note a comma higher than A^2, the A of the C scale; and D^1, a note a comma lower than D^2. The sharps and flats will also be marked 2, when they first appear in transposing from C to the keys above and below. We now exhibit the scales of C, and of G and F, whose key-notes are the fifths above and below C, with the names of the notes of each, and their intervals. It will be seen that the order of the intervals from the key-note is made the same in each, by the alteration of the two notes in each adjoining scale.

Scale of G. 1♯	4		5		6		7		KEY.		2		3		4
		Major T.		Minor T.		Major T.		S.		Major T.		Minor T.		S.	
	C^2		D^2		E^2		F♯^{2}		G^2		A^3		B^2		C^2
Scale of C. ♮	KEY.		2		3		4		5		6		7		8
		Major T.		Minor T.		S.		Major T.		Minor T.		Major T.		S.	
	C^2		D^2		E^2		F^2		G^2		A^2		B^2		C^2
Scale of F. 1♭	5		6		7		KEY.		2		3		4		5
		Minor T.		Major T.		S.		Major T.		Minor T.		S.		Major T.	
	C^2		D^1		E^2		F^2		G^2		A^2		B♭^{2}		C^2

25. The following table exhibits the diatonic scales from five flats to five sharps. The table might have been extended both above into more sharps, and below into flats without limit; and any number of signatures might have been thus obtained; but we have here given but eleven of those most frequently used.

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* An *Enharmonic change* is a change by any interval smaller than a chromatic or diatonic interval, as for instance, the difference between the major and minor tones—between G♯ and A♭—the fourth of a scale and its dominant seventh, &c. These enharmonic changes are not usually expressed in notation, except by the *signature*, but they are necessary to perfect intonation, to bring the music "into harmony," which is implied in the derivation of the term, ἐν and ἁρμονία.

In addition to the diatonic scales, we have added three columns, viz., the leading notes or sevenths of the *minor scales*—the perfect sevenths—and the dominant sevenths, (or the perfect sevenths upon the dominants.)

Signatures.	Key Notes.	Major Seconds.	Major Thirds.	Dominant Sevenths.	Perfect Fourths.	Perfect Fifths.	Leading notes, Minor scales.	Major Sixths.	Perfect Sevenths.	Major Sev-enths.	Octaves.
5 Sharps.	B^3	$C\sharp^3$	$D\sharp^2$	E7	E^3	$F\sharp^3$	F^{+1}	$G\sharp^2$	A7	$A\sharp^2$	B^3
4 Sharps.	E^3	$F\sharp^3$	$G\sharp^2$	A7	A^3	B^3	$B\sharp^1$	$C\sharp^2$	D7	$D\sharp^2$	E^3
3 Sharps.	A^3	B^3	$C\sharp^2$	D7	D^2	E^3	$E\sharp^1$	$F\sharp^2$	G7	$G\sharp^2$	A^3
2 Sharps.	D^2	E^3	$F\sharp^2$	G7	G^2	A^3	$A\sharp^1$	B^2	C7	$C\sharp^2$	D^2
1 Sharp.	G^2	A^3	B^2	C7	C^2	D^2	$D\sharp^1$	E^2	F7	$F\sharp^2$	G^2
Natural.	C^2	D^2	E^2	F7	F^2	G^2	$G\sharp^1$	A^2	$B^{\flat 7}$	B^2	C^2
1 Flat.	F^2	G^2	A^2	$B^{\flat 7}$	$B\flat^2$	C^2	$C\sharp^1$	D^1	$E^{\flat 7}$	E^2	F^2
2 Flats.	$B\flat^2$	C^2	D^1	$E^{\flat 7}$	$E\flat^2$	F^2	$F\sharp^1$	G^1	$A^{\flat 7}$	A^2	$B\flat^2$
3 Flats.	$E\flat^2$	F^2	G^1	$A^{\flat 7}$	$A\flat^2$	$B\flat^2$	B^1	C^1	$D^{\flat 7}$	D^1	$E\flat^2$
4 Flats.	$A\flat^2$	$B\flat^2$	C^1	$D^{\flat 7}$	$D\flat^2$	$E\flat^2$	E^1	F^1	$G^{\flat 7}$	G^1	$A\flat^2$
5 Flats.	$D\flat^2$	$E\flat^2$	F^1	$G^{\flat 7}$	$G\flat^2$	$A\flat^2$	A^1	$B\flat^1$	$C^{\flat 7}$	C^1	$D\flat^2$

In the above table, the column marked "major sixths," contains also the *key-notes of the minor scales*. These key-notes, as will be seen, are a comma lower than the notes of the same letter, which are key-notes of *major scales*, e. g., the key-note of *C minor* (being the relative minor of $E\flat$, in the scale of three flats) is C^1, comma lower than C^2, the key-note of *C major*, in the natural scale. Consequently the leading notes of the minor scales (which are diatonic semitone below their key-notes, and major third above the major third of the relative major scale,) are lower than the key-notes of the major scales by the same interval, viz., a comma. In the column of "perfect sevenths," and "dominant sevenths," the figures are attached to the letters arbitrarily, and not according to the system adopted for the others, (24.) Being derived from a *prime* different from the notes of the diatonic scale, they will not vary from them by even commas. They are marked 7, and their pitch is about a comma and a quarter* below that of the letters of the same name in the column of "perfect fourths," and each is always used (as a *seventh* only) in one chord and no other.

26. Having explained our system of notation, and having before us a table, which contains the exact relative pitch of every note, in eleven major, and eleven minor scales, we are prepared to recur to the illustration we gave concerning the "diminished sev-

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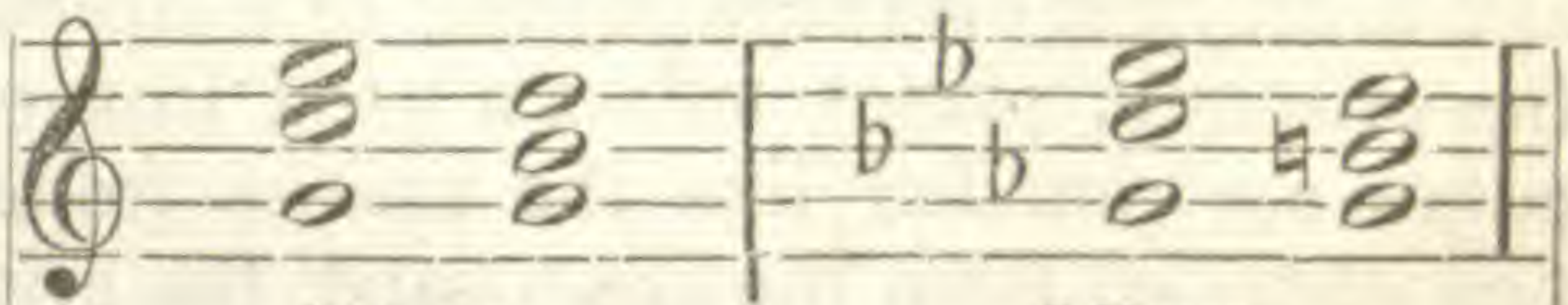
* The ratio of this interval is 63 : 64, and consequently larger than the comma, 80 : 81.

enth," (21.) We again give the example, and also place below the notes, as given in the table. It will be seen that each of the chords is entirely different—that not a note found in any one of the chords, is found in any other.

F^7	A♭^{7}	D^7	B^7
D^2	F^2	B^3	G♯^{3}
B^2	D^1	G♯^{2}	E♯^{2}
G♯^{1}	B♮^{1}	E♯^{1}	C+^{1}

27. We find it stated in certain theoretical treatises, "that the major and minor keys of the same letter," (as C major, and C minor) "are nearly related, inasmuch as the two tonic chords are alike, with the exception of the third, and both have the same dominant chord." We will write the tonic and dominant chords of C major (in the natural scale,) and of C minor (in three flats,) and from the table, ascertain the notes of each. We find the notes of the two keys entirely different, and consequently C major is not related to C minor, except in the *fourth* degree, through the following keys, viz.: F, B♭, E♭, and C minor. As upon the keyed instruments, it has been necessary to use the same sounds in C major and C minor, the writers, referred to, were led to make the statement we have quoted.*



C Major.		C Minor.	
E^2	D^2	E♭^{2}	D^1
C^2	B^2	C^1	B^1
G^2	G^2	G^1	G^1

(*To be continued.*)

Art. XIII.—*Analyses of several Minerals;* by William Fisher.

The following analyses were performed in the Laboratory of Prof. Booth, whose guidance in their performance I acknowledge with pleasure.

1. *Green sand* from New Jersey, a few miles southeast of Philadelphia. It is blueish green, soft and adhesive when moist, in large and hard grains when dry, and containing a trifling admixture of quartz sand. The analysis was performed in the usual

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* A description of the Euharmonic Organ is necessarily postponed to the next number of the Journal. The instrument, however, in a few days, will be set up in Boston, and will be exhibited with pleasure, to those who are interested in the progress of musical science. The writer will be found at No. 13, North Russell street.

manner of a soluble silicate, the soda and potassa being separated by chlorid of platinum. Phosphoric acid was carefully sought for by several processes and by repeated trials without success. The following are the results:

Silica,	53·26
Alumina,	3·85
Protoxyd of iron,	24·15
Magnesia,	1·10
Lime,	1·73
Soda,	1·60
Potassa,	5·36
Water,	10·12
	101·12

2. *Vivianite* from the green sand of Delaware, about four miles west of Cantwell's Bridge. The beauty of the crystals, and the similarity of some of the specimens with Thompson's mullicite induced me to investigate them. The mineral is perfectly crystallized in oblique rhombic prisms, with several terminal planes, and a brilliant cleavage parallel to a lateral end plane. Although the prismatic planes reflect a good image, yet their intervening edges are rounded like the apatite from Rossie, N. Y. When first obtained from the green sand, the crystals were perfectly colorless, but in the course of some weeks changed to a light green color, still, however, retaining their transparency. The phosphoric acid was separated both by sulphuret of ammonium and by fusion with potassa, and the state of oxydation of the iron was ascertained by solution in muriatic acid apart from the air and by carbonate of baryta. The results are:

Phosphoric acid,	27·17
Protoxyd of iron,	44·10
Water,	27·95
Silica,	0·10
	99·32

The analysis shows that the formula is that given to vivianite. In a late number of his Annual Report, Berzelius calculated a different formula from a partial peroxydation of the iron; but the above well crystallized specimen indicated only a slight amount of oxydation, and the change in color of the mineral after removal from the green sand, indicated this oxydation. The true formula is therefore $3FeO, PO_5 + 8HO$.

3. *Garnet*, from Franconia, New Hampshire. Part of the specimen exhibited the usual characters of colophonite, but the projecting points of some of the coarse grains showed the crystallization of garnet in a combination of the 24-hedron, and

48-hedron. The analysis, performed like that of a silicate, fused with carbonate of soda, gave :

Silica,	38·85
Peroxyd of iron,	28·15
Lime,	32·00
	99·00

It therefore agrees with the purest lime-iron-garnet, and its formula is $3CaO, SiO_3+Fe_2 O_3, SiO_3$.

4. *Chondrodite*, from New Jersey. Some very dark red specimens appearing to indicate the presence of oxyd of zinc, which occurs so abundantly in that mineral district, the analysis was chiefly undertaken to determine this point. The fluohydric acid was determined by fusion with carbonate of soda, and by subsequent treatment of the aqueous solution by oxyd of zinc, sal-ammoniac, ammonia and chlorid of calcium. The results corresponded with one of Rammelsberg's analyses and the absence of zinc was fully proved. The analysis gave :

Silica,	33·35
Magnesia,	53·05
Protoxyd of iron,	5·50
Fluorine,	7·60
	99·50

The formula is therefore $Mg\overline{F}+2\,(3MgO, SiO_3)$, in which a portion of the magnesia is replaced by protoxyd of iron.

Art. XIV.—*Memorials of John Bartram and Humphry Marshall, with notices of their Botanical Contemporaries*, by Wm. Darlington, M.D., LL.D., pp. 585, 8vo. Philad., 1849.

It is pleasant to see these memorials of our two patriarchs in natural history, the two earliest native-born and self-taught American botanists. And fit it is that the duty of rescuing these remains from oblivion and fast approaching decay should have fallen to the lot of one who has such a genuine fondness for these old records, and to whom the task of deciphering and editing them is truly a labor of love. Dr. Darlington, the pupil of Barton, who flourished one full generation after Bartram and Marshall, now ranks—so rapid is the flight of time—among the oldest of our surviving botanists, though with eye undimmed and natural force unabated, still ready for every good work.

In the *Reliquiæ Baldwinianæ*, he, several years ago, paid a fitting tribute to the memory of the friend and companion of his youth ; the leisure hours of the last year and more have been devoted to collating, copying with his own hands, and editing the mouldering and often hardly legible correspondence of these earliest cultivators of his favorite science in his native state, and, we believe, the earliest indigenous botanists of the new world.

Instead of elaborating anew the materials for a biography of the elder Bartram, Dr. Darlington has reproduced the meagre sketch which was prepared by his son William, and published in Barton's *Medical and Physical Journal* in the year 1804, as in the main more reliable than any other. Its incompleteness, however, may be gathered from the fact, that it does not, nor does any other published biography, mention the name of Bartram's father, "nor could any of his descendants, enquired of by the editor, furnish that name, neither could they give the exact date of the botanist's birth!" These desiderata are now supplied, through Dr. Darlington's diligence, and the kindness of a friend who obtained them from the ancient records of Darby Monthly Meeting. It appears that he was born "near the village of Darby, in Delaware (then Chester) County, Pennsylvania, on the twenty-third day of March, 1699; that his great-grandfather, Richard Bartram, lived and died in Derbyshire, England; leaving an only son, John, who married in Derby, lived for some years in the town of Ashborn, and in 1682—the year in which the city of Philadelphia was founded—emigrated to Darby, Pennsylvania, with three sons, two of whom died unmarried. The third, William, was the father of John Bartram the botanist.

The latter received such scanty education as the country schools of the colony furnished; and he appears to have obtained, through his own endeavors, some elementary acquaintance with Latin and Greek; but not until his taste for natural history was developed, which, however, must have been early in life. For he was still a young man when he removed from the farm he had inherited from his uncle, and purchased a piece of ground on the Schuylkill, near Philadelphia, for the establishment of the well known garden that bears his name, and built with his own hands (A. D. 1731) the large and comfortable house of hewn stone which is still standing, and which Dr. Darlington has depicted in a large wood-cut which forms the frontispiece of his volume. To him is attributed, we believe justly, the credit of having been "the first Anglo-American who conceived the idea of establishing a botanical garden for the reception of the various vegetables, natives of the country as well as of exotics; and of travelling for the discovery and acquisition of them." He certainly established the first garden of the kind in this country, and filled it with our choicest plants and trees, then in great part novel to botanists. It was not his fault that it was not the nucleus of a public institution, endowed through the wealth and spirit of a prosperous metropolis, instead of sinking into neglect and becoming the site of a coal-yard.

"He began his travels at his own expense. His various excursions rewarded his labors with the possession of a great variety of new, beautiful and useful trees, shrubs and herbaceous plants. His garden at length attracting the visits and notice of many virtuous and ingenious persons, he was encouraged to persist in his labors." This naturally led to a correspondence with the naturalists of Europe. His earliest and his principal correspondent was Peter Collinson, the London merchant, and member of the Royal Society, a most amiable man, dear old gossip, who loved above all things to receive novelties and accounts of curious things from distant parts and to share them with the savans of the day. He is well known by his correspondence with Linnæus, published by Sir James E. Smith, and with Franklin, published in President Sparks's collection of the philosopher's writings and correspondence; and a portion of his characteristic letters to Cadwallader Colden may be remembered by the readers of this Journal.* His letters to Bartram occupy more than half the bulk of the correspondence now published, and exhibit the good London merchant in a very pleasing light. They cover the whole period from 1734 to Collinson's death in 1768, a period of thirty-four years; and the earliest of the series found among the Bartram papers evidently does not commence the correspondence. The originals of the letters addressed by Bartram to Collinson are probably not extant. Those here published are from copies or original draughts preserved by the writer. The first of the series is dated May, 1738; so that we have none in reply to those of Collinson during the four earlier years, which is much to be regretted.

In the second letter here published, the good Collinson initiates John Bartram into the art and mystery of preparing dried specimens of plants. The botanist of the present day may be somewhat surprised to learn that a "quire of whited-brown paper" was thought amply sufficient to hold a year's collection.

"London, January 24th, 1735.

"My good friend, JOHN BARTRAM:—I am very much obliged to thee for thy two choice cargoes of plants, which came very safe and in good condition, and are very curious and rare, and well worth my acceptance. I am very sensible of the great pains, and many tiresome steps to collect so many rare plants scattered at a distance. I shall not forget it; but in some measure to show my gratitude, though not in proportion to thy trouble, I have sent thee a small token: a calico gown for thy wife, and some odd little things that may be of use amongst the children and family. They come in a box of books to my worthy friend, Joseph Breintnall, with another parcel of waste paper, which will serve to wrap up seeds, &c. But there is two quires

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* Selections from the scientific correspondence of Cadwallader Colden, vol. xliv, p. 85, 1843.

of brown, and one of whited-brown paper, which I propose for this use and purpose, and will save thee a great deal of trouble in writing: that is, when thee observes a curious plant in flower, or when thee gathers seed of a plant thee has an intention to convey me a description of, on both these occasions, thee has nothing more to do than to gather branches or sprigs of the plants, then in flower, with their flowers on, and with their seed-vessels fully formed; for by these two characteristics, the genus is known that they belong to. Then take these, and spread them between the sheets of brown paper, laying the stems straight and leaves smooth and regular; and when this is done, put a moderate weight on a board the size of the paper. In two days remove the specimens into the other quire of brown paper, keeping the weight on; and then in a week or two, being pretty well dried, convey them thence into the quire of whited-brown paper. Thus, when now and then thee observes a curious plant, thee may treat it in this manner, by which thee will convey a more lively idea than the best description; and when thee gathers seeds, mark the same number on the seeds as thee marks in the sheet where the specimen is, only writing under it the country name. So, once a year, return me the quire of whited-brown paper, with the dried specimens tied fast between two broad boards; and then I will send some more in their room. When the sheet of paper will hold it, put one, two, or three specimens of the same plant in the same sheet, so they will but lie smooth by each other.

"Besides, what I have further to propose, per this method, is, thy own improvement in the knowledge of plants; for thou shalt send me another quire of duplicates of the same specimens; I will get them named by our most knowing botanists, and then return them again, which will improve thee more than books; for it is impossible for any one author to give a general history of plants. Let the specimens be of the length of the paper.

"Thee canst not think how well the little case of plants came, being put under the captain's bed, and saw not the light till I went for it; but then Captain Wright had a very quick passage; and it was put on board in a right month, for when plants are down in the ground, and in the winter months, they may be stowed anywhere; but it must not be attempted any time this side Christmas."

* * * * * * *

"I wish, at a proper season, thee would procure a strong box, two feet square, and about fifteen or eighteen inches deep,—but a foot deep in mould will be enough; then collect half a dozen laurels, and half a dozen shrub honeysuckles, and plant in this box; but be sure make the bottom of the box full of large holes, and cover the holes with tiles, or oyster-shells, to let the water drain better off. Then let this box stand in a proper place in thy garden, for two or three years, till the plants have taken good root, and made good shoots; but thee must be careful to water it in dry weather.

"I wish that thee would not fail to put three or four specimens of the sprigs of the laurel, with the flowers fully blown (for I long to see it) in the paper, transferring them from one to another, as I have directed. As my design is not to give thee more trouble, so a few specimens will content me.

"I have further to request thee to put up a little box of plants (yearly) in earth, such as thou finds in the woods, that are odd and uncommon.

"What thee observes of the frost, to be sure, had the effect thee describes. I once remember one like it in England; but the effects were not so severe. I hope, next year, thee will be able to make some selections that may make thee some returns.

"The White Flowering Bay [*Magnolia glauca*, *L.*] is a plant that grows in moist places; the leaves are long, of a bay shape, and of a silver color on the back of the leaves. It bears a fine large white flower, like the water lily, of a fine perfumed smell, which is succeeded with a seed-vessel of a cone-like figure. I have a plant that flowers finely, in my garden. It is in abundance of places, in Maryland; but whether it is found more northward, I can't say. It is a fine plant to adorn thy own garden. But give thyself no trouble about it: and, as the fir and cypress cones are not found near thee, we will wait for some more favorable opportunity to collect them. Send first those seeds that are near thee.

"The box of seeds came very safe, and in good order. Thy remarks on them are very curious; but I think take up too much of thy time and thought. I would not make my correspondence burdensome; but must desire thee to continue the same collections over again; and to prevent trouble, only number the papers, and give the country name —or any name thee may know it by again; then keep a list of them by thee, with the number to the names, and when they come here, those that do not come up, we have only to write to thee for the same seed to such a number, to send over again. As I design to make a present of part of these seeds to a very curious person [Lord Petre,] I hope to procure thee some present for thy trouble of collecting. I am thy very sincere friend. P. COLLINSON."—pp. 63–65.

This letter proves that it was Collinson's forethought and care which suggested the plan for making Bartram's collections afford some reimbursement, and furnish the means for new journies and explorations. A paragraph in a succeeding letter shows that he had interested Lord Petre in the undertaking.

"London, March 1st, 1735.

"Kind friend, JOHN BARTRAM:—I am now just returned to town from paying a visit to a noble lord, my most valuable and intimate friend. One of my proposals, I sent thee last year, to collect the seeds of your forest trees, was for him, as he is a universal lover of plants. I presented him with a share of the seeds thou sent last year, which was very acceptable. As he is a man of noble and generous spirit, he very rationally considered thy pains and trouble in collecting them, and desired to make thee some returns, and left it to me. I thought a good suit of clothes, for thy own wear, might be as acceptable as anything, so have sent thee one, with all appurtenances necessary for its making up, which I hope will meet with thy approbation, and help in some measure to compensate for thy loss of time.

"My noble friend desires thee to continue the same collections. Send the same sorts over again, and what new ones happens in thy way, and sent at the same time o' year, and in the same manner, will do very well. Please to look in my other letter for my further remarks on this head. * * * *

"As our noble friend will be always grateful, I hope it will encourage thee to go on; but yet I would have thee so proceed as not to interfere with thy private business. Indeed, the forest tree seeds I hope will bring money into thy pocket; so the time spent in making the collection cannot be said to be lost or misspent. * *

"I hope thee hath mine per Captain Richmond; with a parcel in the Library Company's trunk, and a box of seeds, in sand, per Richmond. I heartily wish thee and thine health and prosperity, and am

Thy real friend, P. COLLINSON.

"Pray give nobody a hint, how thee or thy wife came by the suit of clothes. There may be some, with you, may think they deserve something of that nature.

"If thee observes any curious insects, beetles, butterflies, &c., they are easily preserved, being pinned through the body to the inside of a little box. When it is full, send it nailed up, and put nothing within it, and they will come very safe. Display the wings of the butterflies with pins, and rub off the down as little as possible. When thee goes abroad, put a little box in thy pocket, and as thee meets with them put them in, and then stick them in the other box when thee comes home. I want a *Terrapin* or two. Put them in a box with earth, and they will come safe. They will live a long while without food."—pp. 69, 70.

We must make room for a part of the preceding letter, evidently in reply to one in which Bartram had reproached his correspondent for not sending him the English seeds and plants he had asked for.

"I have procured from my knowing friend, Philip Miller, gardener to the Physic Garden at Chelsea, belonging to the Company of Apothecaries, sixty-nine sorts of curious seeds, and some others of my own collecting. This, I hope, will convince thee I do what I can; and if I lived, as thou does, always in the country, I should do more; but in my situation it is impossible. Besides, most of the plants thou writes for, are not to be found in gardens, but growing spontaneously a many miles off, and a many miles from one another. It is not to be expected I can do as thou does. My inclination's good, but I have affairs of greater consequence to mind; and as I have observed to thee before, affairs of this nature should not interfere with business, and I do request thee not to suffer anything thee does for us to interfere with thine. Indeed, for the cargo thou sent, there was some reason for thy making it thy business, because thee will have some gratification; but in thy other curious collections, which is done purely to oblige us, pray give thy business the preference; but if, in the course of that, without neglecting it, thou can pick up what thou thinks will be acceptable, we shall be obliged to thee, and study some requital. So for the future, no more censure me for not sending the one-sixth part thee wrote for,

for the reasons above; but yet transmit me yearly what thou wants, and any thing in my power, or my friend Miller's, will be always at thy service; and if I send thee the same thing two or three times over, thee must excuse it, and place it to the multiplicity of affairs that fill my thoughts, and not suspect my care; and then thee will deal kindly, and friendly, and lovingly, by P. COLLINSON."—pp. 68, 69.

The next letter informs Bartram that his collection of seeds of forest trees had brought £18 13*s*. 3*d*. from Lord Petre, who also promised an annual subscription of ten guineas to aid him in making further discoveries.

"Lord Petre is very willing to contribute very handsomely towards it. He will be ten guineas, and we are in hopes to raise ten more. This we think, will enable thee to set apart a month, two, or three, to make an excursion on the banks of the Schuylkill, to trace it to its fountain. But so great an undertaking may require two or three years, and as many journeys, to effect it, so we must leave that wholly to thee. But we do expect, that after harvest, and when the season is that all the seeds of trees and shrubs are ripe, thou will set out; and them that happen not to be ripe when thou goes, they may have attained to maturity when thou comes back. We shall send thee paper for specimens and writing, and a pocket compass,—expect thee'll keep a regular journal of what occurs every day, and an exact observation of the course of the river, which, with a compass thee may easily do." —p. 12.

Again, the next letter.

"I have now the pleasure to tell thee that I have got subscribed twenty guineas, to encourage thee to undertake thy intended expedition; and as our gentlemen find encouragement, it will be continued annually. This is a pretty sum in sterling money, which I hope will enable thee to supply thyself with necessaries from hence; or, if more for thy profit, thou may draw for it when we have received thy cargoes. This, I believe, thee will think reasonable, that the gentlemen should first see what they have for their money. This I can assure thee, that thee has to do with people that are not unreasonable in their expectations."—p. 75.

An excursion to Maryland and Virginia being planned for the succeeding autumn, Collinson sends him particular instructions, and letters of introduction, "which letters come to J. Logan to save thee postage," commending him to his friends in those parts, to *Robert Gover*, *Col. Custis*, *Col. Boyd*, *Isham Randolph*, &c. Anxious that his protégé should make a favorable impression, he adds a few words of exhortation as to dress.

"One thing I must desire of thee, and do insist that thee oblige me therein: that thou make up that drugget clothes, to go to Virginia in, and not appear to disgrace thyself or me; for though I should not esteem thee the less, to come to me in what dress thou will,—yet these Virginians are a very gentle, well-dressed people—and look, perhaps, more at a man's outside than his inside. For these and other reasons, pray go very clean, neat, and handsomely dressed, to Virginia. Never mind thy clothes: I will send more another year."—p. 89.

The following postscript to a later letter leads one to infer that the plant collector hardly needed this advice.

"One thing I forgot to mention before, and what very much surprises me, to find thee, who art a philosopher, prouder than I am. My cap, it is true, had a small hole or two on the border; but the lining was new. Instead of giving it away, I wish thee had sent it to me back again. It would have served me two or three years, to have worn in the country, in rainy weather."—p. 114.

The following reminds us of a similar and equally explicit letter of Collinson's to Linnæus himself, published in the Linnæan Correspondence.

"The *Systema Naturæ* is a curious performance, for a young man [Linnæus;] but his coining a set of new names for plants tends but to embarrass and perplex the study of botany. As to his system, on which they are founded, botanists are not agreed about it. Very few like it. Be that as it will, he is certainly a very ingenious man, and a great naturalist. As these were not in our mother tongue, was the only reason I did not send them to thee. I hope not to be forgetful for the future."—p. 106.

It would seem that Collinson was the first to send the American *Ginseng* to China.

"I sent some Ginseng roots to China. If they sell well, a good profitable trade may be carried on. In the mean time sow the seed, and raise a stalk to furnish my friend, when he returns. Keep that a secret, and raise what thee canst: for I have an opinion it will turn to account, if my friend manages it rightly."—p. 125.

"I am well assured it will prove a profitable commodity to China, who value it above anything. I have compared yours with the Chinese, and find them in all respects the same. Your proprietor was so kind to send me a considerable parcel, and I have trusted a particular friend with it, to carry to China, to see how they approve of it, and to find what price it bears; but my friend is under promise not to discover that it is *American;* for if they know that, they are so fanciful it may not be so good as their own."—p. 127.

The next year brings Bartram another remittance.

"I could not omit sending thee the above-mentioned £20 10*s.* by Captain Wright, who is a most obliging man, and he knows thee, and perhaps may give the carriage, though I shall not receive the money this twelvemonth, nay, I have now some standing two years; for it is very hard getting money of great people, though I give them my labor and pains into the bargain. They are glad of the cargo, but are apt to forget all the rest. They give good words, but that will not always do; but for thy sake, and if it will but contribute to keep thee in thy circumstances, I gladly will do all, and much more, if it will but be of service to thee, and encourage thy ingenuity. * * *

"It is very entertaining to survey the great variety of mosses that there is with you, as well as with us. I have sent mine down to the Doctor, who admires at thy diligence. He observes paper is scanty, so has desired me to send thee half a ream of writing paper, which comes in a parcel per Captain Wright, with some paper for specimens.

"The books, Tournefort, are a present from Lord Petre, which I hope will make thee easy."—pp. 140, 141.

Lord Petre was one of the most enterprising and successful planters of that day. How largely Bartram's collections enabled him to raise American trees, may be learned from the following extract.

"The trees and shrubs raised from thy first seeds, are grown to great maturity. Last year Lord Petre planted out about ten thousand Americans, which, being at the same time mixed with about twenty thousand Europeans, and some Asians, make a very beautiful appearance;—great art and skill being shown in consulting every one's particular growth, and the well blending the variety of greens. Dark green being a great foil to lighter ones, and bluish green to yellow ones, and those trees that have their bark and back of their leaves of white, or silver, make a beautiful contrast with the others.

"The whole is planted in thickets and clumps, and with these mixtures are perfectly picturesque, and have a delightful effect. This will just give thee a faint idea of the method Lord Petre plants in, which has not been so happily executed by any: and, indeed, they want the materials, whilst his lordship has them in plenty.

"His nursery being fully stocked with flowering shrubs, of all sorts that can be procured,—with these, he borders the outskirts of all his plantations; and he continues annually, raising from seed, and layering, budding, grafting—that twenty thousand trees are hardly to be missed out of his nurseries."—p. 145.

The next year, however, an affecting letter of Collinson's announces to Bartram the death of his noble patron, of the small pox, in the thirtieth year of his age; and, with a fine tribute to his memory, adds:—"All our schemes are broke. Send no seeds for him nor the Duke of Norfolk; for now he that gave motion is motionless;—all is at an end." Other subscribers, however, were found, and Bartram's operations were continued. In the following extract, for Owegos read *Oswego.* Bartram had made a journey through the northern part of Pennsylvania and the country of the Five Nations to Oswego, an account of which was soon after published.

"I thank thee for thy curious present of thy map, and thy draught of the fall of the river Owegos [?]. I was really both delighted and surprised to see it so naturally done,—and at thy ingenuity in the performance. Upon my word, friend John, I can't help admiring thy abilities in so many instances. I shall be sparing to say what more I think. A man of thy prudence will place this to a right account, to encourage thee to proceed gently in these curious things, which belong to a man of leisure, and not to a man of business. The main chance must be minded. Many an ingenious man has lost himself for want of this regard,—by devoting too much of his time to these matters. A hint thee will take in friendship: thy obliging, grateful disposition, may carry thee too far. I am glad, and delight much in all these things—none more: but then I would not purchase them at the expense of my friend's precious time—to the detriment of his interest, and business (now, dear John, take me right).—I showed them to Sir Hans. He was much pleased. Lord Petre deservedly much admires them; and, indeed, does every one that sees them, when they are told who was the performer.

"All this is writ by rote, or from memory, for I dare not, nay, I cannot look into thy letters; for I have no time to add more, but to tell thee—in the trunk of the Library Company, thee'll find a suit of clothes for thyself. This may serve to protect thy outward man,—being a drugget coat, black waistcoat, and shagg breeches. And now, that thou may see that I am not thoughtless of thy better part, I send thee R. Barclay's *Apology* to replenish thy inward man. So farewell. Success attend thee in all thy expeditions. The first leisure, will consider all thy letters. They are all carefully laid up. The chrysalises are all in fine order. I am in hopes of some new beauties. I can now add no more, but that I am thine.

P. Collinson."—pp. 152, 153.

Bartram was born, educated, and married in the Society of Friends, and was, we believe, still a member of the Society at this date (1742). His letters show a very independent and philosophizing turn of mind, and we may have occasion to cite hereafter some unquakerly remarks of his on the subject of war. It is hardly to be wondered at, therefore, "that the views which he entertained had led to his exclusion from the Society so early as the year 1758." To take fully the point of his decidedly ungracious reception of the Quaker's text-book which the London Friend had so kindly presented, it should be mentioned that Bartram had asked Collinson to purchase for him Tournefort, and other botanical works; to which his considerate correspondent had replied that they were rather costly.—"Now I shall be so friendly to tell thee that I think this is too much to lay out. Besides, now that thee has got Parkinson and Miller, I would not have thee puzzle thyself with others; for they contain the ancient and modern knowledge of botany. Remember Solomon's advice: in reading (?) of many books there is no end." Still the good Collinson always contrived in the end to have all these books sent to him, as presents.

"July the 6th, 1742.

"A few hours past, I received thy letters of March the 3d, and 20th, and April the 25th, 1742.

"Yesterday the ship arrived, which our dear friend Captain Wright sailed in from London, but alas! hath left her captain asleep in Neptune's bosom: and now, such a mortal sickness is on board, that she is ordered to ride quarantine below the town. No goods can be got off.

"I heartily thank Sir Hans Sloane for his kind remembrance of me. I long to see his History; and particularly M. Catesby's books, to see what birds he hath figured, before I set out next week for a journey along our sea-coast, where I believe there are many birds which he omitted to draw—which I shall be very particular to observe their dimensions, shape and colors, if I can compel them, by the charms of sulphur and nitre and lead, to let me dispose of them as I think most suitable.

"I shall endeavor to procure Lady Petre a humming-bird's nest, and eggs, as soon as possible. I have not heard of any being found this year. They commonly build their nest upright upon a limb of a tree, and a little shake with the fall of the tree separates them. The fine, downy composition, is gathered from the stalks of our fern. The bladders of balm, which I sent thee, I gathered on the Balm of Gilead tree, on the Katskill Mountain,—a delicate, fragrant liquor, as clear as water.

"I design, next month, to go myself and gather some seed for you, which I hope will be as much pleasure to you, as fatigue and charge to me to get them. There is no more trust in our Americans, than curiosity. Colonel Salisbury, who lives near them, sent me last winter, a very loving letter, affirming he did what he could to procure them, leaving orders, when he went to York, to gather them; but at his return, there is none gathered. He sent a man on purpose to the mountains, to gather them; but he said the birds had picked all the seed out, being very fond of them.

"I am glad my map and draught were acceptable, although clumsily done,—having neither proper instruments nor convenient time; being, most of them, in part of a first day, or by candle-light,—having no whole original but nature, nor time to take a copy,—being hurried in gathering or packing of seeds.

"I am greatly obliged to thee for thy necessary present of a suit of clothes, which just came in the right time; and Barclay's *Apology*, I shall take care of, for thy sake. It answers thy advice, much better than if thee had sent me one of Natural History, or Botany, which I should have spent ten times the hours in reading of, while I might have labored for the maintenance of my family. Indeed, I have little respect to *apologies* and disputes about the ceremonial parts of religion, which often introduce animosities, confusion, and disorders in the mind—and sometimes body too; but, dear Peter, let us worship the one Almighty Power, in sincerity of heart, with resignation to His divine will,—doing to others as we would have them do to us, if we were in their circumstances. Living in love and innocency, we may die in hope."—pp. 158, 159.

Bartram, at Collinson's request, had gathered some mosses, &c., for Dillenius, who in turn sent him a copy of his *Historia Muscorum.* This is acknowledged by Bartram, in the following extract, and also to Dillenius himself, in a letter printed on pp. 310–11.

"I received thy kind letter of June the 16th, and the seeds and book of Doctor Dillenius, last night. I take it to be the completest of that kind that ever was wrote; for we don't read that Solomon wrote of any plants of humbler growth than the hyssop: so I conclude he knew as little of mosses, as he did of the plants that grew beyond Mount Lebanon, or in America."—p. 161.

The subjoined extracts are from a letter of Collinson, in 1743–4.

"Friend JOHN:—The prices of microscopes are advanced to a guinea; so I have only sent thee one, for thyself, and desire thy acceptance of it, with a book. * * At present, can give thee no assurance of any new contributors, only the Duke of Richmond and P. Miller continue,—who love new things; but whether so small a subscription will countervail thy going among the *saints*, in New England, I must submit to thy consideration. * * * Dr. Dillenius has writ thee a letter;—is greatly delighted with the last seeds, they are so good; says that thou art the only man that ever did things to the purpose. The curiosities for Dr. Gronovius are gone for Holland, with the specimens. I have writ both to him and Linnæus, not to forget the pains and travel of indefatigable John Bartram,—but stick a feather in his cap, who is as deserving as the rest."—p. 171.

That is, to keep in mind a genus *Bartramia.* The genus dedicated to him by Linnæus, in the *Flora Zeylanica*, however, proved to be only a species of Triumfetta; and the name was subsequently given by Hedwig to a fine genus of mosses.

Bartram and Collinson occasionally make themselves merry at the expense of Dr. Witt, of Germantown, a remarkable character in his day, who dabbled in divination as well as botany, and was a little touched with quasi-Swedenborgianism, as would seem from the first part of the following extract. The latter part testifies to Bartram's accuracy of observation about the pine-cones.

"I received the nails, calico, Russia linen, and the clothes for my boys: all which are very good and well chosen, and give great satisfaction. The only thing that gives me any uneasiness, is, that thee hath sent more than what is my due.

"Now, though oracles be ceased, and thee hath not the spirit of divination,—yet, according to our friend Doctor Witt, we friends that love one another sincerely, may, by an extraordinary spirit of sympathy, not only know each other's desires, but may have a spiritual conversation at great distances one from another. Now, if this be truly so,—if I love thee sincerely—and thy love and friendship be so to me—thee must have a spiritual feeling and sense of what particular sorts of things will give satisfaction; and doth not thy actions make it manifest? for, what I send to thee for, thee hath chosen of just such sorts and colors as I wanted. Nay, as my wife and I are one, so she is initiated into this spiritual union; for thee has sent her a piece of calico so directly to her mind, that she saith that if she had been there herself, she could not have pleased her fancy better. * * *

"In opening those fine cones of Cluster Pine, I observed how close the scales adhered, which is contrary to all our pines and firs (except one species of the three-leaved pine); which, before they are well dried, spring open and shed all the seed out, which makes them the difficultest to gather. One may, in the beginning of the week, see the cones green—and before the latter end, all the seed that is good will be shed out, especially the five-leaved, which you are so fond of—and which it is not possible for me to gather any great quantities thereof, as I wrote to thee, last year. I design to get what I can, yearly; but, as I can't be in three or four hundred distant places in three or four days' time, I can't procure great quantities; and if I depend upon others' assistance, I am sure of being deceived.

"As our friend Miller seems to question my account of our pines, I now tell thee I generally take care to speak truth—even to those that I think will bestow no more pains of examination, than to tell me it is not so,—to whom silence suits better than arguments—as ignorance doth to their capacity; but, as I have a great opinion of Miller's learning and judgment, I am engaged in duty and friendship to inform him the best I can, at present.

"All our pine cones are two summers and one winter, from their first appearance to their perfecting and casting their seed, but this one species,—which open not till the second or third year after they seem perfectly ripe. I have been much surprised at observing these trees have upon one branch all the cones of three, four, or five years' growth, at once."—pp. 174, 175.

An allusion to Franklin's discovery occurs in a letter from Collinson, dated January 11th, 1753, while writing of the great difference between the climate of England and North America.

"I have heard thunder but once this year, and that at a distance, whilst you have had it so terrible all over your continent,—as our friend Clayton writes me from Virginia; and we have had scarcely sufficient to make our ingenious friend Franklin's experiment. * * I gathered such a nosegay on Christmas day, would have delighted thee to have seen it. In England, vegetation may be said never to cease; for the spring flowers tread so on the heels of the autumn flowers, that the ring is carried on without intermission."—p. 189.

Bartram is apt to complain, whenever his letters and commissions are not very promptly attended to. This calls forth from Collinson the following mild rejoinder.

"If my friend John Bartram knew better my affairs, my situation in life, my public business, my many engagements and incumbrances,—instead of being in a pet, that I answer not the letter he sends by one ship by the next that sails—he would wonder I do so well as I do, though he thinks it so ill. * * He should never suspect his friend, until he has better foundation for so doing. To serve him, I often neglect my own business. His surmises are well meant; yet they arise from want of experience and not knowing me, and the share I have in the busy world, so well as I could wish; then he would not think me so bad a correspondent. And I dare venture, now I have given him these friendly hints, he will not think me so again; but continue his friendly and informing, as well as his entertaining correspondence. * * I thought he had known me better than to think anything he sends me either lost or neglected. * * * *

"The cranberry thrives wonderfully, and is in blossom; every way agreeing with ours, but much larger. * * *

"Pray give my thanks to Moses, for his two letters. In the box, with the other things, I have sent two fine Cedar of Lebanon cones, just come from thence. * * * * *

"There is a little token, in a box, for Billy, whose pretty performance pleases me much.

"Thy account of the frogs is very humorous; but would it not be more so, to import a cargo of them? And had I a park, or place inclosed, I would wish it. But as it is, strolling people and boys would destroy them. A bull-frog would surprise the whole village; but then it would be certainly killed."—pp. 192, 193.

On more than one occasion, Bartram alludes to a theory in respect to petrifactions and the formation of limestone, which he had communicated to Dr. Fothergill. Collinson seems not to have quite comprehended it; but Bartram writes,—"My dear worthy friend, thee can't bang me out of the notion that limestone and marble were originally mud, impregnated by a marine salt, which I take to be the original of all our terrestrial soils." p. 210. And Collinson afterwards writes, "What shall we say to the strata abounding with fossil sea-shells, &c.? Very probably, as thou conceives, the sea flowed higher, or once overflowed all."—p. 237.

Quite characteristic are Bartram's remarks in the subjoined extract from a letter in January, 1757.

"Many birds, in their migrations, are observed to go in flocks,—as the geese, brants, pigeons, and blackbirds; others flutter and hop about from tree to tree, or upon the ground, feeding backwards and forwards, interspersed so that their progressive movement is not commonly observed. Our blue or rather ash-colored, great herons, and the white ones, do not observe a direct progression, but follow the banks of rivers—sometimes flying from one side to the other, sometimes a little backwards, but generally northward, until all places be supplied sufficiently where there is conveniency of food; for when some arrive at a particular place, and find as many there before them as can readily find food, some of them move forward, and some stay behind. For all these wild creatures, of one species, generally seem of one community; and rather than quarrel, will move still a farther distance, where there is more plenty of food—like Abraham and Lot; but most of our domestic animals are more like their masters: every one contends for his own dunghill, and is for driving all off that come to encroach upon them."—pp. 211, 212.

Here is a curious letter of Collinson's, p. 229, in which he reproves Bartram for "grumbling and complaining, making no allowances for accidents," &c., and ending: "Really, friend John, complain on. I am now so used to that I shall not mind it for the future. But, as thou canst write diverting and curious observations, in this manner I expect to be entertained for the future, which will always give pleasure to thy old friend, P. Collinson." The very next letter from Bartram, despatched, however, before he could have received his friend's homily, sufficiently illustrates the fault which poor Collinson so amusingly deprecates:

"August the 14th, 1761.

"DEAR PETER:—I have just now received two letters that came by the packet.

* * "My Yellow Slipper improves well; but the White declines. '*Send double boxes for Pine and Powel and Williamson.*' Who is this Pine? '*Powel and Eddy desire but half the quantity of walnuts.*' Who is this Eddy? '*But all desire new things; they are tired of old ones.*' Do they think I can make new ones? I have sent them seeds of almost every tree and shrub from Nova Scotia to Carolina; very few are wanting: and from the sea across the continent to the lakes. It's very likely ignorant people may give strange names to tickle your ears withal; but, as I have traveled through most of these provinces, and have specimens sent by the best hands, I know well what grows there. Indeed, I have not yet been at the Ohio, but have many specimens from there. But in about two weeks I hope to set out to search myself, if the barbarous Indians don't hinder me (and if I die a martyr to botany, God's will be done;—His will be done in all things). They domineer, threaten, and steal most of the best horses they can. None could have worse luck than I with your roots sent last fall and this spring."—pp. 231, 232.

The following touches upon politics.

"London, May 22d, 1762.

"Whilst my dear John is in a melancholy mood for the loss of Pitt, I keep myself in equal poise; but the success *in one scale*, and his two rash French expeditions, on their coasts, *in the other*, in which he wantonly sacrificed so many brave Englishmen, to answer no purpose but his vain-glory. Had they been sent *then* to Martinico, some millions had been the difference to England. If we consider the number of our ships taken, and their rich cargoes, the men useless, and the vast produce of that island kept from us, so all things put together (for this is a short sketch), I don't find any cause to lament his abdication. We go on full as well without him. So prithee, my dear John, revive and don't sink, and be lost in doleful dumps under so terrible an event, which portends no harm that I can see; for we have a brave King, and good men at the helm. Never fear: we shall keep Canada, and have a good peace; and Pitt is as well pleased with his mercenary pension of £3000 per annum, and a title in reversion; and has cleverly slipped his neck out of the collar, when it most became him to keep in, to serve his country, but he preferred serving himself before it.

"From one melancholy story we come to another;—the loss of so many fine plants, which affects me more than the loss of Pitt.

"It is a fair probation, how far the principles of vegetation may be maintained when removed from a warmer latitude to a colder. Art will assist nature. There are many fine plants that grow on this side the Tropics, if we will bestow a south wall on them, will thrive and flower well in our northern climate.

* * * * * *

"I cannot advise, for I am fearful thy grand expedition to the lakes will be too much to undertake without suitable companions, for accidents may happen in so long a journey. But if it was thy resolution, my advice will come too late. So, my dear John, farewell.

P. COLLINSON."—pp. 235, 236.

There are three letters from Bartram, written in the autumn of 1763, after his visit to Carolina and Georgia, expressing a strong desire to explore the country of Canada and Louisiana for natural productions, adding, "But this would alarm the Indians to the highest degree. All the discoverers would be exposed to the greatest savage cruelty, the gun, tomahawk, torture, or revengeful devouring jaws. Before this scheme can be executed, the Indians must be subdued, or drove above a thousand miles back. No treaty will make discovery safe."—p. 224. And again—"The most probable and only method to establish a lasting peace with the barbarous Indians is to *bang them stoutly*, and make them sensible that we are men, whom they for many years despised for women. Until then it is only throwing away blood and treasure to make peace with them."—p. 255. And in the same strain is the next letter.

"November 11th, 1763.

"Dear worthy PETER:—I have received my dear friend's letter of August 23d, 1763.

"I think most of our people here look upon all our boasted acquisitions in North America to be titular, and that only of short duration, as the French still claim all one side of the Mississippi, and part of our side. They will draw the chief of their fur trade near them, and will always be setting the Indians against us, suppose we do keep possession of the lakes. But unless we bang the Indians stoutly, and make them fear us, they will never love us, nor keep peace long with us. They are now got so cunning, they will not sell their land, and stand so to their bargain as to let the people live quietly upon it. But when they want goods, it is but rob the traders, steal horses, plunder and insult the back inhabitants, and instead of us calling them to account for their mischief, we sue to them for peace, and give them great presents to kill no more white people for three or four years. By such proceedings, they have us in the greatest contempt, believing they may do us all the mischief they please, and we are ready at any time to buy a peace with them for a few years, under great insults. * *

"The variety of plants and flowers in our southwestern continent, is beyond expression. Is it not, dear Peter, the very palace garden of old Madam *Flora*? Oh! if I could but spend six months on the Ohio, Mississippi, and Florida, in health, I believe I could find more curiosities than the English, French and Spaniards have done in six score of years. But the Indians, instigated by the French, will not let us look at so much as a plant, or tree, in this great British empire."—p. 256.

To all this the benevolent Collinson replies in a more Quakerly way.

"Ridgeway House, December 6, 1763.

"I am here retired, all alone, from the bustle and hurry of the town, meditating on the comforts I enjoy; and whilst the old log is burning, the fire of friendship is blazing—warms my imagination with reflecting on the variety of incidents that hath attended our long and agreeable correspondence. * * * *

"My dear John, thou does not consider the law of right, and doing to others as we would be done unto.

"We, every manner of way, trick, cheat, and abuse these Indians with impunity. They were notoriously jockeyed and cheated out of their land in your province, by a man's walking a track of ground in one day, that was to be purchased of them.

"Your Governor promised the Indians if they would not join the French, that when the war was over, our troops should withdraw from Pittsburg. They sent to claim his promise but were shuffled off. They resented it, as that fortress was situated on their hunting country.

"I could fill this letter with our arbitrary proceedings, all the colonies through; with our arbitrary, illegal taking their lands from them, making them drunk, and cheating them of their property. As their merciless, barbarous methods of revenge and resentment are so well known, our people should be more careful how they provoke them.

"Let a person of power come and take five or ten acres of my friend John's land from him, and give him half price, or no price for it, how easy and resigned he would be, and tamely submit to such usage! But if an *Indian* resents it in his way, instead of doing him justice, and making peace with him, nothing but fire and faggot will do with my friend John! He does not search into the bottom of these insurrections. They are smothered up, because we are the aggressors. But see my two *proposals*, in the October Gentleman's Magazine, for a peace with the Indians.

"My dear John, I am glad thou art so happily recovered from that cruel complaint; and that our good Colonel escaped those terrible fellows. I hope such prudent measures will be taken as will put a stop to their ravages, and establish a lasting peace.

"The peace that thou art so merry with, in your mock mourning, is only glorious by comparison; I mean by comparing it with that peace that Pitt would have made (but thanks to our enemies could not). Then you must have been thankful to him and the French, that they would allow you to keep your own narrow strip of land; but now your bounds are so extensively enlarged, how ungrateful! how unthankful you are! for ever grumbling, never pleased. I refer thee to the preliminary of Pitt's peace, and Bute's. Facts speak louder than faction. We all know here what Pitt's peace would have been, and what Bute's is. * * * * * *

"What a glorious scene is opened in that rich country about Pensacola—if that despised country is worthy thy visitation. But because Pitt did not get it, thou canst not venture there on any pretence! All beyond the Carolinas is forbidden ground. They are none of thy darling Pitt's acquisition!

"But thy son John may go with a good grace. I am glad to find the spirit of Elijah rests upon him. * * *

"I hope what I have writ will be read with candor. Our long friendship will allow us to rally one another, and crack a joke without offence, as none was intended by thy sincere friend,

P. COLLINSON."—pp. 257-259.

Again. "I don't wonder they should be jealous of the invasion of their property. Every man is tenacious of his native rights; and if you invade their rights you must take the consequences. Let those be well *banged*,—I may say well *hanged*—that by their unjust proceedings provoked the Indians to hostilities, knowing beforehand their cruel resentments."—p. 260.

In 1765, when in his sixty-sixth year, Bartram was appointed the King's Botanist in America, to explore the newly acquired country of Florida, &c. The appointment was announced by Collinson, in a letter dated April 9th, 1765.

"I have the pleasure to inform my good friend, that my repeated solicitations have not been in vain; for this day I received certain intelligence from our gracious King, that he had appointed thee his botanist, with a salary of fifty pounds a year; and in pursuance thereof, I received thy first half-year's payment of thy salary, being twenty-five pounds to Lady day last, which I have carried to thy account.

"Now, dear John, thy wishes are in some degree accomplished, to range over Georgia and the Floridas. As this is a great work, and must be accomplished by degrees, it must be left to thy own judgment how to proceed."—p. 268.

"John, thou knows nothing what it is to solicit at court any favor; nay, though it is for their own interest, they are so taken up with public affairs, little things slip through their fingers. For all I can do, I cannot get thee letters of recommendation to any of the Governors.

"All I can at present do, is, our good friend Ellis, who is appointed to an office in the Floridas, has writ to the Governors in thy favor. I send one here enclosed, and will send the other by next ship. * * So thou must make the best of it, and do what seems most agreeable to thy own inclination. Thou may think the appointment not enough. I did not expect any thing. So thou may use it, or refuse it, as thou likes best, or search as far as the salary will go to support it. In this case, I cannot advise thee.

"As thou grows in years, thou will do well to consider if thy present constitution and habit of body can undergo the fatigue of such expeditions. * * * * *

"Our good friend B. Franklin, grows fat and jolly. There is hope of accommodation."—pp. 269, 270. * * *

> Next, "It was highly acceptable to me to hear of my dear John's safe arrival in Carolina, and to find his botanic genius began to exert itself in new discoveries. I wish thou may temper thy zeal with prudence, but I do not think it an instance of it when thou and Mrs. Lamboll rambled in the intense heat of a midday sun. Perhaps it was to procure thee a seasoning."—p. 270.
>
> "Dr. Solander is a strange, idle man. I cannot get thy spring specimens from him, is the reason thou hears nothing from me about them."—p. 271.

But there is no room to continue these extracts, nor to detail the misfortunes of Billy, (William Bartram,) who would be a planter upon the St. John's River, and so get into trouble; nor to advert to some curious bits of early information of "some vast creatures, with the long teeth or tusks of elephants, but with great grinders, belonging to some animal not yet known."

Collinson's last letter to John Bartram is dated July 6th, 1768. There is one to his son, Wm. Bartram, relating his continued exertions for his benefit, dated the 18th of the same month; and he died on the 11th of August, in the 75th year of his age. Bartram himself nearly reached his 79th year, and died, as Dr. Darlington has ascertained, on the 22d of September, 1777.

There is a correspondence with Dr. Fothergill, beginning in 1744, and continued to 1774. This distinguished physician and most benevolent man, took a lively interest in the Bartrams, father and son, especially after the decease of Collinson. A single extract from a letter of his, in 1769, has some interest from its mention of a name afterwards so distinguished.

> "This, perhaps, will be delivered by *Dr. Rush*, a young man, who has employed his time with great diligence and success in prosecuting his studies here; who has led a blameless life, so far as I know; and it seems but just that those who have endeavored to deserve a good character, should have it when it may be of use to them."—p. 341.

Two short letters to Linnæus are printed from Bartram's draughts, one of which refers to a letter recently received from the Swedish botanist. "The letters from Linnæus to Bartram are all missing."

In one of those addressed to the Rev. Jared Eliot, of Killingworth, Connecticut, Bartram gives him a detailed account of his mode of splitting rocks, even seventeen feet long, with wedges;—in the very manner now practiced.

There are few letters from Franklin, between 1757 and 1777. In one of them, dated January 7, 1769, he sensibly urges Bartram to undertake no more long and dangerous peregrinations, at his advanced age, but to devote his leisure hours to "a work that is much wanted, and which no one besides is so capable of performing—I mean the writing the natural history of our country.

I imagine it would prove profitable to you, and I am sure it would do you honor."—p. 403. Repeating the same advice in a later letter, Franklin adds in the Poor Richard vein:—

> "It is true, many people are fond of accounts of old buildings, monuments, &c.; but there is a number who would be much better pleased with such accounts as you could afford them; and for one I confess, that, if I could find in any Italian travels, a receipt for making Parmesan cheese, it would give me more satisfaction than a transcript of any inscription from any old stone whatever."—p. 403.

The correspondence of Bartram occupying a greater number of pages than was expected, the editor felt obliged to restrict very much his selections from the correspondence of Marshall, the author of *Arbustum Americanum*.

Humphry Marshall, the founder of the second botanic garden in this country, and the author of "the first truly indigenous botanical essay published in this western hemisphere," was born in West Bradford, Chester County, Pennsylvania, on the 10th of October, 1722. His father was a native of Gratton, in Derbyshire, England, who came to Pennsylvania about the year 1697, and settled near Darby, but afterwards removed to the forks of the Brandywine. Humphry, who was the eighth of nine children, "used often to state, that he never went to school a day after he was twelve years of age, and consequently he was instructed only in the rudiments of the plainest English education. He was employed in agricultural labors until he was old enough to be apprenticed to the business of a stone-mason, which trade he followed for a few years, and until his marriage, after which he took charge of his father's farm. In 1764, he built with his own hands a brick addition to the paternal dwelling, when he also erected a green-house adjoining it, "doubtless the first conservatory of the kind ever seen, or thought of, in the county of Chester." From the second story he projected a little observatory, in which to indulge his fondness for astronomical observations. From the letters of his correspondents, the good Dr. Fothergill and Dr. Franklin, we find that the latter ordered a reflecting telescope for Marshall, to which the former added a microscope and a thermometer, and *paid for the whole!* And a later letter from Franklin acknowledges the reception of Marshall's "*observations on the spots of the sun*," which he communicated to the Royal Society, where they were highly spoken of, and a portion was printed in the *Philosophical Transactions*, vol. 64, p. 194. In 1773, he purchased a tract of land adjoining the site of the present village of Marshallton, where he built, like Bartram, with his own hands the house, of which the editor has given a pictorial representation. At the same time he laid out the botanical garden which he long sustained, and which "soon became the recipient of the most interesting trees and shrubs of our country, together with many curious exotics, and also a numerous collection of herbaceous plants." In 1785, his account of our forest trees and shrubs, a 12mo volume of about 200 pages, was published. He attained the age of 79 years, but with a partial loss of sight during his later years; and died on the 5th of November, 1801. He was born in the Society of Friends, and lived and died an exemplary member of that fraternity.

It was only while engaged in collecting and editing the biographical materials of this interesting volume, that Dr. Darlington ascertained that our two botanical patriarchs were not only men of kindred minds and pursuits, "but that they were actually cousins-german, the sons of two sisters. James Hunt of Kingsessing, in the county of Philadelphia, had the happiness to call those ladies his daughters, and the rare privilege of enumerating two of the earliest and most distinguished botanists of Pennsylvania among his grandchildren." His cousin Bartram probably awakened his enthusiasm for horticulture and botany, and promoted his efforts. Fitly are their names and memorials here associated, and heartily do we acknowledge our obligations to Dr. Darlington for the unwearied editorial labors which have given us the interesting volume that we have now so inadequately noticed,—a volume which every where abounds with curious and important facts for the naturalist and the historian, and which rescues from oblivion so many memorable particulars of the lives and times of our earliest devotees to science.

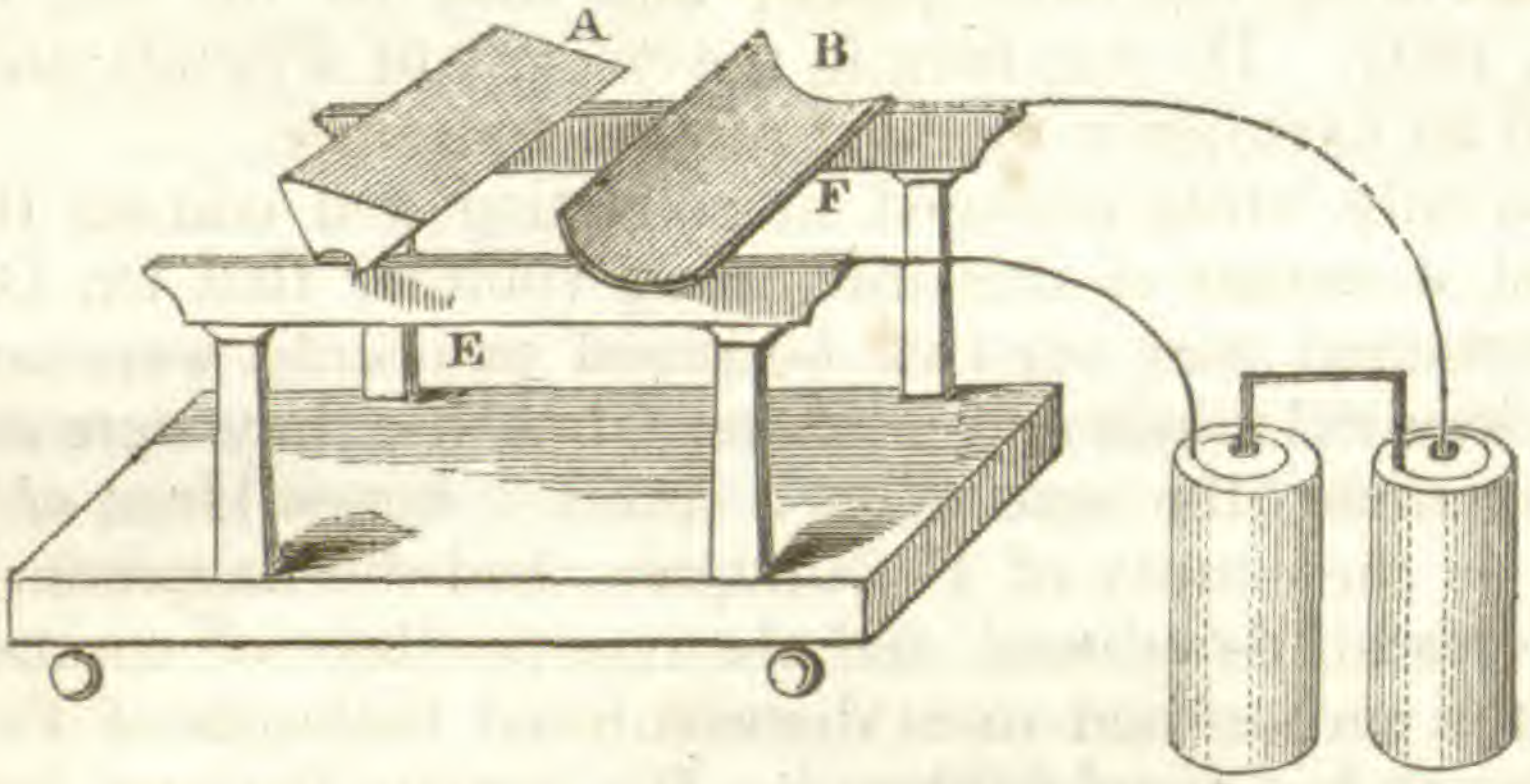
Besides the notes scattered through the work, the editor has given, in a preface, a brief, but very accurate survey of the progress of botany in North America,—of which science he is himself one of the most sedulous and successful votaries. A. GR.

ART. XV.—*Vibrations of Trevelyan's bars by the Galvanic Current;* by Prof. CHAS. G. PAGE, Washington, D. C.

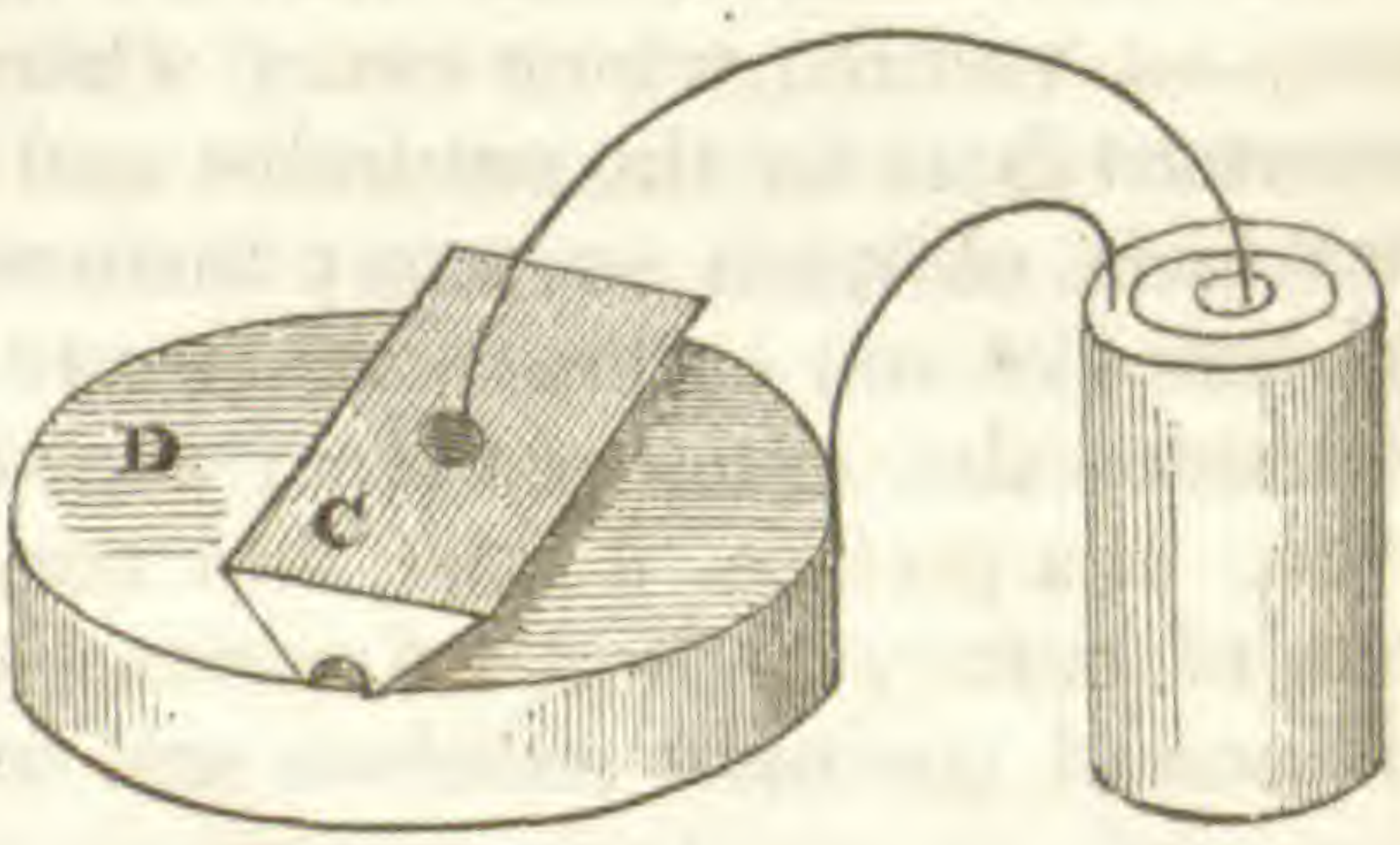
THE vibration of Trevelyan's bars by the action of heat is an experiment more interesting than familiar, and one which has been variously and vaguely explained by most authors. It will not be necessary for me to recapitulate the several descriptions and solutions of this phenomenon, as the novel experiment about to be detailed will embrace substantially the whole subject.

About a year since, while exhibiting to a class the vibration of these bars by heat, it became inconvenient to prolong the experiment, as the vibration ceases as soon as the temperature of the bar is somewhat reduced, and I was induced to seek for some method by which the vibratory motion could be produced and continued at pleasure without the trouble of reheating the bars for each trial. After various fruitless efforts I obtained a most beautiful result by using the heating power of a galvanic current. Fig. 1 shews the mode of performing the experiment with the battery. A and B are the two forms usually given to Trevelyan's bars which, when to be vibrated by the action of heat, are made of brass, and weighing from one to two pounds, and after being sufficiently heated, are placed upon a cold block of lead as seen in fig. 2. The two bars may be placed upon the same block though the vibrations are apt to interfere when two are used. When the bars are to vibrate by the galvanic current, they may be of the same size and form as above, and of any kind of metal,—brass or copper or iron, however, seeming to be most convenient. One or both of the bars may be placed at once without reference to temperature upon the stand, as in fig. 1, the bars resting upon metallic rails, E, F, which latter are made to communicate each with the poles of a galvanic battery of some considerable heating power. Two pairs of Daniell's, of Smee's, or of Grove's battery of large size are sufficient. The battery I employ consists of two pairs of Grove's with platinum plates four inches square. The vibration will proceed with great rapidity as long as the galvanic current is sustained.

1.



2.



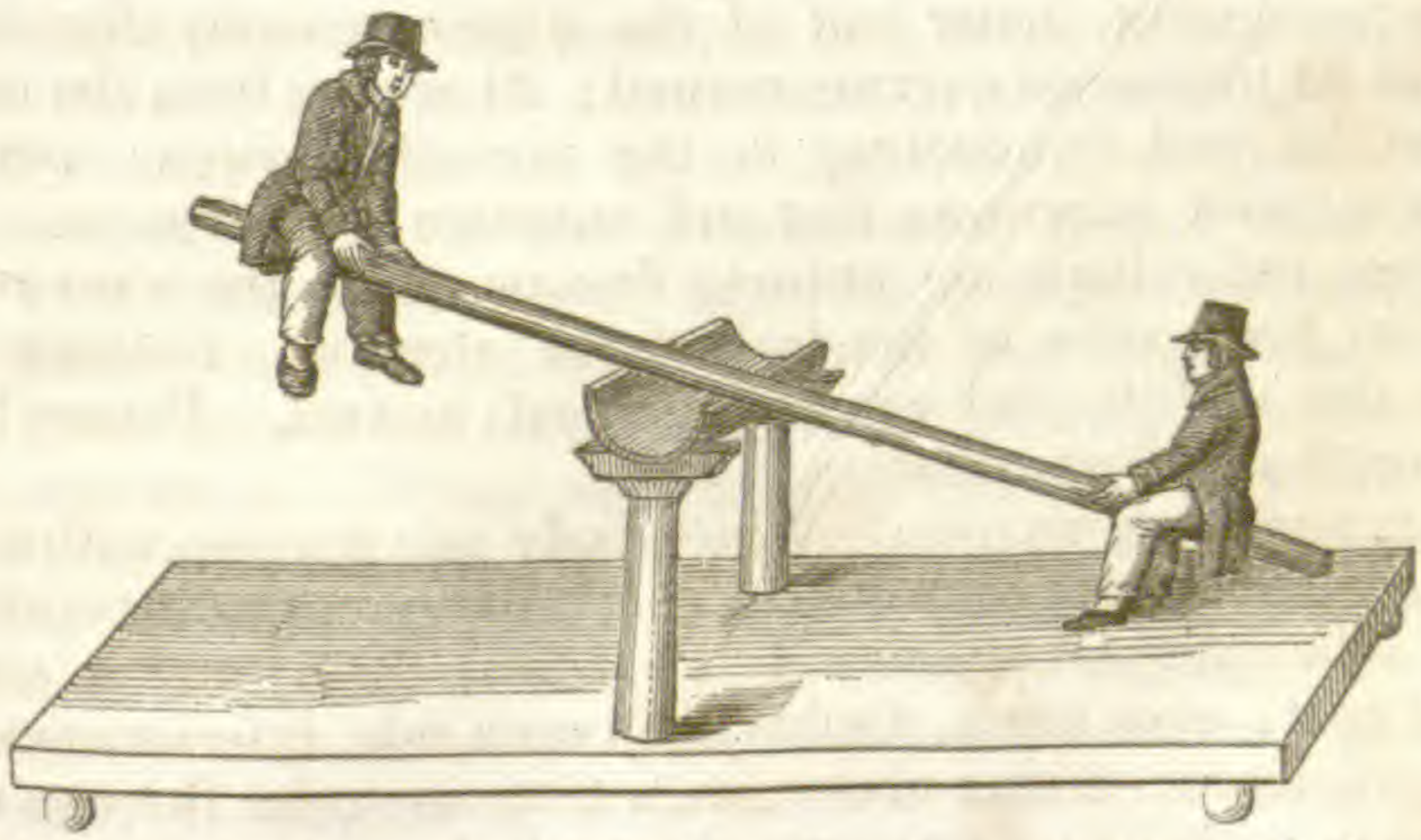
In fig. 2, one pole of the battery is connected with the metallic block and the other pole with mercury in a little cavity in the centre of the vibrating bar. The experiment succeeds much better with the rails, as in fig. 1, and quite a number of bars may be kept in motion by increasing the number of rails and passing the current from one to the other through the bars resting upon them.

The rails are best made of brass wire or a strip of sheet brass, though other metals will answer, the harder metals which do not oxydate readily, however, being preferred. A soft metal like lead is not so favorable to the vibrations in this experiment, although in Trevelyan's experiment lead seems to be almost the only metal that will answer to support the bar which is usually made of brass.

Prof. Graham and other authors have attributed the vibration of Trevelyan's bars to the repulsion between heated bodies, and others have classed the phenomenon with the spheroidal state of heated bodies. I do not consider that any repulsive action is manifested or necessary in either of these cases, nor do I know of any instance in which a repulsion has been proved between heated bodies. It is obvious some other solution is required for this curious phenomenon, and it appears to me that the motion is due to an expansion of the metallic block at the point of contact, and upon this supposition, it appears plainly why a block of lead is required. That is, a metal of low conducting power and high expansibility is necessary, and lead answers these conditions best. In a future communication I will anlayze this matter and explain more fully.

The size of the bars may be very much increased when the galvanic current is employed, and some curious motions are observed when long and large cylinders of metal are used. If they are not exactly balanced, which is almost always the case, they commence a slow rolling back and forth until finally they roll entirely over, and if the rails were made very long they would go on over the whole length. An inclination of the rails is required in this case, but it may be so slight as not to be perceptible to the eye.

3.



If a long rod of some weight be placed across one of the bars, as shown in fig. 3, the vibrations will become longer, and by way of amusement, I have illustrated this with a *galvanic see saw* as it may be termed.

It is well known that where mere contact (without metallic continuity) is made by metals conveying the galvanic current, the metals become most heated at the points of contact, and if the current be frequently broken, the heat at these points is still more augmented. It is for this reason we are able to use various kinds of metals for the experiment, without reference to their conducting powers and expansibilities.

Washington, D. C., Dec. 3d, 1849.

ART. XVI.—*On four new species of Hemiptera of the genera Ploiaria, Chermes, and Aleurodes, and two new Hymenoptera, parasitic in the last named genus;* by S. S. HALDEMAN.

PLOIARIA MACULATA, *Hald.* 1847. Proceed. Acad. Nat. Sc. 3, 151. Brown, darker beneath, above whitish sericeous; head subglobular posteriorly, eyes black and prominent, a transverse impression between them: antennæ and feet annulate with brown and white: mesonotum fulvo-sericeous, with an oblong marginal dark brown macula; base transversely rectilinear between the wings, with a pale medial elongated spine directed backwards between the closed wings: superior wings pale gray covered with whitish reticulations and pale brown maculæ; apex and a larger marginal triangle towards the base, dark brown, divided by pale reticulations, which leave a series of large spots around the apex.—2 lines long. Pennsylvania in June and July: rare. This species is the analogue of the European *P. vagabunda*, to which it bears a close resemblance. The first description was taken from a mutilated specimen.

CHERMES CASTANEÆ. Flavous, thorax, pectus, and eyes black; wings translucent, inner half of the stigma scarcely discolored; 1st and 3d transverse nervure normal; 2d arising from the middle of the 1st and terminating in the normal position; posterior wings without nervures: feet and antennæ pale fuscous. The wingless individuals are entirely flavous, with the eyes rufous. Inhabits both sides of the leaf of the chestnut, forming lines along the midrib, and causing the leaf to curl. Pennsylvania in August and September.

ALEURODES ABUTILONEA. White, body pale flavous, with a tinge of greenish: wings each with a single nervure, the superior ones with two irregular obscure bands across them, and a circular apical spot: eyes black, double upon each side, inferior ones large and prominent: thorax above, with large irregular fuscous spots; abdomen with 3 or 4 transverse lines of the same color: rostrum as long as the head, 2-articulate, apex black: antennæ with the basal articulation robust: feet with short hairs, slender, dimerous. ½ lin. long.

Larva oval, plane above and beneath, elevation about one third the length, periphery vertical; pale flavous, the larger individuals with a conspicuous dark dorsal vitta.

Found upon the lower surface of the leaves of Sida (Abutilon) abutilon, to which the larva is immovably attached. It is sometimes so abundant that there are from 50 to 100 in half an inch square, causing the leaf to curl and die. The perfect insect is very active, walking and flying readily, and leaping from 1 to 1½ inches. It seems nearest allied to A. bifasciatus, *Steph.* When the imago first appears the wings are more translucent and the dark fasciæ are entirely wanting, so that it might be taken for a distinct species.

Burmeister's figure of A. proletella, *Lin.*, exhibits 2 nervures, probably because the wings were in contact when drawn, which, on account of their translucency, would allow the nervures of both to be seen at the same time. Found in Pennsylvania from August to the middle of October.

A. CORNI. Size and general appearance of A. abutilonea: body pale flavous: eyes black; wings pure white, without bands. Pennsylvania in September and October; the larva and imago on the inferior surface of the leaves of Cornus sericea.

Larva flavous, the disc of the larger individuals dark brown: the margin is ciliate with white. A great many are destroyed in the larva state by Amitus corni, *Hald.*, a minute parasitic hymenopterous insect.

AMITUS, (a new genus.) Minute, robust, head transverse, eyes with distinct facets; palpi 0. Antennæ shorter than the body, filiform, geniculate; in the ♂ densely verticillate from the 3d articulation, 10-articulate, scapus somewhat curved, thickened towards its apex, nearly as long as the 3 following; 2d short and thick, *subfusiform*, its apex truncate; 3d as long as the 2d but thinner, and obconic; 4th nearly as long as the 2d and 3d united, robust towards its apex: 5–9 cylindrical and subequal, but becoming shorter towards the apex: apical artic. elongate conical with its apex acute: in the ♀ 8-articulate, shorter than in the male, with the fusiform apical articulation longer, exceeding the 2 preceding ones; the 2d artic. is *robust*, and longer than in the ♂. Thorax robust and elevated, mesonotum with an entire transverse impression. Wings covered with scattered hairs; about as long as the entire body, the greatest width of the anterior ones equalling one-third their length; widely ciliate from the apex to their middle on the posterior side: entirely *without nervures;* anterior ones with the radial margin obtusely concave; posterior ones nearly as long as the anterior ones, and ⅓d of their width, middle of their anterior margin slightly advanced and provided with 2 hooks for attachment to the anterior pair. Abdomen sessile, movable, depressed, convex above and below, subcordate, fully as wide as the thorax, but longer, basal segment composing ⅔ of the whole, besides which there are 4 small segments (♀): ovipositor not exserted. Feet (♂ ♀) slender elongate, pentamerous, posterior femora incrassated, anterior tibiæ with an inferior apical bifid spine curved beneath the basal artic. of the tarsus, which is concave beneath, and armed with a dense pectiniform series of bristles as in *Cinetus.*

The chief sexual distinction is that (in addition to the scapus) in the ♂ the 2d and 4th articulations of the antennæ are incrassated, and in the ♀ only the 2d, which is moreover one of the longest in the ♀ and one of the shortest in the ♂. Their clothing is also distinct, being long, rigid, and curved forward in the ♂, and short and straight in the ♀. The antennæ have no pedicellus, although, from their translucency at the joints, the round base of the 2d articulation moving in the first, bears some resemblance to one.

The *want of palpi* and the *ciliate wings* would place this genus in Mr. Westwood's subfamily Mymarides, the wings however, are not narrowed, and there is no vestige of a nervure, so that I prefer considering it as a distinct type under the name Amitides. The name, from α, μιτος (*a thread*,) is in allusion to the absence of nervures.

A. ALEURODINUS. Polished back, clothed with minute white hairs; a transverse impression above the mouth; antennæ rufous, apex brownish; anterior feet and all the trochanters and tarsi, pale rufous; posterior tarsi, the final joint of the others, and the base of the anterior femora, discolored. ¾ millim. long, or 1¼ to the end of the wings in repose.

Parasitic in the larva of Aleurodes corni, *Hald.*, of which it destroys a great many. I found it with that insect beneath the leaves of Cornus sericea, on the margin of a water course. It leaps, walks and flies with facility, and when touched, simulates death. The antennæ are kept in a constant state of vibration. I have kept them a week or more, living in confinement. The ova (crushed from the ovaries) are fusiform, rounded at one extremity and produced at the other like the neck of a flask.

Two mutilated specimens of another species of parasite were raised with the preceding and imperfectly examined. The color is pale flavous; the wings have a subcostal nerve not quite straight, ending in a short stigmal branch about the middle, the wings in all other respects as in *Amitus;* feet slender and apparently pentamerous; *eyes* black, covered with numerous short *erect bristles*, more distinct than in *Chelonus:* head, thorax and abdomen closely united, thorax large, abdomen with the sides parallel and the apex obtusely rounded, in one specimen (♂ ?) the abdomen seems but half the width of the thorax, and in the other its sides form straight lines with it; *antennæ* (see annexed figure) 5-articulate, shorter than the body, scapus narrowed towards its apex, 2d articulation obconic, 3d and 4th very short, 5th oar-shaped, (whence the generic name,) longer than all the preceding united, widened towards the apex, which is obtusely rounded. It may possibly be parasitic in the larva of the *Amitus* described above, as it is somewhat less in size. I propose to name the genus Eretmocerus, and the species E. corni.

Columbia, Pa., Dec., 1849.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the comparative Cost of making various Voltaic Arrangements;* by Mr. W. S. Ward, (Proc. Brit. Assoc., 1849, in Athen., No. 1142.)—The author stated that a series of calculations founded on data, produced to the Chemical Section at Swansea, showed the efficient power of three generally used forms of battery known as Smee's, Daniell's, and Grove's, would be equal when 100 pairs of Smee's, 55 pairs of Daniell's or 34 pairs of Grove's were used, and that the expense of working such batteries as regards a standard of 60 grains of zinc in each cell per hour, would be about 6*d.*, 7½*d.* and 8*d.* respectively.

This communication led to conversations on the economy of the electric light and electro-magnetic engines, in which Dr. Faraday, Mr. Shaw, Mr. Hunt, Mr. Elkington and other gentlemen joined. Dr. Faraday remarked on the imperfect character of the electric light, and its inapplicability for the purposes of general illumination; all objects appearing dark when the eye was embarrassed by the intensity of the electric arc.—Mr. Shaw and Dr. Percy instanced the magneto-electric machines which are employed at Birmingham for electro-plating, in which the current cost of the motive power—viz., a steam-engine to put the magneto-electric machine in action, was the only working cost.—Mr. Elkington stated that they had never been induced to abandon the voltaic battery which they employed in their manufactory, finding it more economical than the magneto-electrical machine of which he was the patentee. He also stated the remarkable fact that a few drops of the sulphuret of carbon added to the cyanid of silver in the decomposing cell, had the property of precipitating the silver perfectly bright, instead of being granulated so dead as it is when thrown down from the solutions ordinarily employed.

2. *Researches on Wax;* by Benjamin Collins Brodie, (Phil. Mag. for Oct., 1849, p. 244.)—In this Journal for May, 1849, we have given an abstract of the first and second memoirs of the author upon this subject; the present is a continuation of the same investigation, and we can bestow upon it no higher praise, than to say that it is throughout characterized by the ability and conscientious accuracy which commended the previous memoirs to the confidence of chemists. In these

it will be remembered he has described *cerine*, the part of ordinary wax soluble in boiling alcohol; which consists essentially of cerotic acid in a free state. The chinese wax was found to be a compound ether, analogous to spermaceti, which by fusion with potash is resolved into a cerotate and *cerotol*, the latter the alcohol of this series (C_{27}).

The portion of ordinary wax which remains after repeated treatment with boiling alcohol, is generally designated as *myricine;* it is greenish, uncrystalline, and melts at 64° C. Dilute potash has no action upon it, but it is saponified by boiling with a concentrated solution, or fusion with hydrate of potash. The result is a mixture of potash salts with neutral bodies analogous to cerotol; but the separation of these is very difficult and tedious; by decomposing the soap by an acid, and treating the mixture with alcohol, the greater solubility of the acids effects a partial separation. The neutral waxy matter thus obtained, yields by repeated crystallizations from ether, or better from coal naphtha, a highly crystalline body of a satiny lustre and a fixed melting point of 85° C. This substance which constitutes the greater portion of the myricine is a new alcohol which yields by analysis the formula $C_{60} H_{62} O_2$ ($C_{30} H_{62} O$); to this the author gives the name of *melissine*, but for reasons given in speaking of the alcohol of cerotic acid, *melissol* would be preferable. By fusion with potash lime it yields *melissic* acid $C_{60} H_{60} O_4$ ($C_{30} H_{60} O_2$), which resembles the preceding wax acid but fuses at 88°—89° C. The action of chlorine upon melissol, a chlorinized aldehyde, *chlor-melal* (*melissal*)*;* its action with sulphuric acid is also precisely similar to cerotol, a coupled acid being formed. By heat, part distils unchanged, and part is converted into water and a hydrocarbon.

The principal acid resulting from the saponification of myricine, is one which when purified from accompanying acids still more fusible, has a fixed melting point of 62° C. This was found by its analysis and by that of its silver salt, to be the *palmitic* or *ethalic* acid $C_{32} H_{32} O_4$, ($C_{16} H_{32} O_2$).

The distillation of myricine gives a mixture of acids and hydro-carbons; the first part of the distillate consisting almost entirely of acids and the final portions of the hydrocarbons; an odor of butyric acid is observed during the process. The whole product was saponified, and the acids resulting, when purified by repeated crystallization, gave pure palmitic acid.

Among the hydrocarbons is one which from the examination of Ettling, was supposed to be identical with the *paraffine* of Reichenbach and isomeric with olefiant gas. Mr. Brodie's analyses confirm those of Ettling, but the fusing point of the hydro-carbon from wax, when purified by pressing in blotting paper, repeated crystallization from ether, distillation from potassium, and re-crystallization from ether, is raised to 62° C., while the paraffine of Reichenbach melts at 43°·5 C. The analyses of this substance show that it is one of the hydro-carbons represented by $(C_2 H_2)n$, (R in M. Gerhardt's notation,) and as the difference between its fusing point and that of melissol is the same as exists between cerotene and its corresponding alcohol, the author regards this as the hydrocarbon $C_{60} H_{60}$ ($C_{30} H_{60}$) and designates it as *melene* (better *melissene*).

By careful crystallization from ether or a mixture of ether and naphtha, a highly crystalline substance may be obtained from crude myricine, (fusing at 64° C.), which has a melting point of 72° C. The numbers obtained by its combustion correspond very closely with the formula $C_{92}\,H_{92}\,O_4$, which is that of the palmitic ether of melissol; this compound is regarded by the author as the origin of the alcohol and acid obtained by the saponification of myricine.

The other products of the saponification are neutral bodies of lower fusing points than melissol, which by the action of potash and lime yield acids apparently belonging to the type $\mathbf{C}n\,\mathbf{H}\,(C\,H)n\,O_2$, but they have not yet been obtained sufficiently pure to be well characterized. Associated with the palmitic acid is another acid, soft, very soluble and of a low melting point; but its separation from the palmitic acid is very difficult. A specimen of beeswax from Ceylon, fusing at 65°·5 C., was found to contain not cerotic acid, but to possess all the characters of the crude myricine from ordinary wax, yielding by saponification melissol and palmitic acid. T. S. HUNT.

3. *On the Phosphoric Ethers;* by F. VÖGELI.—(Compt. Rend. des Trav. de Chemie, March, 1849, p. 85, from Pogg. Anal., t. lxxv, p. 282.) When phosphoric anhydrid is exposed to the vapor of ether, it absorbs it and becomes liquid; this liquid diluted with water and saturated with carbonate of lead, yields a precipitate of phosphate of lead with the sparingly soluble phosphovinate $P\,O_5, C_4\,H_5\,O, 2Pb\,O$; the solution evaporated at a low temperature, yields first laminæ of the latter salt, and finally groups of needles of a new compound, which the author calls biethereophosphate of lead, $PO_5, 2C_4\,H_5\,O, Pb\,O$. This salt fuses at 356°, and at a higher temperature is decomposed into phosphate and phosphovinate of lead, with the evolution of white vapors which condense into a neutral colorless liquid, miscible with ether, alcohol, and even with water. This M. Vögeli regards as the phosphoric ether $PO_5, 3C_4\,H_5\,O$. Phosphoric anhydrid with absolute alcohol likewise furnishes the two acids; and ether dissolves in syrupy phosphoric acid, but produces only the ordinary phosphovinate.

[These new vinids illustrate beautifully M. Gerhardt's views of the functions of polybasic acids, and his law of basicity.* The phosphoric acid, which is tribasic, has hitherto been known to yield but one compound with alcohol, the phosphovinic acid, which being the product of its reaction with but one equivalent of alcohol, is necessarily bibasic. The new acid containing the elements of two equivalents, is monobasic, while the third compound with three equivalents of the vinic elements is in accordance with the same law, neutral. In relation to phosphoric acid $PH_3\,O_4$ ($P_2\,O_5$, 3HO in the Berzelian notation), these are derived from its reaction with respectively one, two, and three atoms of alcohol, $C_2\,H_6\,O$, and the elimination of a corresponding number of atoms of water. The first acid being already known as the *phosphovinic*, the new acid may be appropriately called the *phosphodivinic*, and the neutral ether, *phosphotrivinid* or *phosphovinid*. Their formulas in the nomenclature of M. Gerhardt will be

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* Précis de Chim. Org., tom. 1er, p. 102. Also this Journal, Sept., 1847, p. 177, and July, 1849, p. 89, *et seq.*

Phosphate, ...	$P(H_3)O_4$
Phosphovinate, . . .	$P(H_2, C_2H_5O)O_4$
Phosphodivinate, . . .	$P(H, 2C_2H_5O)O_4$
Phosphotrivinid, . . .	$P(3C_2H_5O)O_4$.]

T. S. H.

4. *On the Estimation of Nitrous acid;* by H. SCHWARZ.—(Liebig's Annalen, April, 1849.)—This process is founded on the decomposition of urea by nitrous acid into carbonic acid and nitrogen, noticed by M. Millon, and employed by him in the estimation of urea. (See this Jour., vol. vi, p. 256.)

The well known twin flask apparatus of Will and Fresenius is used; in one flask sulphuric acid is employed as usual—in the other a solution of urea and the nitrite to be analyzed. The apparatus is weighed, sulphuric acid is drawn over, and when the reaction is finished, a sufficient quantity of air is passed through the flasks, and a second weighing gives the loss of CO_2 and N. A loss of 1·00 answers to ·76 of nitrous acid. G. C. SCHÆFFER.

5. *New mode of preparing Nitrogen;* by B. CORENWINDER.—(Ann. de Chim. et de Phys., July, 1849.)—No former process for obtaining pure nitrogen is both easy and expeditious. The author employs the remarkable decomposition of nitrite of ammonia by heat, into nitrogen and water—but instead of the salt formally prepared, he makes use of solution of nitrite of potash and hydrochlorate of ammonia. Through a solution of caustic potash, sp. gr. 1·38, is passed nitrous gas (obtained from the reaction of starch 1 pt. and nitric acid 10 pts.) until the product is acid, the solution is then made alkaline by caustic potash, and may be preserved in this state without change. To prepare nitrogen, add to 1 vol. of this solution 3 vols. of very strong solution of hydrochlorate of ammonia, and heat moderately in a small flask—the gas is disengaged very soon, and the decomposition goes on very regularly. To remove the small quantity of ammonia set free by the slight excess of caustic potash, the gas must be passed through water acidulated with sulphuric acid. The nitrogen thus obtained is said to be perfectly pure.

[An economical substitute for the solution of the nitrite prepared as described above, would be found in the nitrite of potash obtained by cautiously heating nitre—in this case there would be sufficient excess of alkali to ensure the stability of the salt in solution.] G. C. S.

6. *New Process for detecting Iodine and Bromine;* by M. A. REYNOSO.—(Comptes Rendus, April, 1849.)—To avoid the well known difficulties in the use of chlorine, it is proposed to employ peroxyd of hydrogen to set free the iodine or bromine. A fragment of binoxyd of barium is put into a test tube, and water, hydrochloric acid and starch paste are added—when we wish to test for iodine, as soon as bubbles arise, the liquid to be tested is poured in. In testing for bromine, ether must be substituted for starch paste.

When sulphurets, sulphites, or hyposulphites are present, on account of the absorption of oxygen to form sulphates, &c., more than the usual quantity of peroxyd of hydrogen is required. The sulphate of baryta formed, retards the action unless the mixture is agitated, and in fact it is better in all cases to do so to hasten the evolution of the peroxyd of hydrogen. This process is said to indicate the presence of less than 1 part of iodide of potassium in 100,000 of water. G. C. S.

7. *On the amount of Ammonia contained in the Atmosphere;* by M. Fresenius.—The quantitative determination of the ammonia in the atmosphere, by M. Gräger, gave 0·323 grms. ammonia or 0·938 carb. amm. in 1,000,000 grm. of air. In this determination, the quantity of ammonia already existing in the chlorid of platinum, (used to precipitate the ammonia collected from the air,) was not determined. In an experiment made by Dr. Kemp, 3·68 grms. of ammonia, or 10·37 carbonate of ammonia were obtained. In this case the ammonia was absorbed by a solution of corrosive sublimate, and the quantity estimated from the white precipitate formed.

The very great discrepancies in these experiments, led M. Fresenius to renew the investigations. Two gasometers of 10,000 cub. centimetres (610 cub. in. or about 11 qts.) each, were arranged so as to fill one in the day, the other at night. To each of these there was attached a collecting apparatus of two small flasks connected together and containing dilute hydrochloric acid (1 pt. acid sp. gr. 1·12, and 20 pts. water). For forty days the air was passed through the apparatus. The quantity passed by day was 345,250 cub. cent., (about 12·2 cub. ft.) by night 344,250 cub. cent. (about 12·1 cub. ft.)

The usual precautions in estimating ammonia by chlorid of platinum were observed. The ammonia already existing in the chlorid of platinum was estimated, making use of the same quantity as that employed in the two experiments. The ash of the filters was also very carefully determined.

The air which passed during the day and night gave respectively ·0027 and ·0029 of platinum and ash, from which ·00064 and ·00067 were to be deducted for the ash, and ·00182 for platinum, from determination of ammonia previously existing in the chlorid. The remainders were ·00024 and ·00041 platinum. From this it would result that 1,000,000 grms. of air contain during the day ·098 grm. of ammonia, or ·283 carb. amm.—during the night ·169 ammonia, or ·474 carb. amm.

The author presents these results as an approximation, the quantity of ammonia obtained being too small for accurate results, as any error in weighing or determining the ash, would produce an enormous difference in the results. G. C. S.

8. *On the varieties of Chloroform;* by MM. Soubeiran and Mialhé.—(Journ. de Pharm., July, 1849.)—Chloroform is obtained, as is known, both from common and methylic alcohol (pyroxylic spirits)—the products although generally considered as identical in composition, have such different properties as to render an investigation very desirable.

The methylic chloroform differs from the alcoholic in having an empyreumatic and nauseous odor, a lower specific gravity and a lower boiling point, while its effects upon the system are disagreeable, producing sickness and heaviness in the head. The properties are communicated by a substance which could be separated by repeated rectification over chlorid of calcium, the salt retaining it. By washing with water, an oil was separated, lighter than water, with a boiling point rising from 185° to 271°, and possessing a peculiar and very strong empyreumatic odor. Chlorine is a constituent. Sulphuric acid was found to be the most suitable substance for destroying this impurity of the chloroform, which was then found to be in every respect identical with that obtained from common alcohol.

This impurity amounted in some commercial chloroforms to 6 per cent. Chloroform from common alcohol, furnished a very small quantity of an oil containing chlorine, but differing from that before described.

The authors consider these oils as chlorinated compounds intermediate between chloroform and one of the chlorids of carbon. They also advise that the preparation from methylic alcohol should not be used for inhalation, even that from common alcohol needing a redistillation, as the residue obtained will be found to produce in a remarkable degree headache and giddiness.

The authors have also noticed the curious fact that, when chloroform is poured upon a double filter, part runs through and part is congealed by rapid evaporation, into silky scales. G. C. S.

9. *On the Composition of Shea Butter and Chinese Vegetable Tallow;* by Dr. R. T. THOMSON, and Mr. E. T. WOOD, (Phil. Mag., May, 1849.)—The Shea butter first noticed by Mungo Park, appears to be very abundant in the regions along the Gambia and Niger, and constitutes one of the principal articles of commerce among the African natives. It is apparently identical with the Galam butter, and is obtained from a species of Bassia. The fruit of this tree is about the size of a pigeon's egg—with a shell about as thin, and "the kernel when new is nearly all butter."

The fat as obtained by crushing the nut and boiling with water, is white with a shade of green—solid at common temperatures, like soft butter at 25°, and a clear liquid oil at 110°.

When saponified, this oil yields a fat acid, which when purified from a small quantity of oleic acid, fuses at 142°, and on analysis proves to be margaric acid.

Chinese vegetable tallow has been long known as derived from the fruit of the Stillingia sebifera, it is hard and white, with a shade of green. It fuses at about 80°. Saponified it yields an acid which softens at 143°, but only becomes quite fluid at 154°. The authors suppose it to be principally margaric acid with a mixture of stearic.

From the apparently unlimited supply, it is suggested that both of these oils might be advantageously employed in soap making. G. C. S.

10. *On the occurrence of Butyric Acid in the Fruits of the Soap tree;* by Dr. VON GORUP BESANEZ, (Journ. für Prakt. Chem. in Chem. Gaz.)—The seeds of the Sapindus saponaria, when pounded and softened in water, are used for washing linen. The peculiar odor led to an examination. On distilling with water combining the distillate with soda, and again distilling with sulphuric acid, a quantity of pure butyric acid was obtained.

The fruit of the tamarind by the same treatment furnished formic and acetic acids, the odor of butyric acid was at the same time developed. As formic acid was also obtained from the fruit of the soap tree, and as tartaric acid exists in both fruits, the author is disposed to think that the butyric, acetic, and formic acids are derived from the oxydation of tartaric acids. With this opinion, as far as butyric acid is concerned, few chemists will agree. G. C. S.

11. *On the preparation of Hyposulphite of Soda;* by M. FAGET, (Journ. de Pharm., May, 1849.)—The salt of commerce contains more or less of sulphate; if prepared from *bisulphite* of soda and sulphur, the product contains a large quantity of sulphate and but little hyposulphate. The neutral sulphite should therefore be used. It is best prepared by the following process.

A solution of carbonate of soda is divided into two equal portions, one of them is saturated with sulphurous acid to form the bisulphite, which is then rendered neutral by the second portion. There is present however, an excess of sulphuric acid, owing to the solvent action of the water. This is to be expelled by boiling before adding the sulphur, which may be added afterwards and the solution boiled without risk.

G. C. S.

12. *On the amount of Lime in Lime Water;* by M. WITTSTEIN, (Buchner's Report in Chem. Gaz.)—Of cold water, 732 parts dissolve 1 part of anhydrous lime. The solution in boiling water gave uncertain results—1311, 1495 and 1579 parts of boiling water dissolving 1 of lime.

13. *On the preparation of Succinic acid from Malate of lime;* by LIEBIG, (Liebig's Ann., April, 1849.)—Piria has shown that impure asparagine in solution ferments and furnishes succinate of ammonia. (See this Journal, vol. vi, p. 421.) Now asparagine is simply the amid of malic acid (malamid). M. Dessaignes with a view to confirm the relation between malic acid and asparagine, devised the following experiment. Neutral malate of lime was exposed under water for about 3 minutes—at the end of which time besides carbonate of lime, mucilaginous matter, &c., there was obtained a crop of crystals which afforded succinic acid. Liebig has fouud that a fermentation got up with yeast or putrefying cheese, produces the same result in a far shorter time. The following proportions are recommended,—3 pounds crude malate of lime are mixed with 10 lbs. water at 104° and 4 oz. putrid cheese previously rubbed up with water. At 86° to 104° the fermentation is over in five or six days. The heavy granular crystalline deposit formed, is a double salt of succinate and carbonate of lime. This is to be well washed with cold water, and dilute sulphuric acid added until effervescence ceases: an equal amount of dilute sulphuric acid is again added and the whole boiled until the granular form of the deposit disappears. A linen bag is used to separate the gypsum which is washed, and the liquid in them concentrated until a pellicle appears. Concentrated sulphuric acid is then added to decompose some bisuccinate of lime remaining in the succinic acid. Water is next added and the succinic washed out and purified as usual. 3 lbs. of malate of lime furnished 15 to 16 oz. of dazzling white acid.

[In the United States, the cheapest source of malic acid is the common sumach, the salt contained in the heads of this plant is the *acid* malate of lime, which should be neutralized for the preceding process.

It is rather singular that M. Liebig should lay the whole obligation of science for this discovery to the account of M. Dessaignes, while his experiments were undertaken with direct relation to those of Piria which are much older, as shown by the above reference to the pages of this Journal.] G. C. S.

14. *Chemical Analysis of a Calculus from the bladder of a Whale;* by WILLIAM KELLER, M. D., (Proc. Acad. Nat. Sci., Philad., July, 1849, p. 185.)—Whalers report that it is not unusual to find a number of calculi in the bladder of the whale. These calculi are about the size of a hen's egg, on the surface very smooth, and of a white color. On breaking them they are seen to be formed of concentric layers, from the thickness of a sheet of paper to that of a quarter of an inch; the chemical composition throughout being very nearly the same. Mr. Saul Muller and myself took for analysis different layers, and found them of the same composition. The chief constituent of the calculus is the double phosphate of ammonia and magnesia. The quantity of ammonia could not be directly ascertained, passing off at the summer temperature. But it will be seen that the quantity of phosphate of magnesia found, will answer to the quantity of ammonia and water found necessary for the formation of the double phosphate.

The pulverized stone was first exposed to the heat of a water bath, to ascertain the quantity of water; heated with ether and alcohol to find the quantity of fat; then dissolved in nitric acid, the residuum incinerated, the loss was organic matter and uric acid, while the residuum was silicic acid. The quantity of magnesia was ascertained as ammoniaco-magnesian phosphate, the phosphoric acid as phosphate of iron. The carbonic acid, the quantity of which was very small, was found by the apparatus of Will and Fresenius. The rest of the component parts were in such small quantities that they could not be weighed; they were iron, lime, chlorine and soda. The ammonia and water were ascertained by calculation.

Found.		Calculated.	
P_2O_5	27·21	P_2O_5	27·21
Mg O	15·75	Mg G	15·75
Fat	0·39	NH_4	6·08
$\bar{U}$	2·66	HO	44·59
SiO_2	2·18	Fat	0·89
HO	32·17	$\bar{U}$	2·66
CO_2	0·05	SiO_2	2·18
	80·41	CO_2	0·05
			98·91

Traces of NaO, CaO, FeO, Cl.

15. *On the presence of Fluorine in the Waters of the Firth of Forth, the Firth of Clyde, and the German Ocean;* by G. WILSON, M.D., (Proc. Brit. Assoc., 1849, in Athen., No. 1142.)—In 1846, the author announced the discovery to the Royal Society of Edinburgh, of fluorine as a new element of sea water. He was led to search for it, after observing that fluorid of calcium possesses a certain small but marked solubility in water, which explains its occurrence in springs and rivers, and necessitates its occasional, if not constant presence in the sea. The only specimens of sea water he had examined before this summer, were taken from the Firth of Forth, at Joppa, about three miles from Edinburgh. He obtained the mother-liquor or bittern from the pans of a salt work there, and precipitated it by nitrate of baryta. The precipitate after being washed and dried was warmed with oil of vitriol in a lead basin, cover-

ed with waxed glass having designs on it. The latter were etched in two hours, as deeply as they could have been by fluor-spar treated in the same way, the lines being filled up with the white silica, separated from the glass. The author has recently examined in the same way bittern from the salt-works at Saltcoats, in the Firth of Clyde, but the indications of fluorine were much less distinct than in the waters on the East Coast. On procuring, however, from the same place, the hard crust which collects at the bottom and sides of the boilers used in the evaporation of sea-water, he found no difficulty in detecting fluorine in the deposit. This crust or deposit consists in greater part of sulphate of lime, and of carbonate of lime and of magnesia, but it contains also much chlorid of sodium, and the other soluble salts of sea-water, entangled in its substance. When sulphuric acid, accordingly, is poured on it, it gives off much hydrochloric and carbonic, as well as some hydrofluoric acid, and the latter is thus swept away before it has time to corrode the glass deeply. The author preferred, nevertheless, to use the crust exactly as he got it, that the proof of the presence of fluorine might not be impaired in validity by the possibility of that substance being introduced by the water or re-agents which must have been employed, had the chlorids and carbonates been separated from the crust by a preliminary process. The crust, accordingly, after being dried and powdered, was placed along with oil of vitriol in a lead basin covered by a waxed square of plate glass, with letters traced through the wax. A single charge of the crust and acid corroded the glass very slightly, but by replenishing the basin with successive quantities of these materials, whilst the same plate of engraved glass was used as the cover, he found no difficulty in etching the glass deeply. Operating in this way, he has found fluorine readily in the boiler deposit from the waters of the Firths of Forth and Clyde. It is a less easy matter to subject the waters of the open sea to the requisite concentration, before examination. It occurred to the author, however, that the incrustations which are periodically removed from the boilers of the ocean steamers would serve to determine the question whether fluorine is a general constituent of the sea. He made application, accordingly, at Glasgow and Leith for the deposits in question. It appears, however, that the deep-sea steamers which leave the former have their boilers cleaned out at other ports, so that he has as yet been unsuccessful in procuring crusts from the west coast of Scotland. He has obtained at Leith the crust from the boiler of a steamer called the Isabella Napier, which trades between that port and Wick, so that the greater part of the water consumed as steam by its engines is derived from the German Ocean, although a portion is necessarily obtained from the Firth of Forth. The crust from the boilers of this vessel was treated in the way described, and at once yielded hydrofluoric acid. A single charge, indeed, of the materials marked the glass distinctly, and four charges deeply. We may therefore infer that fluorine is present in the waters of the German Ocean, for different portions of the deposit yielded it readily, and marked glass as deeply as the deposit from the water of the Firth of Forth did, which could not have been the case if the whole crust had not contained fluorine pretty equally diffused through it. From what is known of the comparative uniformity in composition of sea-water, it may safely be inferred that if fluorine be present in the waters of the Firths of Forth and Clyde, and in the German Ocean, it will be found universally present in the sea. Mr. Middleton, before 1846, came to the conclusion that fluorine must be present in sea-water, since it occurred, as he had ascertained, in the shells of marine mollusca. Silliman, junior, without a knowledge of Middleton's views, drew the same inference from its invariable presence in the calcareous corals brought to America by the United States expedition from the Pacific Ocean. The author has found fluorine abundantly present in the teeth of the Walrus, which points to its existence in the Arctic Ocean ; and it seems so invariably to associate itself with phosphate of lime, that it may be expected to occur in the bones of all animals marine and terrestrial. The author has found fluorine likewise in kelp from the Shetlands, but much less distinctly than he anticipated. Glass plates were only corroded so far as to show marks when breathed upon. Prof. Voelker, also, was kind enough at the author's request to search for fluorine when analyzing the ashes of specimens of the sea pink (*Statice Armeria*), which had grown close to the sea shore, and contained iodine, and found fluorine in the plant. When all these facts are considered, it is not too much, the author thinks, to urge that fluorine should now take its place among the acknowledged constituents of sea-water. He has entered at length into the consideration of the natural distribution of this element, and into other details connected with it, in a paper in the ' Transactions of the Royal Society of Edinburgh, vol. xvi, part 7, and in a communication made to the Association at its Southampton meeting. The *Statice Armeria* may certainly be added to the list of plants containing fluorine, and so may the *Cochlearia Anglica*, in specimens of which obtained from the Bass Rock, and analyzed in Dr. Wilson's laboratory, Dr. Voelker has also detected this element.

Specimens of etched glass were shown to the Section in illustration of this communication.

Prof. Forchammer confirmed the results of Dr. Wilson. He had examined sea-water from near Copenhagen, and found fluorine in every instance. He had also examined many shells and marine products from various localities, and they all gave the same body—the quantity of which was always greater in sea than in land animals. Mr. Pearsall thought he had detected fluorine in many waters from springs and rivers.

16. *On the Artificial Production of certain Crystallized Minerals, particularly Oxyd of Tin, Oxyd of Titanium, and Quartz ;* by M. A. Daubrée, (Compt. Rend., 27th Aug., 1849, 227.)—In a memoir presented in 1841 to the Academy, the author showed that the fluorids appeared to have played an important part in the formation of stanniferous veins. This idea which was then supported only by observations on the structure and composition of deposits of tin, is now confirmed by experiment; for by imitating the process of nature as there explained, he has obtained crystallized oxyd of tin. Not having the apparatus suitable for the production of the stannic fluorid, he employed in its place the chlorid of that metal—the great analogy existing between the fluorids and chlorids permitting this extension of the results obtained on the last to the corresponding fluorids.

The method consists simply in bringing at the same time in a red hot porcelain tube two currents, one of chlorid of tin and one of vapor of water. The oxyd of tin which results from the decomposition of the two vapors, lines the mouth of the tube with mineral crystals. When the perchlorid of tin is introduced, dissolved in a current of dry carbonic acid, (in place of vaporizing the perchlorid by heat alone,) the crystals are obtained of a larger size. The crystals thus obtained are, generally, colorless with the adamantine lustre belonging to the natural mineral, and so hard as readily to scratch glass. Although very small they have the edges and angles perfectly sharp. From the modifications of the crystals, M. Daubrée regards the oxyd of tin as a new example of dimorphism, of which the new form of the artificial mineral is a right rhombic prism, while the natural mineral has the form of a square prism. The artificial crystals always have the two vertical truncating faces greatly extended, so as to present forms much resembling Brookite. The artificial tin crystals have the same longitudinal striæ, parallel to the vertical edges of the primary. The angle of the two truncating faces (133°) is the same as in brookite—(e^3 on $e^3 = 134°$ Levy): thus the artificial rhombic oxyd of tin is isomorphous with brookite.

The natural oxyd of tin has for a long time been recognized as isomorphous with rutile. It appears from these results that the two primary forms of oxyd of tin correspond exactly to the two forms of titanic acid. This isodimorphism furnishes a new and remarkable instance of the geometrical relation which unites the two primal forms of a dimorphous body. The density of the artificial oxyd of tin, which is 6·72, is inferior to that of the square prismatic variety. The density of brookite as compared with rutile, is the same. In two isodimorphous substances, it happens, therefore, that the molecular arrangement of the square prismatic form is more dense than that of the right-rhombic.

Because the artificial oxyd of tin has a form different from that of the native mineral, we are not at liberty to conclude that the two crystalline systems correspond to modes of production which are very different from each other; for in the Oisans and in Switzerland, the same veins and often the same specimens contain at least two of the species of titanic acid, anatase and brookite. The conditions are therefore very similar, which decide the change of molecular equilibrium, producing the two forms of titanic acid.

The vapor of perchlorid of titanium treated by the same methods to which the chlorid of tin was submitted, gave titanic acid in little bristling mammillary masses, the crystalline points perfectly sharp, but of microscopic dimensions. These little crystals have the form of brookite.

The chlorid and fluorid of silicon, treated in the same manner in a porcelain tube, gave unsatisfactory results, but repeating the trial in an earthen retort, and in a crucible protected in an outer crucible and heated to a white heat, he obtained in two experiments a deposit of silica of a vitreous fracture, the mammillary surface of which presented here and there very small crystalline faces, among which are visible triangular faces like those in quartz.

17. *On the origin of the Titaniferous veins of the Alps*, (ibid., 229.)—Many districts of the Alps are known by the beautiful crystals of rutile, anatase and of brookite, which they furnish. The minerals which compose these veins have encrusted previously existing fissures in the same manner as metalliferous veins, properly so called. The mode of occurrence of the titaniferous veins of Saint Gothard and of Oisans, recalls in most particulars, certain small stanniferous veins which the author has already shown elsewhere, to be posterior to the rock which contains them. These veins, however, are injected intimately into the encasing rock. The penetration of crystals of rutile into the interior of crystals of specular iron and of quartz, proves that these three minerals have been precipitated, if not simultaneously, at least under the same conditions. Now the specular iron of these veins recalls by its brilliancy and peculiar form the specular iron of volcanic regions, which as has been shown by Gay Lussac and Mitscherlich, has been produced from the decomposition of chlorid of iron by the vapor of water.

We seem authorized in assigning a similar origin to the specular iron of these titaniferous veins. This first assumption is strengthened if we remember that titanic acid which has been obtained only in an amorphous condition by methods heretofore known, disposes itself in crystals when its chlorid is treated at an elevated temperature by the vapor of water; so it is the same with silicic acid. Thus by a threefold reason are we led to conclude that the minerals of the Alpine titaniferous veins, owe their origin to the decomposition of their respective chlorids and fluorids by the vapor of water. It favors our view that while in the volcanic districts the chlorine has entirely disappeared from the deposits of specular iron; yet in the Alpine veins we still find many evidences of the presence of this agent. It is in fact deposited at the same time with the three species of titanic acid—the fluorids, fluor-spar which is frequent, the fluo-silicates (mica rich in fluorine), the fluo-phosphates (apatite), and lastly the borosilicates (axinite and tourmaline); these each are, so to speak, a complementary product of the fluo-silicates. The apatite of St. Gothard contains 0·002 of hydrochloric acid, showing that chlorine was not wanting during the formation of these veins. Moreover, the presence of crystallized hydrous silicates, as chlorite and various species of zeolites, serves to show that water also bore its part in the filling up of these titaniferous veins.

We arrive, therefore, by proofs of a different character, as well from a study of the deposits as from direct experiment, to the conclusion that rutile, anatase, brookite, specular iron, and at least in part the quartz, which fill up the narrow veins of St. Gothard and Oisans, have been formed from the decomposition of the fluorids of titanium, of silicium, and of iron, associated with fluorids of boron and of phosphorus, and probably also with chlorids of the same bodies. From these several combinations which are volatile and undecomposable by heat alone, (but which are instantly decomposed by the vapor of water,) and from the reactions which have operated upon the encasing rocks, have resulted the fixed substances which now fill the titaniferous veins.

The author then proceeds to amplify the subject by applying the foregoing facts and reasonings to other localities and combinations of minerals.

II. Mineralogy and Geology.

1. *Analysis of Schuylkill Water;* by M. H. Boyé, (Proc. Amer. Assoc., 1848, p. 123.)—The following analysis is published by M. Boyé, with full details of the process he adopted. We here cite his results.[*]

	Grains in 1 gallon.	In 100 residue.
Alkaline chlorids,	0·153	3·75
Alkaline sulphates,	0·560	13·74
Alkaline carbonates,	0·185	4·53
Carbonate of lime,	2·190	53·67
Carbonate of magnesia,	0·484	11·87
Alumina and oxyd of iron (phosphates ?)	0·077	1·88
Silica,	0·395	9·68
Organic matter,	0·036	0·88
Total residue,	4·080	100·00
By a separate experiment, total residue,	4·421	

The above numerical results reduced to 10,000 parts of water, and given, as obtained by analysis, without endeavoring to arrange the ingredients in the manner in which the analyst may consider them as combined in the water, will stand thus:—

	In 10,000 parts.
Sulphuric acid,	0·051775
Chlorohydric acid,	0·016275
Carbonic acid,	0·220195
Potassa and soda,	0·076723
Lime,	0·211350
Magnesia,	0·040095
Alumina and oxyd of iron (phosphates ?)	0·013200
Silica,	0·067710
Organic matter,	0·006170
	07·03493
Deduct water in chlorohydrates,	0·004022
Total residue in 10,000,	0·699471

The following exhibits a tabular view of the different amounts of solid, fixed, and insoluble residue obtained by Prof. Silliman and M. Boyé—

	Boyé.	Silliman.
	Grains in 1 gallon.	Grains in 1 gallon.
Solid residue,	4·080 4·421 } at 250° or over.	5·50 at 212°.
Fixed at a red heat, from the above.	3·794 calculated	4·26 3·69 by direct experiment.
Insoluble in water,	2·896 "	2·145

2. *On Acid and Alkaline Springs;* by Prof. W. B. Rogers, (Proc. Amer. Assoc., 1848, p. 94.)—In this communication after referring to

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[*] For Prof. B. Silliman's, Jr., examination of the same water, see this Journal, [2], ii, 218.

the principal classes of mineral springs, thermal and of ordinary temperature, and comprehended under the terms acidulous, saline, sulphuretted and chalybeate, Prof. R. entered into a particular account, geological and chemical, of two very distinct classes of springs of frequent occurrence in the Appalachian region, particularly in Virginia and Eastern Tennessee. The one is remarkable for containing a considerable amount of *free sulphuric acid*, along with sulphates of iron and alumina, the other is distinguished by containing a small quantity of *carbonate of soda*, along with carbonate of lime and magnesia, much silica and some carbonic acid and sulphuretted hydrogen.

These springs are of very common occurrence in the slates and shales known as the Marcellus, Hamilton, &c., in the New York series, and designated in the nomenclature of the Profs. Rogers, as the post-meridial, older and newer slates and shales respectively. In those parts of these formations, which abound greatly in decomposing bisulphuret of iron, and which are not interstratified with calcareous beds, the springs which occur belong to the former of the two classes. Such, for example, are the celebrated Alum springs and Brinkley's springs near the eastern base of the great Warm Spring mountain in Virginia. At these and similar localities, the crumbling slates are imbued with the products of the decomposed pyrites, and yield to the infiltering waters a portion of free acid, as well as sulphates of iron and alumina. But what is specially remarkable in the composition of these waters, is the fact, that the proportion of free sulphuric acid present, often very greatly exceeds that which the oxydation of the bisulphuret could furnish. This excess Prof. R. proposed to explain in the following way: While the bisulphuret is subject to oxydation, as above mentioned, a part of the sulphates thus formed, reacting with the organic matter, always present in these rocks, gives rise to sulphuretted hydrogen gas. This again, as recently shown by Dumas, in the presence of air and organic matter, gives birth to sulphuric acid—and thus the additional supply of this acid, formed at the expense of the sulphates, will be imparted to the percolating water.

Of the second, or alkaline springs, Prof. R. stated, that they were found in the same general slaty belt with the others, but always in connection with those parts which contain more or less *carbonate of lime.* Instances of these springs are seen in the Grey Sulphur and Dibbrell's springs, as well as many others in Virginia and Tennessee.

The absence of sulphuric acid in these waters, is an obvious consequence of the reaction between the carbonate of lime and the acid in passing into the mass. The same reaction giving rise to the evolution of a great amount of carbonic acid, would, as it were, saturate the pores of the slate with this substance, which, in virtue of its large excess, would have power to decompose the sulphuret of sodium, and perhaps other salts present, and thus give origin to the small amount of carbonate of soda, which imparts alkalinity to these waters. The great proportion of silica, in the solid residuum of these springs, may doubtless be ascribed to the solvent power of the alkaline carbonate.

3. *On Reptilian foot-marks in the gorge of the Sharp Mountain near Pottsville, Pa.;* by Isaac Lea, (Proc. Amer. Phil. Soc., 1849, p. 91.)—The object of this communication is to announce to the Society, that

I have discovered the foot-prints, in bas-relief, of a *reptilian quadruped*, lower in the series than has yet been observed. On the 5th of April last, in the examination of the strata in the gorge of the Sharp Mountain, near Pottsville, Pa., where the Schuylkill breaks through it, a large mass of remarkably fine old red sandstone attracted my attention. Imprinted upon it, I was surprised to find six distinct impressions of foot-marks, in a double row of tracks, each mark being duplicated by the hind foot falling into the impression of the fore foot, but a little more advanced. The strata here are tilted a little over the vertical, and the surface of rock exposed was about twelve feet by six, the whole of which surface was covered with ripple marks and the pits of rain drops, beautifully displayed in the very fine texture of the deep red sandstone.

The six *double impressions* distinctly show, in the two parallel rows formed by the left feet on the one side and the right feet on the other, that the animal had five toes on the fore feet, three of which toes were apparently armed with unguinal appendages. The length of the double impression is four and a quarter inches;* the breadth four inches; the distance apart in the length of the step of the animal thirteen inches; across, from outside to outside, eight inches. The mark of the dragging of the tail is distinct, and occasionally slightly obliterates a small part of the impressions of the foot-marks. The ripple marks are seven to eight inches apart, and very distinct, as well as the pits of the rain drops. These foot-marks assimilate remarkably to those of the recent *Alligator Mississippiensis*, and are certainly somewhat analogous to the *Cheirotherium*.

The geological position of this reptilian quadruped is of great interest, from the fact that no such animal remains have heretofore been discovered so low in the series. Those described by Dr. King, in the great western coal field, are only eight hundred feet below the surface of the coal formation. (No. 13, of Prof. Rogers, the State Geologist.)

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* The figure is rather more than half the natural size of the impression.

The position of the Pottsville "foot-marks" is about 8500 feet below the upper part of the coal formation there, which is 6750 feet thick, according to Prof. Rogers, and they are in the "*red shale*," (his No. 11,) the intermediate siliceous conglomerate (No. 12) being stated by him to be 1031 feet thick at Pottsville. These measurements would bring these foot-marks about seven hundred feet *below the upper surface of the old red sandstone.*

A mass of coal plants exists immediately on the northern face of the heavy conglomerate, here tilted ten degrees over the vertical, and forming the crest and "back-bone" of Sharp Mountain. This conglomerate mass is about one hundred and fifty feet thick at the western side of the road below Pottsville. On the same road side, about 1735 feet from these coal plants, is the face of the rock, tilted slightly over the vertical, and facing the north. It is proper to state, that the limestone of the old red sandstone exists here, about two feet thick, and underlies these "foot-marks" sixty-five feet. I was fortunate enough to obtain these impressions in a large and heavy slab, which is now in my possession.

On the slab there are obscure remains of other organized matter; small spots, with filamentous radiations, and a small bone or reed-like mark, which is difficult to make out.

4. *Gold on the farm of Samuel Elliot, Montgomery County, Md., thirty miles from Baltimore*, (Proc. Amer. Phil. Soc., 1849, p. 85.)—The locality has been known but a few months, and appears to be valuable. Three samples examined at the mint, yielded as follows:—

No. 1	yielded at the rate of	744	grains per cwt. of ore, or	$610 00	per ton.
No. 2	"	960	"	787 20	"
No. 3	"	206	"	168 80	"
Average,		636		522	

The quartz which forms the matrix of the gold, crops out amidst a decomposed talcose slate, so that quarrying is very easy. Ores of copper and iron are also present.

Messrs. Bowman & Ebbett, of New York, state that much gold appears to be disseminated throughout the gangue, in so minute a state of division, as to be invisible to the naked eye.

5. *Gold of California*, (from a letter to one of the editors from Rev. C. S. Lyman, dated, San Francisco, Oct. 29th, 1849.)—The gold the past season has turned out much better than was expected. Many rich deposits, in all parts of the mines, have been opened. On the middle fork of the Rio de los Americanos, two men recently dug $28,000 in two months. I saw a portion of it in lumps of the size of hens' eggs and larger. The Mariposa has yielded several similar prizes and so has the Mokelemnes. But for these few fortunate diggers, there are thousands who scarce earn a dollar a day. From the best information I can get, industrious workers have not averaged more than eight or ten dollars a day—some estimate it much lower; multitudes do not pay expenses, particularly clerks, professional men and others unaccustomed to hard work.

The gold has at last been discovered in place—in veins penetrating quartz beds—on the Mokelemnes and in the vicinity of the Mariposa and one or two other places. I have this from gentlemen who have seen the veins and who are reliable witnesses. These veins are of course not worked yet, as it is more profitable to dig the wash gold. One of these veins has been "denounced" (as it is termed) under the Mexican laws, by Mr. Fremont. The working of the innumerable rich veins, which undoubtedly will be opened in the mountains, will constitute an immense and profitable mining business for centuries. I have no fear that the gold, as many imagine, will all be dug out in a year or two.

III. BOTANY AND ZOOLOGY.

1. *Description of a Nut found in Eocene marl;* by EDMUND RUFFIN. (Communicated for this Journal.)—About two months ago, one of my laborers, employed in excavating marl, brought to me the shell of a nut, or large seed, which he had that day found imbedded in the marl, at the depth of about five feet below its upper surface. The marl is eocene—about forty per cent. of it being shelly matter, mostly disintegrated, with enough fine clay to render the mass impervious to water. As it lies low, and is covered naturally by oozing springs, the marl is barely moist, from absorption. Though the composition of the earth, and manifest manner of its original deposition, make it certain that at first the marl was very soft, yet the subsequent addition of materials, and the still later superimposed earth, had by weight so compressed the lower beds, as to make the marl very compact and close. The overlying earth (sand, gravel, and clay) there had been six feet thick. The calcareous marl is eight feet; and this lies on green-sand earth, of great depth, and containing very little shelly or calcareous matter.

As in my long experience in the excavation of marl, and much more extended examination of various marls and their fossils, I had never seen or heard of any such discovery as this, I was careful in scrutinizing the facts stated. The result of the scrutiny was my being perfectly satisfied with the truth of the statement. There could have been no possible object for the negro to attempt a deception. And even if there had been such a design, he could not have provided such means as he here produced, in an unknown if not a unique fossil specimen, in a remarkably good state of preservation. This is the principal and all-sufficient evidence of the good faith of the laborer. He could not possibly have been himself deceived. He had been for years accustomed to work in this marl, and to preserve for me all rare or curious specimens of fossils. At this time, this labor had been in progress for some weeks without intermission; and he had that day (with his assistants) dug several feet into the solid marl before reaching the level of the nut. It was seen partly exposed in a lump of marl just loosened by the hoe from its bed, and was immediately separated. The discoverer did not know the importance of it, and therefore did not preserve the cell or hollow impression of the nut in the lump of marl, which would have been conclusive evidence of the locality of the relic.

When brought to me, the nut had been washed very nearly clean of all the adhering marl. The distension by moisture was very great, (as was learned afterwards by the great shrinking,) and consequently the freshness of appearance, as shown in color, to the touch, and by flexibility, was so much the greater. The perfection of the preservation was indeed wonderful—and scarcely less than I should have expected of any like nut, as an acorn or horse-chestnut, similarly buried for but a few years.

The shell of the nut was almost perfect. The only exceptions were that by compression it was (apparently) flattened; and in being so compressed, a crack had been made and kept open at the upper (or germ) end. The shell while distended by moisture, in color, smoothness of surface, and in partial elasticity, appeared much like old leather, softened by being water-soaked. The color was dark brown, approaching to black. The mark of the stem-attachment, though small, was as distinct as if the nut had been new.

Expecting that the drying of the nut would cause it to crumble and to lose its form, (which however has not occurred,) I made the annexed rough and mechanical, but accurate drawings of the outlines, within thirty hours after the nut was found. Figures 1 and 2 respectively represent the upper and lower compressed sides; and 3, the lower end with the mark of stem-attachment (*a*) held uppermost. How great the distension then was may be seen by comparing the then size with fig. 4, which is the same view as fig. 1, but marked since the thorough drying and shrinking of the shell. The outlines were marked by tracing around the object with a pencil, and using every care to preserve the exact profile of size, as closely as possible. Since drying, the

1.

3.

2.

4.

cracks are more extended in length, but less open. The shell is about the twelfth of an inch thick; and now appears more like lignite than any more recent vegetable matter. Of course nothing of the kernel, or true seed, remained. In its place there are some particles of black vegetable matter intermixed with some powdery marl—all which do not near fill the present cavity.

Though my labors in excavating marl of different kinds during many years, and my much more extended personal examinations elsewhere, have given me opportunities rarely enjoyed by others for seeing and gathering fossil specimens from their localities, I make no claim to the character of a scientific investigator of this subject. Therefore, I do not known whether (as I infer it is) this nut is an extinct species—or whether the like has been found before.

This marl, bordering the Pamunkey river, has peculiar characteristics, and also has rare value as a manure. The fossil remains are generally much decayed. Among the kinds most common, are shells of *Ostræa sellæformis* and *Cardita planicosta*, either of which sufficiently identifies the marl with the eocene. Some other fossils are either new, or very rare, at least to my observation. Among the most rare is a fragment of a spine of an extinct *Echinus*, which is eight inches long, and more than three quarters of an inch in diameter, where thickest. By comparison of the size with the species of the largest specimens known to me of recent *Echini*, this extinct species must have had a very large body, beset with spines 3 feet long. I have also found smaller fragments of these species in the eocene marls of Coggin's Point, James river, Va., and of the Santee in South Carolina. The *flutings* of the surface of these spines are beautifully regular; so as to seem like delicate artificial carved work.

Lignite is often found in this eocene marl. I have two specimens of impure amber which were found in this kind of marl, though not in my own diggings. One of these was broken from a solid mass which was said by the person who found it to have been nearly a foot in diameter.

Marlbourne, Va., July 4, 1849.

2. *Synopsis Generum Crustaceorum Ordinis "Schizopoda"* J. D. DANA elaboratus, et Descriptiones specierum hujus ordinis quæ in Orbis Terrarum circumnavigatione, Carolo Wilkes e Classe Reipublicæ Fœderatæ Duce, auctore lectæ.—(Pars I.)

ORDO II. CRUSTACEA SCHIZOPODA.

Crustacea Macrourorum pullos affiliantia, branchiis sive externis pedes thoracis abdominisve pertinentibus, sive obsoletis; pedibus pluribus birameis palpo valde elongato; maxillipedibus pedes sequentes sæpe assimilantibus.

Tribus I. DIPLOÖPODA.

Pedes thoracis biramei, palpo natatorio, nulli prehensiles. Carapax cephalothoracem plerumque tegens, segmento cephalico non bene discreto.

Subtribus I. MYSIDACEA.

Corpus elongatum, subcylindricum. Basis pedum thoracicorum brevis.

1. *Pedes thoracis branchigeri.*

Fam. I. EUPHAUSIDÆ.—Antennæ primæ birameæ. [In speciebus scrutatis segmentum abdominis posticum barbâ nudâ ad extremitatem utrinque armatum.]

Genus 1. THYSANOPODA, (*M. Edwards*).—Oculi symmetrici, breves. Pedes thoracis quatuordecim, duobus posticis obsoletis branchiis exceptis. Flagella duo antennarum primarum elongata.

Genus 2. EUPHAUSIA, (*Dana*).—Oculi symmetrici, breves. Pedes thoracis non unguiculati, numero duodecim, quatuor posticis obsoletis branchiis exceptis. Flagella duo antennarum primarum elongata. Segmentum abdominis posticum acuminatum.

Genus 3. CYRTOPIA, (*Dana*).—Oculi paulo oblongi, apicem externum obliquè gibbosi, lenticulis totis in gibbositatem versis. Articulus antennarum primarum primus apicem *inferiorem* productus. Segmentum abdominis posticum obtusum aut truncatum.

2. *Pedes thoracis abdominisve non branchigeri.*

Fam. II. MYSIDÆ.—Antennæ primæ birameæ, secundæ laminâ basali instructæ. [Pedes thoracis postici nunquam obsoleti?]

1. *Pedum rami ambo thoracicorum extremitatem multiarticulati.*

Genus 1. MYSIS, (*Latreille*).—Pedes thoracis duodecim, maxillipedes numero sex. Antennæ primæ flagellis duobus confectæ. Pedes abdominis parvuli, debiles.

2. *Pedum ramus internus thoracicorum non multiarticulatus, bene unguiculatus. Oculi symmetrici.*

Genus 2. PROMYSIS, (*Dana*).—Pedes thoracis duodecim, maxillipedes sex. Antennæ primæ flagellis duobus laminâque oblongâ confectæ. Pedes abdominis oblongi, natatorii, longitudinem fere æqui. [Segmentum abdominis posticum emarginatum vel bilobatum.]

Genus 3. MYSIDIA, (*Dana*).—Pedes thoracis sexdecim, inter sese similes, toti bene palpigeri. Antennæ primæ flagellis duobus laminâque oblongâ confectæ. Pedes abdominis quarti valde elongati, (an discrimen sexualis tantum). [Segmentum abdominis posticum emarginatum vel bilobatum.]

SYN. Themisto, *Goodsir*. Hoc quoque vocabulum generis Amphipodum auctoritatem prius.

Genus 4. SIRIELLA, (*Dana*).—Pedes thoracis sexdecim, toti bene palpigeri, posticorum duodecim ramo pediformi apicem setis brevibus mobilibus (instar digitorum) juxta unguem instructo. Antennæ primæ flagellis duobus confectæ, laminâ carentes. Pedes abdominis toti rudimentarii. [Rostrum brevissimum. Segmentum abdominis posticum apicem rotundatum et spinulis ornatum.]

Genus 5. MYTO, (Kröyer, Tids. N. R. i. 470).—Pedes thoracis quatuordecim, primi secundi tertii quartique palpigeri, quinti sexti septimi simplices. Appendices caudales segmentoque caudali connati, ideoque cauda latè triangulata, margine postico longo. Flagella antennarum primarum non articulata.

3. *Oculi e latere pedicelli externo obliquè spectantes, lenticulis totis parce obliquè versis.*

Genus 6. LOXOPIS, (*Dana*).—Oculi elongati. Antennæ primæ flagellis duobus confectæ, laminâ carentes. Appendices abdominis rudimentarii. [Segmentum abdominis posticum truncatum, vel obtusum, extremitate spinuloso.]*

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* Podopsis, *Thompson*, (Zoological Researches, i, 59, tab. 59, fig. 1,) pullus (forsan mutilatus) incertæ sedis videtur. Oculi longissimi. Antennæ primæ fere obsoletæ; secundæ laminâ instructæ. Pedes duo longissimi, articulo tenui annulato confecti; reliqui breves. Pedes abdominis natatorii.

Sequentes *Furciliæ* et *Calyptopes* forsan pulli Decapodum aut quorundam Schizopodum; generibus jam enumeratis hoc discrepant: *Apex inferior articuli antenna-*

Fam. III. Sceletinidæ.—Antennæ primæ simplices, elongatæ; secundæ birameæ.

Genus 1. Rachitia, (*Dana*).—Carapax anticè acuto-tricuspidatus, post frontem non constrictus—Oculi longi obconici. Segmentum abdominis sextum valde elongatum, [segmentis in specie scrutatâ anticis simul sumtis non longioribus, utroque spinam longam dorsalem gerente.] Antennæ primæ flagello longo tenuissimo confectæ.

Genus 2. Sceletina, (*Dana*).—Carapax anticè acuto-tricuspidatus, paulo post frontem instar colli constrictus, deinde ovatus posticè augustans. Oculi prælongi, obconici. Pedes thoracis elongati duodecim, biramei, ramo pediformi 4–5 articulato, altero (palpo) parce setoso; alii pedes breves quatuor, anteriores. Pedes abdominis rudimentarii. [Segmentum abdominis posticum lineare, truncatum vel emarginatum.]

Hæc animalia Luciferibus paulo affines.

3. *Pedes abdominis appendicibus branchiiformibus instructi.*

Fam. IV. Cynthidæ.—Antennæ primæ birameæ, secundæ laminâ basali instructæ.

Genus Cynthia, (*Thompson*).—Pedes thoracis quatuordecim, biramei; maxillipedes quatuor. Oculi breves symmetrici.

Subtribus II. Amphionacea.*

Corpus depressum, carapace foliaceo. Basis pedum thoracicorum elongatus, palpo a corpore remoto.

Fam. I. Amphionidæ.—Corpus elongatum, abdomine longitudinem mediocri, thorace per carapacem tecto.

Genus Amphion, (*M. Edwards.*)

Fam. II. Phyllosomidæ. Corpus latus et breve, abdomine perbrevi aut rudimentario, thorace per carapacem plerumque non tecto.

Genus Phyllosoma, (*Leach.*)

Tribus II. APLOÖPODA.

Pedes thoracis nec biramei nec prehensiles. Corpus gracile, longum.

Fam. I. Luciferidæ.—Cephalothorax valde elongatus, segmento cephalico (oculos antennasque pertinente) longè attenuato. Oculi tenuiter valdeque elongati.

Genus Lucifer.—Antennæ primæ simplices, secundæ laminâ basali instructæ. Pedes thoracis quatuor postici (ct. xiii, xiv,) obsoleti; octo precedentes (ct. ix, x, xi, xii,) elongati, setigeri; deinde duo antici (ct. viii,) instar maxillipedum flexi. Maxillipedes duo (ct. vii); maxillæ quatuor (ct. v, vi); mandibulæ (ct. iv,) duæ non palpigeræ.

Tribus III. STOMATOPODA.

Os mandibulis duobus maxillisque duobus instructum, membris sequentibus pediformibus. Pedes antici (ct. vi) vergiformes, elongati; 8 sequentes chelati; 6 postici aliis remoti, sæpius bifidi.

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rum primarum primi longè acutèque productus. Animalia scrutata tota immatura, pedibus plus minus rudimentariis.

Gen. Furcilia, (*Dana*).—Carapax plus minus rostratus. Oculi aperti. Pedes abdominis bene natatorii. Antennæ primæ furcatæ ramis (immaturis?) subæquis 1–2 articulatæ; segmentum abdominis posticum truncatum, extremitatem sæpius spinulosum. Animalia in mari alto lecta.

Gen. Calyptopis, (*Dana*).—Carapax non rostratus, oculos omnino tegens. Antennæ primæ birameæ, ramis (immaturis?) subæquis 1–2 articulatæ. [Segmentum abdominis posticum truncatum, extremitate sæpius spinuloso.]

* Genus *Cuma* cum affinibus Schizopoda et Macroura affiliat. Forsan Ordo "Cumacea" hìc cadit, his dignotus:—Oculi minuti sub carapacem celati: Pedes partim biramei: Appendices caudales prælongi, styliformes et posticè furcati.—M. Edwards, Ann. des Sci. Nat., xiii, 292, Kröyer, Tidsk. iii, 503 and ib. N. R., ii, 123; Goodsir, James. J., xxxiv, 119.

Fam. I. SQUILLIDÆ.—Rostrum carapace per articulationem discretum.

Genus 1. SQUILLA.—Digitus manus maximæ intus spinoso-dentatus. Ramus pedum thoracis sex posticorum minor angustus.

Genus 2. GONODACTYLUS.—Digitus manus maximæ integer. Ramus pedum thoracis sex posticorum minor angustus.

Genus 3. CORONIS.—Ramus pedum thoracis sex posticorum minor lamellatus.

Fam II. ERICHTHIDÆ.—Rostrum carapace non discretum. Branchiæ sæpius rudimentariæ, aut obsoletæ.

Genus 1. SQUILLERICHTHUS.—Erichtho affinis. Digitus manus maximæ intus dentatus.

Genus 2. ERICHTHUS.—Corpus latus. Pars cephalothoracis antica os precedens brevior. Carapax thoracem sæpius omnino tegens. Digitus manus maximæ intus non dentatus.

Genus 3. ALIMA.—Corpus angustus. Pars cephalothoracis antica os precedens longior. Carapax thoracem sæpius non omnino tegens. Digitus manus maximæ intus non dentatus.*

Tribus I. DIPLOÖPODA.—Subtribus 1. MYSIDACEA.

Familia 1. EUPHAUSIDÆ.

Genus *Euphausia.*

1. EUPHAUSIA PELLUCIDA.—Gracilis. Carapax brevissimè rostratus. Segmenta abdominis margines laterales integra, arcuata. Articulus antennarum primarum primus apicem non productus. Lamina antennarum 2ndarum basalis basi paululo longior. Pedes tenuissimi, articulo ultimo brevissimo, palpo fere triplo breviore quam pes. Segmentum caudale lamellis caudalibus paulo longius, barbis subapicalibus salientibus. Branchiæ posticæ subdigitatæ.—Long. 6'''. Incolorata.

Hab. in mari Pacifico, prope insulas "Kingsmills;" Lecta Ap. 1841.

2. EUPHAUSIA SPLENDENS.—Carapax brevissimè rostratus; segmenta abdominis quatuor margines laterales integra, subæquè obtusa. Articulus antennarum 1marum primus apicem productus. Lamina antennarum 2ndarum basalis basin non superans. Pedes tenuissimi, articulis tribus ultimis longitudine subæquis, setis longis breviter plumosis, palpo plus duplo breviore quam ramus alter. Segmentum caudale lamellis caudalibus longius, barbis subapicalibus salientibus. Branchiæ posticæ ramosæ.—Long. 6'''.—Paulo rubescens.

Hab. in mari Atlantico, lat. bor. 1°–2°, long. occ. 17°–18°. Lecta diebus 29, 30, Oct. 1838.

EUPHAUSIA GRACILIS.—Carapax brevissimè rostratus. Segmenta abdominis margines laterales subæquè rotundata. Articulus antennarum 1marum primus apicem parce productus et acutus. Lamina antennarum 2ndarum basalis basin multo superans. Pedes tenuissimi, articulis tribus ultimis longitudine subæquis, setis longiusculis, palpo parvulo, quadruplo breviore quam ramus alter. Segmentum caudale lamellis caudalibus non longius. Branchiæ posticæ ramosæ.—Long. 6'''. Parce rubescens.

Hab. in mari Pacifico, lat. aust. 15½°, long. occ. 148°; lecta die Sept. 1839.

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* Longitudo carapacis discrimen Erichthi et Alimæ non semper valet; longitudo partis cephalothoracis os precedentis melius.

Euphausia superba.—Carapax brevissimè acutè rostratus. Segmenta abdominis margines laterales arcuata, integra, sexto non longiore. Articulus antennarum 1marum primus apicem productus et obtusus. Lamina antennarum 2ndarum basalis basi vix brevior. Articulus pedum ultimus pertenuis, penultimo multo brevior. Branchiæ posticæ instar rotæ paulo involutæ, ramis subradiatis, arcuiformibus, ramulis seriatis setiformibus. Segmentum caudale laminâ caudali proximâ paululo brevius.—Long. 2′′. Rubra.

Hab. in mari Antarctica, prope long. orient. 150° et lat. aust. 60°.

3. *Eyes of Sapphirina, Corycæus, etc.;* by J. D. Dana.—In a brief description of these genera in the Proceedings of the Academy of Arts and Sciences of Boston, and in this Journal,* a peculiar kind of eye is mentioned, upon which an additional remark is here added. These eyes are simple, and of extremely large size for the animals. The lens is a prolate spheroid, situated internally within the thorax, far remote from the cornea; the cornea is a broad oblate lens, perfectly pellucid and colorless, and connected with the exterior shell. The diameter of each of the latter in many Corycæi is nearly half the breadth of the thorax, and the two stand in the front like a pair of spectacles, huge for the minute animals so provided. In the same animal the prolate lens may be situated as far back nearly, as the middle of the thorax, so that a long space intervenes between it and the cornea. The oblate form of the spectacle-like cornea, (we have called them in Latin, *conspicilla*,) is fitted to compensate for the too great convexity or prolate ellipticity of the lens, and it serves the same purpose as glasses for a near-sighted person.

The genus Sapphirina is closely related to Corycæus, and has the same peculiar eyes. The only mention of these conspicilla, which has been made by any previous author, is to be found in a memoir in F. J. F. Meyenii Obs. Zoolog. in Itin. circum Terram institutas accedunt Guil. Erichsonii et H. Burmeisteri Descript. et Icones Insectorum a Meyenio in ista Expeditione collectorum; from the 16th vol. Nova Acta Cæs. Leop. Car. Nat. Cur., page 156, pl. 27.—The species (probably a true Sapphirina) is called *Carcinium opalinum.* The conspicilla, by a mistake of observation (and it is not the only one in the description and much magnified figure), are spoken of as *dimples* (Grubchen). They are not noticed by Thompson who established the genus Sapphirina. Similar eyes occur in some of the Caligus group, and the writer has established one genus, *Specilligus*, on this ground, which otherwise is identical with Nogagus.

A cornea of lenticular form is by no means peculiar to these species of Crustacea; but they have hitherto been observed only in compound eyes, in which case the lens and cornea are minute and not far distant.

4. *Contributions to Conchology, Nos.* 1–4: *and Monograph of* Stoastoma, *a new genus of new operculated land shells*, by Prof. C. B. Adams, of Amherst College.—Although more than three centuries have elapsed since the West India Islands were first revealed to Europe, it may safely be said that few portions of the world can reward the search of the naturalist with so much that is novel and interesting. This is

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* See last volume, p. 280; also, Proceedings of the Acad. Nat. Sci., Philadelphia, 1845, ii, 285.

more particularly true as regards the department of mollusca, and especially the tribe of air-breathing or land mollusca.

A few only of the larger species of this tribe found their way at an early date into European cabinets, and were described and figured by the conchological writers of the last century. At a later period, through the intercourse between France and the islands dependent on her, French cabinets were enriched with many species from Hayti, Martinique and Gaudaloupe, which adorn the great monograph commenced by Baron Ferussac. The Rev. Lansdowne Guilding, an accomplished English naturalist, resident for many years upon the island of St. Vincents, brought to light the productions of that island; and since then, resident collectors at St. Thomas and at other islands have added something to our knowledge of the land conchology of their vicinities.

The monograph of the genera Helicina and Cyclostoma in Sowerby's Thesaurus Conchyliorum, contained many new West India species. Dr. Gould has described a few species from the island of Cuba, in these and other genera; and Dr. L. Pfeiffer, the author of the admirable Monographia Heliceorum Viventium, also collected many new species from the same island and has published them in Wiegmann's Archiv. A recent hasty visit to the same quarter by Dr. Newcomb, has acquainted us with interesting species from the Isle of Pines, and Mr. Gosse, an English gentleman who visited Jamaica to collect birds, brought home also many new shells which now enrich the Cumingian collection, and have been described by Dr. Pfeiffer.

But the only published work of any extent, which professes to give a detailed account of the conchological fauna of any part of the West Indies, is d'Orbigny's Mollusques de Cuba, forming part of Ramon de la Sagra's history of the Island of Cuba. This work is still incomplete. The first volume of the "Mollusques" was published in Paris in 1841, and is yet little known in this country.

Such are the sources of our knowledge of the West India land shells, aside from that supplied by Prof. Adams's labors in Jamaica. A visit to that island in the winter of 1843–4, enabled him to ascertain just enough of its zoological and especially its conchological riches, to excite a desire in lovers of science that this field might be more thoroughly explored. A hasty examination of but a small portion of the island on that occasion, enriched our catalogues with about 120 new species, of which about 70 were marine, and 50 were land-shells.

In the winter of 1848–9, Prof. Adams made a second visit to this island, and a brief review of the results is contained in the papers named at the head of this article. We see with surprise how rich a field has been lying neglected almost at our doors. The "Contributions to Conchology" contain descriptions of 137 supposed new species of land and fresh-water shells; and these added to those found in the first visit, make a total of 187 species contributed to science by Prof. Adams. The extent of this "contribution" will be appreciated, when it is observed that the whole number of land and fresh-water species yet known to inhabit the island is only 286.

The operculated species constitute a large share of this increase; of 101 species from Jamaica, 66 were discovered by Prof. Adams. Among them there is a new genus called *Stoastoma*, characterized by a semicircular aperture and projecting labrum, embracing as far as known, about a dozen species, all minute, and forming a connecting link between Cyclostoma and Helicina. Many of the new species of Cyclostoma are remarkable for their beauty, as for instance, C. Augustæ, C. proximum, C. 5-fasciatum, and C. ignilabre; and others for the novelty of their forms, such as C. monstrosum and C. tectilabre, in which last the operculum is much larger than the aperture, and is of course entirely external. The genus Trochatella furnishes some beautiful species, of which T. Tankervillei, *Sow.*, and T. Josephinæ, *Adams*, are worthy of note—the latter forming a connecting link between the typical species of the genus and that most elegant of land-shells, the T. pagoda Velasquez, from the Isle of Pines.

Of the 157 species of Jamaica Helicidæ, Prof. A. has contributed more than 100, many of them of unusual beauty, and of which we instance Cylindrella Agnesiana, Achatina elegans and the group it represents, Helix peracutissima, H. fluctuata, H. virginea, &c.

Professor Adams has also contributed much, bearing upon the important subject of geographical distribution. The most striking result presented, is that while the marine species of the West Indies are widely distributed, some few extending to Brazil, to our Southern States, and even to West Africa and the Mediterranean, and not more than ten or fifteen per cent. being peculiar to Jamaica,—the case is quite the reverse with the terrestrial shells, not more than six to nine per cent. of the Jamaica species being common probably to this and any other island. Dr. Gould has noticed similar facts in examining the terrestrial shells from the several islands and groups in the Pacific, and from the little we know of the fauna of the other West India islands, there is reason to believe that the law will hold good in regard to most of them. Of the few species which are common to the islands in general, many, there is reason to believe, have been distributed by human agency. Of the 230 species of Helicidæ on the contiguous islands of Jamaica and Cuba, only *nine* are said to be common to both, and a closer examination of the specific character of these, will probably show some of them to be really distinct. Nor can we suppose that future explorations will materially alter the per-centage of community of species, for since most of them are restricted to limited localities—such researches will increase the number of new and peculiar species, in at least as great a proportion as of those common to other islands. These facts show that the field open to the conchologist in the tropical archipelagos is far wider than was ever supposed. For if an examination of one tenth of the surface of Jamaica has led to such results, how will our future catalogues be swelled with the lists of species still undiscovered on that island and the other great islands of Cuba, Hayti, Porto Rico, besides the many of smaller extent. And if this law holds true of different islands of the same group, how much more in regard to groups which are widely separated? It renders almost certain, what at one time would have been thought impossible—that the existing species of terrestrial shells may far outnumber the marine species.

Some remarks upon the different proportion in which certain genera of land shells are distributed in the eastern and western hemispheres, may not be out of place here. Of the genus *Clausilia*, so abundant in the old world, and especially in the southeastern parts of Europe, and now embracing about 200 species, but one has been found upon this continent. One species only is known in the West Indies, and this is an aberrant form, quite different in aspect from those of Europe. But the place of this genus is well supplied in tropical America by *Cylindrella*, of which about 70 species are already known, more than 30 of them existing in Jamaica. On the other hand, the Philippine Islands furnish the only species of *Cylindrella* which is known to exist in the eastern hemisphere. The genera *Proserpina*, *Tomigerus*, *Gesmelania* and *Stoastoma*, are, as far as known, confined to the western hemisphere, while with only one or two exceptions, *Vitrina* has been found only on the eastern. *Achatinella* and *Pupina* are restricted to the islands of the Pacific, and *Tornatellina* as yet contains but one West India species.

The following table, although based on data necessarily imperfect in the present state of our knowledge, may have some interest in showing the proportion which the known terrestrial species of Jamaica, bear to those of the West Indies,—and also the proportion which the latter bear to the known terrestrial species of the globe.

	Total No. of known species.	No. of known West India species.	No. of known Jamaica species.	Proportion of W. I. species to the whole.	Proportion of Jamaica spec's to the whole.
Fam. CYCLOSTOMIDÆ.					
Truncatella,	15	4	3	27 per cent.	20 per cent.
Pupina,	10	0	0	0 "	0 "
Cyclostoma,	300	82	63	27 "	21 "
Stoastoma,	11	11	11	100 "	100 "
Helicina,	160	54	24	34 "	15 "
	496	151	101	37·6	20
Fam. HELICIDÆ.					
Daudebardia,	3	0	0	0 "	0 "
Vitrina,	60	0	0	0 "	0 "
Succinea,	75	14	4	19 "	5 "
Helix,	1,250	151	61	12 "	5 "
Anostoma,	3	0	0	0 "	0 "
Tomigerus,	2	0	0	0 "	0 "
Streptaxis,	26	0	0	0 "	0 "
Pruserpina,	6	4	2	67 "	33 "
Bulimus,	700	39	16	5½ "	2 "
Achatinella,	30	0	0	0 "	0 "
Achatina,	192	51	28	26 "	15 "
Gibbus,	2	0	0	0 "	0 "
Gesmelania,	4	4	4	100 "	100 "
Cylindrella,	69	57	35	83 "	51 "
Balea,	9	0	0	0 "	0 "
Tornatellina,	11	1	0	9 "	0 "
Clausilia,	225	1	0	½ "	0 "
Pupa,	175	23	9	13 "	5 "
	2,842	345	159	12 "	5½ "

The family of Auriculidæ has not been worked out with sufficient accuracy to institute a similar comparison, but the whole number of known species contained in it does not probably exceed 100.

The following table, which is made up from such data as are furnished in Pfeiffer's Monographia Heliceorum :

Cuba,	92	species.	Barbadoes,	7	species.
Jamaica,	145	"	Granada,		
Hayti,	10	"	Trinidad,		
Porto Rico,	16	"	Bahamas,	3	"
St. Thomas,	13	"	Bermuda,	4	"
Tortola,			General,	5	"
St. Croix,			Uncertain,	14	"
St. Vincents,	8	"		——	
Guadaloupe,	27	"		344	"
Martinique,					

The table is of use only to show how little we yet know of the other West India islands. In this estimate, which is confined to the Helicidæ, each species is referred to the island or group, supposed to be its proper habitat.

We are happy to say that Prof. Adams is engaged upon an extended monograph of the shells of Jamaica, in which his labors will be presented to the world in a more complete form, and it will no doubt be eagerly awaited by the lovers of natural science. J. H. R.

5. *Eryx maculatus, a new species from Madras ;* by Edward Hallowell, M.D., (Proc. Acad. Nat. Sci., Philad., July, 1849, p. 184.)—Head of moderate size, depressed, covered with scales, larger in front ; rostral plate large, triangular ; a single nasal plate on each side ; nostril small ; thirteen labial plates margin the upper jaw ; pupil vertical, eye surrounded by a circular series of plates ; iris brownish red ; neck of same size as head posteriorly ; body thicker in the middle, becoming somewhat slender towards the tail ; scales small, carinated ; a row of single plates under the tail, followed by others which are bifid ; tail short, truncate, (mutilated ?)

Color.—Light brown above, with numerous spots of the same tint but darker ; abdomen light slate color.

Observations.—This beautiful reptile was pointed out to me so long ago as 1840, by the late Dr. Harlan. It was brought from Madras, in the neighborhood of which it was found upon a sandy soil. It appeared to be perfectly harmless. The drawing was taken during life by Mr. Richard, and is remarkable for its accuracy. The above short description is made up from it, the notes which were written during its life having been mislaid. It is so good however, that a description of any kind is almost unnecessary. The entire length was about one foot and a half. I have long hesitated to publish a description of this animal, coming as it does from a part of the British possessions so well known as Madras, but having recently observed in the Annals and Magazine of Natural History, several species of reptiles described by Mr. Gray, as new from the same locality, not being found in the British Museum, and differing so entirely as it does from any figure of Eryx hitherto published, I have ventured to present it to the Academy with the name I have given it.

6. *Descriptions of four new species of North American Salamanders, and one new species of Scink ;* by Prof. Spencer F. Baird, (Jour. Acad. Nat. Sci., Philad., [2], i, 292.)—The following descriptions conclude a memoir exhibiting great research, which presents a revision (without

descriptions) of all the North American Tailed-Batrachia. The author gives a thorough review of the synonymy, with references to all original authorities, and a notice of localities.

AMBYSTOMA MACRODACTYLA, *Baird*. Scull longer than broad. Toes long, unwebbed. A broad dorsal reddish brown stripe. Beneath dark brown, unspotted.

Specimens in the Academy of Natural Sciences of Philadelphia. Brought from Astoria, Oregon, by J. K. Townsend, M.D.

Body rather more slender than in the other species of *Ambystoma;* the proportions nearly those of *Desmognathus fuscus*, (Raf.) The colors somewhat like those of a badly preserved *Plethodon erythronotus*, (Green.) Ground color dark brown. A broad dorsal stripe, originally, it is probable, of a chestnut brown color, now very obscure. Sides sprinkled with grayish. The brown of the sides becomes more concentrated towards the vertebral line. Tail sub-round, not compressed. Largest specimen about 2¾ inches. From the snout to the insertion of the hind legs 1½ inches.

AMBYSTOMA MAVORTIA, *Baird*. Scull broader than long. Toes short. and broad. Tail much compressed. Color dark brown, with several large yellowish blotches beneath, and transverse bands of the same on sides of body and tail.

One specimen procured in New Mexico by Dr. Wislizenus while attached to Col. Doniphan's expedition.

Body thick and clumsy, more so than in *Ambystoma punctata*. Feet short; toes broad. Tail slightly ensiform; longer than the head and body.

General color (as preserved in spirits) a dull black or dark brown, with two or three yellowish blotches occupying the greater part of the belly. About nine broad transverse bands of yellowish on the sides of the body, confluent to a certain extent with that on the belly. Similar markings on the tail, forming nearly complete ellipses, and about twelve in number. The back is not crossed by the yellowish, but is rather darker than the ground color. The interspaces of the transverse yellowish markings are confluent with the dark brown on the back. Extremities blotched like the body. Total length eight inches.

This species comes nearest to *Triton ensatus*, Esch.; it differs from it in color, and in the arrangement of the palatine teeth.

AMBYSTOMA EPISCOPUS, *Baird*. Head wedge-shaped. Scull longer than broad. Tail much compressed, shorter than the body. Body yellowish with dark mottlings and darker spots.

One specimen sent by Clinton Lloyd, Esq., from Kemper County, Mississippi.

Proportions of the body nearly those of *Ambystoma opaca*, Grav. The specimen much corrugated, and its colors obscured by alcohol. The general color appears to have been a shade of yellowish over the whole body, obscured on the back by very minute dusky mottlings: this mottling less evident on the feet and tail; abdomen and tail beneath almost entirely free from it. Head, back, and sides of the tail with numerous spots of a darker mottling than that just described. These are sub-circularly distributed rather uniformly on the head and body; they are larger, and more irregular on the sides of the tail;

their average size is that of the iris. On the sides, between the fore and hind legs, the dark mottling is concentrated into an obscure broad dark band. Length about five inches.

PSEUDOTRITON MONTANUS, *Baird.* Similar to *P. ruber*, (Daud.) Tail as long as the body. Iris dark, without the longitudinal bar.

Two specimens obtained in the South Mountain, near Carlisle, Pennsylvania.

Ground color of all the upper parts reddish brown, with sparse circular spots of well defined black or dark brown. Beneath deep salmon color: spots few on the sides and the outside of the limbs. Iris dark chestnut brown almost black, with faint mottlings of bronze on the inner border, and without the dark bar of *P. ruber.* In this latter species the iris is brassy yellow with a dark longitudinal bar. Proportions of body most like those of *P. salmonea*, (Storer.) The insertion of the hind legs is just half way between the snout and tip of tail. In *P. ruber* it is considerably nearer the tail, which thus becomes shorter than the head and body. The crown of the head is more elevated, and the occiput more convex in *P. montanus* than in *P. ruber*, the scull also is more elongated. The spots on *P. ruber* are more numerous, and generally not so well defined. When also the ground color in *P. ruber* is darker than the usual rich salmon color, the spots are very much crowded, indistinct, and confluent with the ground tint. Costal furrows in *P. monatus* 17; but 16 in *P. ruber.*

Of the two specimens obtained, one was six inches long, the other three. The latter was even more characteristically marked than the former. Both were described when living.

PLESTIODON ANTHRACINUS, *Baird.* Size between *Lygosoma lateralis* and *Plestiodon fasciatus*, without any indication of a vertebral line. Four narrow longitudinal yellow lines, and on each side a broad stripe of anthracite black.

Upper parts dark bronze; each scale has a faint border of this color, with a central cloud of the same. Small blotches on the plates of the head. The lateral band of black begins at the nostril in a sharp point, passes back including the eyelids and widening to the ear; after this it continues parallel to beyond the vent, when it tapers to the end of the tail. The tint of the black is that of highly polished anthracite coal. On each side of this lateral anthracite band is a narrow stripe of pale yellow, the upper passing through the middle of one row of scales, the lower including the contiguous edges of the rows. The remainder of the row of scales above the upper yellow stripe is also anthracite, with which color the sides immediately below the lower stripe are also tinged. Beneath yellowish white. Under the microscope each lower scale exhibits a finely dotted reticulation. Tail dark blue above, beneath lighter. Outside of legs and feet black like the sides, inside lighter. Iris black. In a single very old specimen the whole head to behind fore legs was tinged with the red color found in almost all of the *Plestiodontes.* Measurements of a specimen of medium size: total length $5\frac{1}{4}$ inches; tail from vent $3\frac{1}{4}$; head to ear $\frac{3}{8}$; breadth of head $\frac{1}{4}$; greatest breadth of dorsal band $\frac{3}{16}$; of lateral band $\frac{1}{8}$.

Found quite abundantly about old logs, in the North Mountain near Carlisle, Pennsylvania. More common than either *Plestiodon fasciatus*, or *P. quinquelineatus.*

7. *On Infusorial Deposits on the River Chutes in Oregon;* by M. EHRENBERG, (Monatsb. Acad. Berlin, Feb., 1849, p. 76.)—Ehrenberg first draws attention to the results of his former researches, that the Rocky Mountains are a more powerful barrier between the two sides of America, than the Pacific Ocean between America and China; the infusorial forms of Oregon and California being wholly different from those of the east side of the mountains, while they are partly identical with Siberian species. This fact is confirmed by his examinations of earth from the gold region of California, and from the Chutes river of Oregon, obtained by Fremont. The latter deposit is situated at an elevation of seven to eight hundred feet, and constitutes a bed five hundred feet thick of porcelain clay. It is overlaid by a layer of basalt one hundred feet thick.

Prof. Bailey who examined this material for Fremont, reported that it consisted of fresh water infusoria, and many species were distinguished.* Ehrenberg on farther investigation has made out seventy-two species of polygastrica with siliceous shells, sixteen species of phytolithuriens, and three of crystalline forms. The more prevalent species are *Discoplea oregonica*, *Gallionella granulata*, *G. crenata*, *Eunotia Westermanni*, *Cocconema asperum*, etc. The Discoplea and Raphoneis oregonica are the only two species characteristic of the locality. The beds are more recent than those of the Klackamus river, a few miles from the Falls of the Willammet.

8. *On the Fossil American Tapir;* by JOSEPH LEIDY, M. D., (Proc. Acad. Nat. Sci., Philad., June, 1849, p. 180.)—Dr. Leidy in his memoir describes portions of the fossil Tapirus americanus, and sustains the view that it is identical with the recent T. americanus.

IV. ASTRONOMY.

1. *On Nebulæ observed with Rosse's Telescope*, (Proc. Brit. Assoc., 1849, Athen., No. 1143.)—At the meeting of the British Association at York, in 1844, it was announced that a reflecting telescope of six feet aperture, which had been about two years in progress, was nearly completed, and some slight account was at the same time given of the means which had been taken to render the instrument convenient and effective. A short notice of the principal results which have since been obtained may perhaps not be uninteresting to the present meeting. In the beginning of February, 1845, the instrument was so far finished as to be useable, and in the first instance it was directed to some of the brighter nebulæ in Herschel's Catalogue. Many of them were immediately resolved, and very frequently the aspect and form of well-known nebulæ were completely changed, fainter details not previously seen being brought out by the great light and magnifying power of the telescope. Before the end of April the wonderful spiral arrangement in 51 Messier was discovered. The speculum, though there was a slight defect of figure, was in fine working order, and defined with great sharpness when the air was steady. At the approach of the short nights when the season for observing the nebulæ was nearly over, the instrument

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* Fremont's second Expedition, p. 302.

was dismounted, as it was desirable to take the earliest opportunity of completing certain portions of the mechanism which had been put together in a temporary way in a rough state, and it was not till the close of the year that it was again in working order. During the year 1846, the examination of the nebulæ in Herschel's Catalogue was continued, many sketches were made, and another spiral nebula was discovered, 99 Messier. The moon was observed occasionally, and the superiority of the instrument with six feet aperture over that of three under equal magnifying powers in bringing out minute details was very remarkable, so great is the effect of light even when we have to deal with an object so bright as the moon with an aperture of three feet. As yet, however, but little time has been devoted to an examination of the moon: the moonlight nights have usually been taken advantage of for experiments on the polishing and figuring of the mirrors, and the information which has been obtained relates principally to matters of detail from which it would be premature to attempt to deduce general conclusions, suitable to the present notice. The succeeding year, 1847, there was but little done. Unprovided at that time with an assistant capable of making trustworthy use of the pencil and micrometer, and being almost wholly occupied with the duties incidental to a year of famine, it was impossible to do more than re-examine a few of the objects of the previous year. From the beginning, however, of the year 1848 till the present time, the instrument has been constantly employed whenever the season and weather permitted it, and the following are some of the results:—

H 604 was found in some degree to resemble the great spiral nebula 51 Messier, but it is a much fainter object, and appears to be made up of elliptic streaks disposed rather irregularly with a tendency to spirality, but without that distinct symmetrical spiral arragement which is so marked a feature of 51 Messier. If H 51 Messier were seen somewhat obliquely and were considerably fainter it would probably very closely resemble it. H 854 has an arrangement of very elliptic annuli and is apparently a system of the same class seen very obliquely. H 838, M 97 is a very extraordinary object, with a dark hollow centre somewhat in the shape of a figure 8 easily seen; and with a disc irregularly shaded, but showing in the shading a decided tendency to spirality when seen under favorable circumstances; two stars are placed in a remarkable manner in the central opening. We may conceive it to be a spiral system greatly compressed; the edges are filamentous. H 2205 has a faint but large spiral appendage, to which the ray as figured by Herschel is in some measure a tangent. Several other nebulæ are recorded in our note-books as belonging to the class of spirals. The well-known planetary nebula in Aquarius, H 2098, which, in former years, had been often examined with a telescope of three feet aperture, and with no other result than that it exhibited a filamentous edge, when seen with the great instrument, was found to have two ansæ like Saturn. Many have since seen it, and the resemblance to Saturn out of focus has usually suggested itself. It is probably a globular system surrounded by a ring seen edgeways; while H 450—which turns out to have a bright centre surrounded by a comparatively dark ring, and that again by a bright ring—though a much fainter object, is not improbably a system of the same characters seen directly. H 84 and

86 is a remarkable group of nebulæ. It consists of eight, two of them pretty bright. Such groups are not uncommon, but in this instance there are, I believe, more nebulæ in a given space than in any other group we have noticed. It was observed by Mr. Stoney. The nebulæ were not connected by any perceptible nebulosity, but there are cases where a nebulous connection was distinctly traced ; several minute nebulæ, or nebulous knots hanging together as it were by a very faint but unmistakable nebulosity. The nebulæ of Andromeda and Orion have of course been observed. As to Andromeda, there seems to be little doubt that the companion is resolvable, and the nucleus of the great nebula has that granular appearance which indicates resolvability. It has however, not been seen as yet under very favorable circumstances, and we have not commenced a sketch of it. The nucleus was examined on three occasions, and the abrupt edge of the preceding streak in Mr. Bond's drawing was traced to its visible limits ; but unfortunately he did not receive the drawing till the nebula was out of reach, otherwise of course more attention would have been directed to it. Subsequent to the receipt of the drawing, the nebula was seen by Mr. Stoney in my absence with the instrument of three feet aperture, but at a distance from the meridian. The appearance was very much as in Mr. Bond's drawing, except that the contrast between the preceding portion as bounded by the preceding edge of the preceding streak, and the following portion of the nebula, was much greater. The question, however, of most interest is, what do these streaks indicate? With the great instrument, dark streaks have been observed in many of the nebulæ—sometimes almost straight as in Andromeda ; for instance, H 887, H 1909, H 1041, H 1149, are cases in point, the streaks being nearly straight. H 1357, to which Mr. Bond refers, is if possible a still stronger case than it appears to be by Herschel's drawing, as I find a sketch in our journal showing that the appendage is part of the nebula, the nebulosity extending and encasing both extremities of the opening just as in Andromeda. We have also found a variety of examples of curved streaks ; for instance H 264, H 491, H 406, H 731, H 854, H 875, H 1225, and others. Also H 1486, H 464, H 2241, besides the well-known annular nebula and the little annular nebula, figure 48, sketched by Herschel, are some of the examples of nebulæ with comparatively dark centres ; the darkness being apparently of the same quality as the dark streaks but of a different shape.

With these facts therefore I think it not improbable that the dark lines noticed by Mr. Bond in the nebula of Andromeda, and which with sufficient power are perceptible in so many other nebulæ, sometimes nearly straight, sometimes variously curved, and also the dark spaces, are all indications of systematic arrangement. When we see a dark space in the centre of a planetary nebula, it is impossible to resist the impression that we are looking at an annular system bound together by some mysterious dynamical law. If we see a bright centre as in H 450 surrounded by a dark annulus, and that again by a bright annulus, we have a system of another kind, and in the spirals of which 51 Messier is the most remarkable example we have yet found, we have a regularity of arrangement equally accordant with our preconceived notions of the order which should subsist in a regular independent system. The very elongated elliptic annular nebulæ where the minor axis is sometimes almost evanescent, shew us pretty clearly the nature of the slight, long, dark, and nearly straight streak in some cases found parallel to the axis of a long ray. A little consideration of the appearances which annular and spiral systems must present when viewed in different positions, in some instances affords a pretty satisfactory explanation of the confused streakiness we have observed in several of the nebulæ. This, however unsatisfactory it may appear, is the best explanation our working journal books at present afford of the streaks observed by Mr. Bond in the nebula of Andromeda. Mr. Bond's paper has excited so much interest, and I have been so often questioned relative to it, that I have prematurely, in anticipation of more numerous sketches and measurements, which will probably throw additional light on the subject, ventured to lay before the Association the very little which is at present known to us. It was in the spring of 1846 that we first perceived the brighter portions of the nebula of Orion in the neighborhood of the Trapezium breaking up into minute stars. Whenever the sixth star was nicely separated, this appearance was clearly perceptible. We had repeatedly examined Orion with the telescope of three feet aperture without a suspicion of its being resolvable; however, its resolvable character once known we were enabled with it on very fine nights to see some of the stars. With the six feet telescope the space within the Trapezium is still dark, just as Herschel describes it, and I feel convinced there is no optical illusion. Last season my attention was directed by Mr. Stoney to Orionis, which is on the edge of a dark spot; the dark spot includes the companion, and is about 12″ diameter; we have not yet had an opportunity of examining it with the great instrument. A few copies from our collection of sketches accompany this notice; they have been made within the last day or two by a drawing master in the neighborhood. He has transposed white for black, and enlarged the scale to make them more suitable for exhibition in the Section. In sketching we employ solely the black lead pencil, black representing light, and the eye by habit makes transposition without effort. The copies are not quite accurate, but they are sufficiently exact for the purpose.

2. *A Model of the Moon's surface.*—Mr. Blunt exhibited a model of part of the moon's surface, at the recent session of the British Association. It represented the moon as it appeared through a Newtonian telescope of 7 ft. focus and 9 in. aperture, under a magnifying power of about 250.

V. MISCELLANEOUS INTELLIGENCE.

1. *Meteorite in North Carolina.*—On the authority of a communication from J. H. Gibbon, Esq., of the Branch Mint of the United States at Charlotte, North Carolina, we give a condensed view of facts regarding a fall of meteoric masses in that state, not having room for the less important details.

On Wednesday, the 31st of October, 1849, at 3 o'clock, P.M., several persons in the town of Charlotte were astonished, and not a few were exceedingly terrified, by a sudden explosion, followed at short intervals by two other reports, and by a rumbling in the air to the east and south.

The sounds were distinct, and continued more than half a minute; they were imputed by some to thunder—but there were no clouds, the evening was calm and mild like the Indian summer, and only a mist was seen in the eastern horizon; nor were the impression of others better founded that the explosions were due to the blasting of rocks on a railroad; but sheriff Alexander having once before witnessed the explosion of a meteor, justly traced the detonation to that cause.

The negroes, who are very acute observers of sounds in the open air, denied the thunder, and an old fisherman said that the reports were like those of three pieces of heavy artillery followed by the base drum. Horses both in harness and under the saddle started with alarm.

Enquiry began to be made for fallen stones, and on Monday a servant of the mint brought in a report from the county of Cabaras, twenty-five miles distant, that there were notices stuck up on the trees, inviting people to come and see "a wonderful rock that had fallen from the skies on the plantation of Mr. Hiram Post."

Mr. Gibbon of the mint, with Dr. Andrews, travelled twenty-one miles, and partly at night by torch-light, to see "the large mass of metallic rock." They found placed in a conspicuous position upon a barrel elevated upon a post,* "a bluish gritty rock," of irregular form, eight inches long, six broad and four thick, bearing marks in spots, of recent fracture, but otherwise black as if it had been exposed to heat and smoke, the black color being relieved where the crust had been broken, and a little of the clayey soil in which it was buried in its descent still adhered to it. It had the curved indentations usual in meteorites, as if it had been soft and had yielded to impressions, and lustrous metallic points appeared through the ground color, which had generally a bluish slaty appearance, but no such rock was known in the neighborhood. Mr. Post took the travelers by torch-light to see the place where the mass fell. He was at the time in company with a young man on horseback; they heard overhead a whizzing sound—the whole atmosphere appeared to be in commotion—they compared the sound to that of chain shot, or of platoon firing. Nothing was visible; but their attention being directed by the sound towards a large pine tree east of them, they heard the stone strike "with a dull, heavy jar of the ground," while the dog, in terror, crouched at his master's feet.

Mr. Post, (in his peculiar language,) had *sighted* the sound, and his negro man ploughing in a field had done the same from a different direction, and by ranging with the aid of these intersecting lines, they the next morning found the stone, which had splintered a pine log lying on the ground; by sounding with a sharp stick in the hole made by the stone in its fall, they soon found it, and extricated it from its hiding place, which was ten inches below the surface; the dried leaves which had been "driven about by the percussion, aided in discovering the spot, about three hundred yards from the place where Mr. Post had

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* With laudable liberality and caution joined, the worthy proprietor of the boon which had fallen on his land—had annexed a written notice—"Gentlemen, sirs—please not to break this rock, which fell from the skies and weighs 19½ pounds.
HIRAM POST."

stood at the moment of the fall, which was in the woods, but there were no marks on the trees—although the impression was that numerous small bodies had fallen, "making a noise like hot rocks thrown into water."

Mr. Gibbon and his companion viewed the place both by torch and daylight, and were convinced of the accuracy of the statement.

The people of the vicinity imagined that a rock had been thrown up from a volcano or from blasting, or had come from the moon, and were not easily persuaded that it could be formed in the atmosphere.

As is usual in cases of extraordinary celestial phenomena, some were terrified by the supposed approach of the day of judgment, or of war, or some other dire calamity, and a militia colonel, in a spirit quite professional, said that "there must be war in heaven, for they were throwing rocks."

At the request of Dr. Andrews, the stone was diverted from another destination, in favor of Prof. Charles U. Shepard, of the Medical College of South Carolina at Charleston—from whom we learn that at a recent date the specimen had not yet reached him.

In due time we shall have the result of his scientific examination; but from the circumstances we have no hesitation in admitting this case as genuine: the facts are perfectly familiar to hundreds on record, and in many particulars are in accordance with the remarkable event of this nature which happened in Weston, Connecticut, in December, 1807, and with which the senior editor of this Journal, with his college colleague, Prof. Kingsley, was at the time familiar. There is no room to discuss theories, but we feel fully assured that aerolites are not formed in our atmosphere, are not projected from terrestrial or lunar volcanoes, but have a foreign origin, giving us the only reports of the physical constitution of other worlds which have ever reached our earth.

By an additional communication from J. H. Gibbon, Esq., dated November 29, 1849, it is rendered probable, that "luminous materials were seen advancing from several points in the atmosphere towards a common centre, where a solid mass of heated metal (materials) exploded and was violently projected in different directions to the earth."

It is stated also that there was a distinct appearance of a single fiery elongated body, like iron advanced to a white heat, sparkling in its passage from west to east, rising like a rocket but not vertically, and passing through the air with a long white streak or tail following a denser body in the form of a ball of fire.*

Still it is to be observed that neither the fire ball nor any light was seen by many who heard the successive reports and the fall of the stones, and the rumbling "like loaded wagons jolting down a rocky hill,"† but this is no way extraordinary, as it was day time, with a clear sky, and those only would see the fire ball who were looking in the proper direction at the time "when it was in its most ardent state." At the explosion, the meteor was about 45° high.

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* "The true flaming sword of antiquity."

† This was the very comparison used at Weston, in December, 1807, by the people there, in describing a portion of the reports heard on that occasion.

The estimation of time between the disappearance of the light and the arrival of the sound was very different, as made by different persons, at several minutes, even as high as five. The latter supposition would make the meteor almost extra-atmospheric, but doubtless the period of five minutes is much too high, and we infer that the meteor, like that at Weston, was fully within the atmosphere, and probably not over fifteen or twenty miles from the earth when it exploded. It was seen through 250 miles from the line of Virginia, to Sumpter district in South Carolina, and from east to west it was seen through sixty miles.

2. *Further Contributions to Anemometry;* by Prof. PHILLIPS, (Proc. Brit. Assoc., in Athen., No. 1145.)—Referring to his former reports on this subject [see Ath., No. 987, p. 994, and No. 1088, p. 887], the author said that his researches into the force and velocity of wind have been directed to the completion of a method of wind registration which should be independent of mechanical movements, momentum and friction. He wished to register the wind by one of the effects of the displacement of its molecules, not the movement of its mass. For this purpose only one method has occurred to him as sufficiently applicable, viz., the evaporation of a liquid. He had experimented on water, saline solutions and alcoholic mixtures, and he found reason to think that with either of these liquids an instrument really indicating the movement of wind by the registration of the evaporatton which the wind causes, is producible. Such an instrument need occupy but a very small space, and will have the desirable quality of being most accurate in those very low velocities of wind which elude entirely Lind's Anemometer and are scarcely sensible by any registering machinery. It will be remembered that for the interpretation of the register of evaporation with a register of wind velocity, it was necessary first to correct for the hygrometric state of the air. This being done, the cooling power of wind was found by experiment to be nearly as the square root of its velocity. In this experimental result, Prof. Phillips was induced to place confidence, because it appeared to represent and flow naturally from what may be thought the true physical action of the moving air. Having lately had occasion to examine extensively and carefully into the amount of air which passes (or is made to pass) through the rarefied passages of collieries, where the currents are sometimes so slow that machine anemometers even of a most delicate description are insensible to the movements of the air—where even the miner's candle affords but a rude guess, and where the situation is such that smoke or the powder-flask cannot be appealed to—he was happy to find that the problem was perfectly and easily solved by noting the cooling power of the current. For this purpose a registering or integrating anemometer is not required. The currents underground are steady, and required only an anemoscope or indicater of the momentary velocity. Evaporation from the wet bulb may therefore be abandoned; the common thermometer with its bulb clear of the frame will answer the purpose of experiment, in every conceivable instance.*

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* It appears from Prof. Forbes's 'Report on Meteorology' to the British Association in 1832, that the idea of employing a thermometer for indicating the velocity of wind was entertained by Prof. Leslie.

3. *Discovery of another huge reptile by Dr. Mantell.*—Dr. MANTELL has added to his interesting discoveries of fossil lizards, an arm bone or humerus fifty-four inches long. "It is closely allied in form and proportion to the humerus of a crocodile." Dr. Mantell has sent to the Royal Society a memoir on the subject of this new species, and it will probably be soon published.

4. *Colossal Birds of New Zealand*, (Lit. Gaz., Nov. 17, 1849.)—The splendid collection of the remains of these gigantic bipeds, formed by Mr. Walter Mantell of Wellington, announced a few weeks since, has arrived in safety, and contains objects as marvellous and interesting as the one previously transmitted by the same enterprising young naturalist, and which is now in the British Museum. The present collection consists of upwards of 450 bones, referable to several genera of birds. One series is in the same condition as those formerly received by Dr. Mantell, and among which were the skulls and mandibles and egg-shells described by Prof. Owen in the Zoological Transactions. These are from the west shore of the north island, and were dug up from a bed of marl and volcanic sand. The other series is from a tertiary deposit, on the coast of the south island, at a place called *Waikonaiti*. These bones belong principally to the colossal Dinornis, the *D. giganteus*, &c. The gems of this collection are *two entire legs and feet* (that is, the *tarso-metatarsal*, *phalangeal*, and *ungueal* bones) of the same individual, which were found erect, about a yard apart, in the very position in which they were when the bird was alive; the twelve bones of each foot, together with the *tarso-metatarsals* are as fresh and perfect as if inhumed but a few years. Indications of winged birds, of genera, and probably species, still indigenous to the islands, are among these treasures; which also include numerous *pleistocene* (or newer tertiary) shells, and specimens of rocks and minerals, collected by Mr. Walter Mantell during his late journey through the south island, as government commissioner for the purchase and allotment of the land recently obtained.

5. *Cabinet of Geology and Mineralogy for sale.*—The cabinet of the late Lardner Vanuxem of Bristol, Pa., is offered for sale. The cabinet consists of a very good collection in mineralogy, European and American; and a geological collection embracing a very complete series of all the American formations, with large numbers of the characteristic fossils of the palæozoic and cretaceous periods; the whole very completely arranged, with labels of localities, sections illustrating relative position, &c. This collection, for teaching the geology and palæontology of the United States, is superior to any other collection which can be procured at the present time. For more particular information, address James Hall, Albany, N. Y.

6. *Correction.*—In the notice of Capt. Cullum's work on Military Bridges, it is stated that the work was published by the "Engineer Department" of government. There are strictly two Engineer Bureaus, and that which receives the general title, is the Bureau of the Engineers of Fortifications. The other, the Bureau of Topographical Engineers, has in charge a series of publications, No. 4 of which is Capt. Cullum's able work.

VI. BIBLIOGRAPHY.

1. *Endlicher, Generum Plantarum Supplementum Quartum: Pars II.* Vienna, 1847.—This second part of the 4th supplement was made to anticipate the first, which, we believe, remained unpublished at the untimely death of the accomplished Endlicher, in March last. Beginning with the Coniferæ, which the author had recently made the subject of a special study, the present fasciculus goes on through the Exogenous Apetalous orders only. Under several of the orders, such as the *Betulaceæ*, *Cupuliferæ*, *Polygoneæ*, *Daphnoideæ*, and *Proteaceæ*, a complete systematic enumeration of species is given. A. GR.

2. *Endlicher*, *Synopsis Coniferarum.* Saint Gall. 1847. 8vo. pp. 368.—This interesting monograph of a small, but most important family or class of trees, bears the marks of the vast learning and untiring industry of its lamented author. It treats, 1st, the *Cupressineæ*, which are divided into five groups. A genus *Libocedrus*, is established for one New Zealandian and two Chilian trees, formerly referred to Thuja; and *Biota*, a section of Thuja of Donn is raised to the rank of a genus, including the oriental Thuja orientalis, *L.*, and T. pendula, *Lamb.* *Thuja* proper is thus left as a N. American genus, including T. occidentalis, *L.*, T. plicata, *Donn*, and T. gigantea, *Nutt.* Spach's genus *Chamæcyparis* (Chamæpence, *Zucc.*, Retinospora, *Sieb.* and *Zucc.*) is adopted for our Cupressus thyoides, the C. Nutkatensis of Oregon, and the Mexican C. thurifera, with three Japanese species, which form a separate section. In *Taxodium*, T. microphyllum, *Brongn.*, and T. adscendens, *Brongn.*, are kept as specifically distinct from T. distichum. The genus *Glyptostrobus* is established for the Chinese Taxodium Sinense or Thuja pensilis, *Lamb.* The dubious evergreen species of Taxodium, of Western N. America, no longer find a place even among the Cupressineæ, but are removed to the Cunninghamieæ in Abietineæ, where the author has established for them a genus, under the uncouth and unexplained name of *Sequoia*, S. sempervirens, *Endl.*=Taxodium sempervirens, *Lamb. Pin.* t. 64. S. gigantea, *Endl.*=T. sempervirens, *Hook. & Arn.*, *Hook. Ic. Pl. t.* 379. Much still remains to be made known in respect to these two interesting trees. It is to be hoped that Dr. Torrey will illustrate them from materials which have been supplied to him by Col. Fremont. The true Abietineæ are all resolved into the old Linnæan genus *Pinus*, which Endlicher arranges under the sections:—

A. SAPINUS.

(1.) *Tsuga*, which includes the Japanese Pinus Tsuga, the Himalayan P. Brunoniana, our Hemlock Spruce (P. Canadensis), and the Oregon P. Douglasii.

(2.) *Abies*, comprising our two species of Balsam Fir, five Oregon and Californian, two Mexican, five European and Caucasian, two Himalayan, and three Japanese species.

(3.) *Picea*, including our White, Black and Red Spruce (the latter still maintained as a species), two from our North West Coast, the Norway Spruce of Europe, one Oriental, two Siberian, one Himalayan, and two Japanese species.

(4.) *Larix*, comprising one European, two Siberian, one Japanese, and two North American Larches, one of the latter very doubtful.

(5.) *Cedrus*, the Cedar of Lebanon, and the Deodar of Nepal and Thibet.

B. Pinus.

(6.) *Cembra*, embracing the P. Cembra of Europe and Siberia, P. Peuce of Rumelia, with P. sparsiflora and P. Koraiensis of Japan, the Kurile Islands, and Kamtschatka.

(7.) *Strobus*, for our White Pine, the allied Lambert Pine and P. monticola, of Oregon and the Rocky Mountains, a Mexican species, and the P. excelsa of Himalaya.

(8.) *Pseudo-Strobus*, for fifteen Mexican or Central American species, of which P. Montezumæ is an example.

(9.) *Tæda*, comprising our Long-leafed, Loblolly, and Pitch Pines, eight Oregon and Californian, two Mexican, two Chinese, two Himalayan, one Philippine, and one Persian species.

(10.) *Pinaster*, comprising the P. Pinaster and eight other European and North Asiatic species, two Chino-Japanese, and one Sumatran species, with one from N. W. America, and six natives of Eastern North America.

(11.) *Pinea*, comprising the Stone Pine of the Mediterranean region, the Mexican P. cembroides, and the Californian P. Fremontiana, *Endl.*, which is Dr. Torrey's P. monophyllus, Endlicher having unjustifiably changed the specific name on the assumption that each leaf consists of a pair united.

The *Podocarpeæ*, &c., having no representations in our part of the world, need not be here enumerated.

Of the *Taxineæ*, we have representations of two out of the five genera, namely, *Torreya* (of which the writer in 1839 had occasion to point out the original specimens of Taxus nuciferæ, *Kæmpfer*, as belonging to a second species of the genus) and *Taxus*. One Yew belongs to Europe and Caucasus, one to the Himalayas, one to Japan, one to Mexico, and one to North America.

Of the Gnetaceæ, one genus, *Ephedra*, has a representative in Western N. America.

Our geologists will be pleased to know that the latter part of this volume is occupied by a complete synopsis of fossil Coniferæ.

A. Gr.

3. *Contributions to the History of British Fossil Mammals* (*first series*); by Richard Owen, F.R.S., &c. London, 1848.—This memoir is one of the many evidences which have been presented within a short period to the scientific world, of the great activity with which the labors of the most eminent of English naturalists are pursued. It comprises a description of the remains of several genera of extinct animals, under the following heads. I. Description of the teeth of a Palæotherium. II, III, IV. On the teeth and cranium of the Paloplotherium. V. On the dentition of Dichodon cuspidatus. VI. On Megaceros Hibernicus and Castor Europæus. VII. On the genus Hyopotamus, and the species H. vectianus and H. bovinus, with remarks on the classification of the Ungulata.

The systematic zoologist will be most interested in the last of these, which presents an important modification of the classification of Pachyderms and Ruminants, by which the natural affinities of the members of these groups are more perfectly preserved than by the classification adopted by Cuvier in the Animal Kingdom, or by that of any succeeding naturalist. The basis of this change, however, is derived from Cuvier himself. The group of Ruminants has been regarded as quite distinct, and characterized by the absence of incisors in the upper jaw, by the absence of canines, by their complex stomachs, and by the single metatarsal and metacarpal bones. These are characteristic marks of a large portion of the group; but there are a few genera which approximate more or less to that portion of the Pachyderms which, like themselves, have their toes in *even numbers.* The camel has incisive teeth in the upper jaw, and like the musks and muntjacs, has canines. In the Moschus aquaticus and the Anoplotherium, the metatarsus is double, and in all the musks it presents indications in the adult of former separation, and subsequent fusion. If to this statement we add the facts derived from embryology, showing that, in all Ruminants so far as examined, the metatarsal bones are at some period distinct, also the discovery of Mr. Goodsir, that in one species, incisors exist in a rudimentary condition, and of Prof. Owen, that it has an anterior premolar which does not appear in the adult, we shall have abundant evidence that " no very well defined line of separation exists between the Ruminants and Pachyderms. In all the members of the last group whose toes are in even numbers the stomach is more or less complex, while in the Musks the third stomach, the *psalterium*, or maniplies is deficient, and this is the last portion of the stomach developed in the typical ruminants. In view of these and other considerations, Prof. Owen adopts the Linnæan ordinal term UNGULATA, which includes the *Ruminants* and *Pachyderms.* These he arranges in two principal groups, adopting a method which Cuvier had foreshadowed, based upon the odd and even number of toes of the hind foot. This will place all the animals with complex stomachs in one (the even-toed) group, and those with simple stomachs in another (the odd-toed) group.

ORDER UNGULATA.

	ARTIO-DACTYLA. (Number of toes even. Complex stomachs.)	PERISSO-DACTYLA. (Number of toes odd. Simple stomachs.)
Ruminating.	Anoplotherium, Moschus, Antilope, Bos, Ovis, Cervus, Camelopardalis, &c.	Palæotherium. Tapirus. Equus. Rhinoceros, &c.
		PROBOSCIDIA.
Non-ruminating.	Hippopotamus, Dicotyles, Sus, &c.	Mastodon. Elephas.

We cannot close this notice without quoting the following paragraph, the justice of which all who have noticed the course of Cuvier's successor in the chair of comparative anatomy, will unhesitatingly acknowledge. In speaking of one of the illustrations of the correlation of parts discovered by Cuvier, but which Blainville did not have the honor to acknowledge, Prof. Owen says: " in a work of high merit but the tone of which, towards the memory and discoveries of Cuvier every lover of science must deplore, we look in vain for any acknowledgment for the source of the beautiful generalization of the relation of the particular forms of the astragalus, to the parity or imparity of the hinder digits, or any ascription of the credit due to a prevision, which it had been the good fortune of the author of the 'Osteographie' to verify." M. de Blainville both in his published works and public lectures, has not only treated the memory of Cuvier with neglect, but seems to have been actuated by a worse spirit than that of indifference.

J. W.

4. *Iconographic Encyclopædia;* by C. HECK, translated and edited by Prof. S. F. BAIRD, of Dickinson College, Pa. Part 3.—Rudolph Garrigue, New York.—The plan and character of this work were mentioned with some detail in our last. Part third, sustains all that we observed with regard to the elegant character of the engravings and their finished accuracy and fullness of detail. The plates of this part illustrate Geology, Physical Geography and Botany. The principles of geology are well brought out by drawings that speak to the eye. Stratification, horizontal and disturbed, and structure of various kinds, are illustrated on plates 43 and 46; volcanoes are the subject of many excellent sketches on plates 44, 45; and their geographical distribution on these and other plates, a complete mercator's chart of the world being given on a small scale on plate 47; mountains, waterfalls, caverns, and scenery of different latitudes are presented on other plates—not a mere bald outline, but in pleasing landscapes and scenes, executed in the best style of the art. The botanical department is illustrated with like beauty and fullness. On plate 55, we recognize the magnificent sketch of a species of Banyan, from the Narrative of the Exploring Expedition by Captain Wilkes, volume v, p. 26; on plate 56, a Palm grove on the Island of Fakaafo, from the same volume, p. 14, though with some added shrubs and trees that are never found on Coral Islands; on plate 47, a view of the Antarctic continent from amid the icebergs, from the same work, volume ii, p. 325, besides reduced copies of the sketches of some of the craters of the Sandwich Islands, from volume 4, of Captain Wilkes's Narrative.

5. *The Astronomical Journal*, edited by BENJAMIN APTHORP GOULD, Jr.—No. 1, of the Astronomical Journal, announced in our last, was issued on the 2nd of November last. It appears in a large 4to form. This number is occupied with a memoir by Prof. Peirce on the Development of the Perturbative function of Planetary Motion. No. 2, which has just been issued, contains:—Zodiac of Hygea, by Prof. J. S. Hubbard; on the orbit of the Great Comet of 1843, by the same; on the velocity of the Electrical Wave or current through a metallic circuit, by O. M. Mitchell.

6. *Foster's Complete Geological Chart.*—A large geological chart under this title, some six feet or more square, largely lettered and well varnished, has recently been seen by us. It emanates from Albany, N. Y., and appears to have been intended to illustrate geology to the schools of that state. Strange to say, there is not one word of New York geology to be detected in it, and not even a hint with regard to American rocks. With some truth (in lineal descent from a well known French chart), it combines much that was formerly supposed to

be true, with much that is now known to be false, and is a caricature of geological science though pretending to be made up from the best authorities. It abounds in bad orthography, and includes names of French origin that are not found in English or American works. High up in one corner stands the funniest sort of volcano spitting red streaks of fire, down whose sides are pieces of bitumen in squirming shapes, following one another in parallel lines from top to bottom—a locality for bitumen not hitherto known. The whole thing is below criticism, and however altered or improved, its adoption would be a disgrace to a state that stands so high for its geological researches.

7. *American Almanac and Repository of Useful Knowledge, for the year* 1850.—This periodical sustains its high character for fullness of statistical details and thorough science. The number for 1850 contains, besides its usual range of information, an article by Prof. Lovering, on Melloni's researches in Radiant Heat.

G. A. MANTELL, Esq., F.R.S., &c.—Observations on the Osteology of the Iguanodon and Hylæosaurus; 36 pp. 4to, with 7 plates, from the Phil. Trans. for 1849.

PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY, No. 43, vol. v, April to September, 1849.—p. 84, Gold in Maryland.—p. 91, Footmarks near Pottsville, Pa.; *I. Lea.*—New analogy in relation to the periods of rotation of the primary planets discovered by *D. Kirkwood.*

PROCEEDINGS OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA, 1849, vol. iv, *June*, p. 180. Tapirus Americanus fossilis; *J. Leidy.*—*July*, p. 184, Eryx maculatus; *E. Hallowell.*—Chemical analysis of a calculus of a Whale; *W. Keller.*—*August*, p. 194, A new Cecidomyia; *M. H. Morris.*—The Driver Ants of Western Africa; *T. S. Savage.*—p. 200, Identity of Anomma with Dorylus.—p. 203, New Hymenoptera of the genera Ampulex, Sigalphus, Chelonus and Dorylus; *S. S. Haldeman.*—*September*, p. 210, On the Wheat Midge; *J. W. Dawson.*—p. 211, Species of Termitidæ of West Africa; *T. S. Savage.*—Size of the Brain in different races of men; *S. G. Morton.*—*October*, p. 225, Enterobrus and other new genera of Entophyta, with description of species parasitic in Articulata, &c., with new Entozoa; *J. Leidy.*—On the odoriferous glands of the Invertebrata; *J. Leidy.*—*October*, p. 236, New species of birds of the Family of Caprimulgidæ; *J. Cassin.*

ALFRED SMEE, F.R.S: Elements of Electro-biology, or the voltaic mechanism of man. 134 pp. 8vo. *London*, 1849.

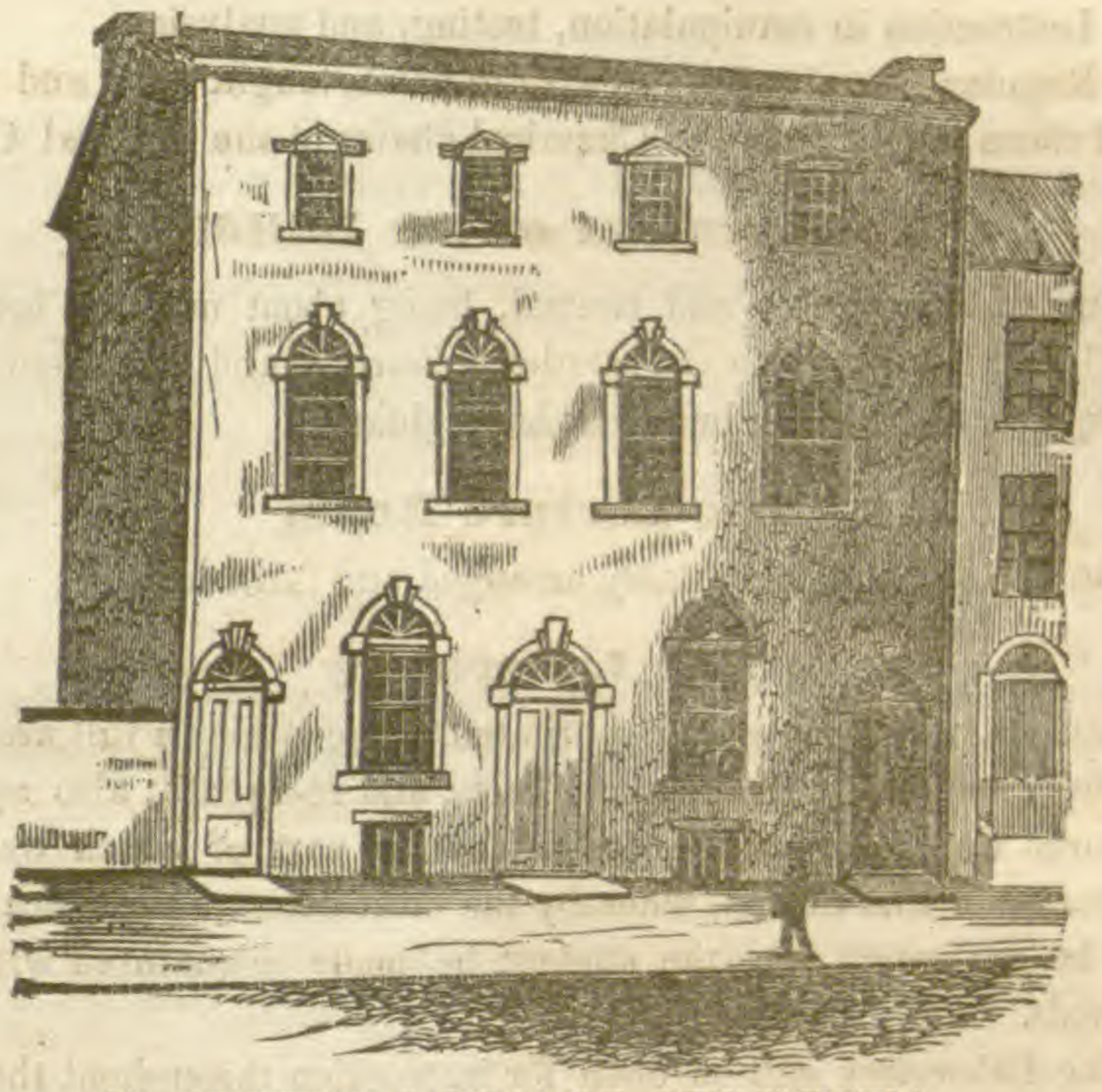
UEBERSICHT DER ARBEITEN und Veränderungen der Schlesischen Gesellschaft für vaterlandische Kultur in Jahre, 1847; mit 6 Tafeln, 400 pp. 4to. Abbildungen. *Breslau.* 1848.

URANUS; Synchronisch geordnete Ephemeride aller Himmelserscheinungen des Jahres 1849, erstes und zweites Quartal, zunächst berechnet für den Horizont der Sternwarte zu Breslau; Vierter Jahrgang. 8vo. *Breslau*, 1849.

ANNUAIRE MAGNÉTIQUE et Météorologique du Corps des ingenieurs des Mines, published by order of His Majesty, Emperor Nicholas I, under the auspices of his excellency, M. de Wrontchenko, Ministre des finances et Chef des ingenieur des mines, by A. T. Kupffer. Année, 1845, St. Petersburg, 1848. 1000 pp. 4to, with numerous plates.

RESUMÉS des Observations Météorologiques faites dans l'étendue de L' Empire de Russie; par A. T. Kupffer. 1er Cahier, 4to, St. Petersburg, 1846.

ANNALES DES SCIENCES NATURELLES, MARCH, 1849.—Researches on Annelida (Helminthidæ); *E. Blanchard.*—On Ferns; *A. Wigand.*—On the genera Quiina and Poraqueiba; *L. R. Tulasne.*—Conspectus generis Hapophyllum; *E. Spach.*—APRIL. On Helminthidæ, continued; *E. Blanchard.*—Embryology of Teredo; *A. de Quatrefages.*—Three species of the genus Anthicus; *L. Dufour.*—Note on Buprestis pulchra; *L. Dufour.*—On "Polypiers," Fam. Astræidæ; *M. Edwards* and *J. Haime.*—On the Cephäelis ipecacuanha; *H. A. Weddell.*—On the genus Ulex and a new species; *J. E. Planchon.*—New species of plants from the Berlin Garden; *Kunth.*—Sixth century of vascular plants; *J. Berkely* and *C. Montagne.*—Descriptions of new plants.



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Laboratory, Haines Street, Philadelphia,
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The next No. of this Journal will be published on the first of March.

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Mr Treman

Vol. IX. MARCH, 1850. No. 26.

Published the first day of every second month, price $5 per year.

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38. 100 species from the Silurian group of Sweden and Norway,	18 00
39. 80 species from the Silurian group of Dudley in England,	
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II. CASTS.

Persons wishing to purchase casts, can be furnished with two plates of engravings, representing them.

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2.	Megalonyx Jeffersoni, Harlan. Four different bones; femurs, phalanges, etc., from the same locality,	2 00
3.	Zeuglodon cetoïdes, Owen; Basilosaurus Harlani; Hydrarchos, Koch. Two teeth, from the tertiary group of Alabama,	00 75
4.	Iguanodon, Hylæosaurus and Gavial. 14 different bones from the Weald clay of Sussex, England, The originals are in the British Museum.	5 00
5.	Pterodactylus crassirostris, Goldf., Pl. II, fig. 7. Two pieces from the lithographic slate of Bavaria, The original is in the Museum of Bonn.	3 00
6.	Mystriosaurus spec. (Teleosaurus.) Pl. I, fig. 1. Cast in 4 parts, 12 feet long, of the best specimen ever discovered, found in the Lias-slates of Boll, Würtemberg, The original belongs to Mr. Krantz.	26 00
7.	Mystriosaurus longipes, Pl. II, fig. 5. Perfect skeleton from the same locality, The original in the Imperial Museum at Vienna.	9 00
8.	Mystriosaurus, species. Pl. II, fig. 8. Head of a small sized specimen from the same place, The original is in the Royal Museum at Berlin.	1 50
9.	Mystriosaurus, species. Vertebral spine with extremities, same locality,	6 00
10.	Ichthyosaurus platyodon. Pl. II, fig. 2. Perfect head of a skeleton 60 feet long,	9 00
11.	Perfect fin of the same specimen. Pl. II, fig. 3,	5 00
12.	Ichthyosaurus intermedius. Pl. II, fig. 4. Head, thorax and fins perfect,	7 00
13.	Ichthyosaurus tenuirostris. Pl. II, fig. 9. Perfect head, Originals of Nos. 10–13 in A. Krantz's cabinet.	1 25
14.	Ichthyosaurus communis. Pl. II, fig. 10. Fin perfect, The original is in the Imperial Museum at Vienna.	0 75
15.	Plesiosaurus dolichodeirus, Conyb. Pl. I, fig. 2. Skeleton perfect, 6 feet long, from the Lias slates of Glastonbury in Somersetshire, The original is in the British Museum.	25 00
16.	Pelagosaurus, new sp. Pl. II, fig. 14. Head, perfect, from Boll, Würtemberg, The original in A. Krantz's cabinet.	1 00
17.	Pentacrinus subangularis. Pl. II, fig. 1. The best known specimen; stem 7 feet long; same locality, In A. Krantz's cabinet.	$5 00
18.	Labyrinthodon. Pl. I, fig. 3. Head perfect, from the Keuper coal beds at Gaildorf in Würtemberg, The original in the Museum at Stuttgardt.	7 00
19.	Pistosaurus longævus, H. von Meyer. Pl. II, fig. 12. Head; from the Muschelkalk at Bayreuth, Bavaria, The original in the Royal Museum at Berlin.	1 00

20. Proterosaurus Speneri. Pl. II, fig. 11.
Vertebral spine and extremities; from the cupriferous slate of Rothenburg, ... 1 25
The original in the Royal Museum at Berlin.

21. Holoptychius nobilissimus, Ag.
From the Old Red Sandstone of Scotland, . . . 5 00
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22. Several species of Trilobites, remarkable for rareness or beauty, such as represented on Pl. II, figs. 13 and 14, each piece, . . 0 25

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100 different species,	$ 9 00
200 " "	22 00
300 " "	36 00
500 " "	70 00
1000 " "	150 00
2000 " "	350 00
3000 " "	560 00

B. *Rock-specimens.*

Size 3 by 3 inches.		*Size 3 by 4 inches.*	
100 different specimens,	$ 5 00	100 different specimens,	$ 9 00
150 " "	9 00	150 " "	15 00
200 " "	15 00	200 " "	27 00
300 " "	25 00	300 " "	45 00
500 " "	54 00	500 " "	100 00
1000 " "	135 00	1000 " "	265 00

C. *Minerals.*

Size 2 by 2 inches.		*Size 3 by 3 inches.*	
100 different specimens,	$ 5 50	100 different specimens,	$ 9 00
200 " "	13 00	200 " "	21 00
300 " "	21 00	300 " "	35 00
500 " "	42 00	500 " "	72 00
1000 " "	105 00	1000 " "	155 00
2000 " "	260 00	2000 " "	375 00

References given by Prof. B. Silliman, Jr., New Haven, J. D. Dana of New Haven, Conn., Prof. Agassiz of Cambridge, Mass., Prof. Troost of Nashville, Tenn.

November, 1849. [3t]

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THE
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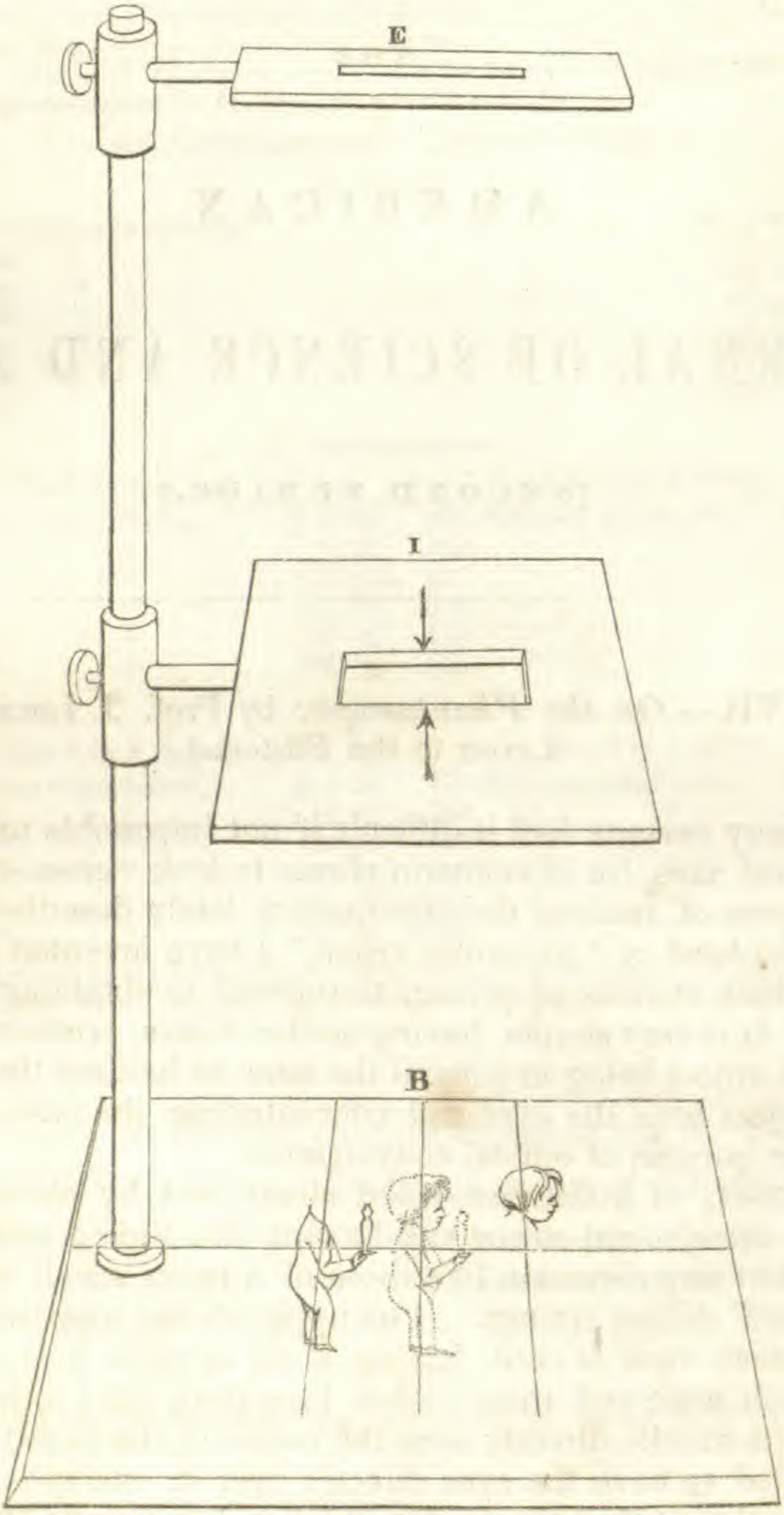
[SECOND SERIES.]

Art. XVII.—*On the Phantascope;* by Prof. J. Locke. (In a Letter to the Editors.)

As many persons find it difficult if not impossible to converge the optical axes, (or in common phrase to look "cross-eyed,") for the purpose of making the experiments lately described by me, under the head of "binocular vision," I have invented an instrument which enables all persons to succeed in obtaining the chief results. It is very simple, having neither lenses, prisms nor reflectors, the object being in general the same as holding the finger or other object near the eyes and concentrating the attention upon it for the purpose of optical convergence.

It consists of a flat base-board about nine by eleven inches, with an upright rod at one end bearing two sliding sockets to be clamped at any elevation like those of a retort stand, or adjustable by stiff sliding springs. The upper socket supports horizontally a small vane or card, having a slit or sight hole one fourth of an inch wide and three inches long from right to left. This slit has its middle directly over the center of the base-board, and is intended to have the eyes directly over it, one eye at one end and the other at the other;—two small holes, say one fourth of an inch, occupying the place of the ends of this slit would answer, except for the unequal distances between the eyes of different observers. The lower of the two sockets bears horizontally a movable screen of pasteboard or thin wood, having a slit at least three inches wide from left to right, and about one inch in the other direction, with its center also perpendicular over the center of the base-board. This screen has marked vertically across its middle an index, shown by two arrows in the figures marked I.



E. Eye screen.—I. Index screen.—B. Base-board.

Experiments.—In experimenting with the Phantascope, the operator places whatever is to be tried upon the lower tabular base-board, looks downward through the upper slit and slides the screen up or down until he attains the adjustment required.

Exp. 1.—Let there be two identical letters, say A, placed or drawn on the base-board about two and a half inches apart from left to right, let the movable screen be nearly down, and directing the eye not to the letters, but to the index, draw the sliding screen bearing the index gradually upward; the two letters seen indirectly, will appear as four; or each letter will be double AA   AA; continuing to raise the screen and to regard the index, the double images will recede more and more until their position will be thus A   A A   A; continuing still to raise the screen, the two internal images approach until they are optically superimposed and coalesce into one, thus;

A   A   A

This middle or superimposed figure, is the phantom or image where there is really no object. Cease to look at the index I, and turn the attention to the base-board itself, and this phantom figure instantly vanishes. If the two letters be placed on the base-board at the same distance as the eyes are apart, say two and a half inches, then this normal position of the screen will be just half way between the eyes and the base-board. If they are placed further apart, the screen must be raised higher; the distance from the eyes to the index screen being in all cases, to the distance from that screen to the base-board, as the distance between the eyes is to the distance between the objects viewed. In the case above, the phantom image is formed exactly as if there were a letter in the area of the index screen of half the size of the primitive letters on the base-board, and optically the letter should appear then, but the knowledge of the observer that there is nothing at that place, will often prevent the deception.

Exp. 2.—Lay upon the base board a card having letters or other figures which are identical in size and form set in regular rows and at equal distances all over, thus:

A A A A A A

A A A A A A

A A A A A A

and proceed to raise the screen as before; you will form phantom images as before between each of these figures, or possibly you will superimpose the first object upon the third, when you will have, not a single phantom but a whole plane of them, each pair presenting a phantom between. This phantom surface will be likely to effect a complete deception, and will rise from the base-board and coincide with the index plane, when it may be contemplated with the same deliberation and ease to the eyes, as if it were a real object. This would be sure to be the case if the index plane were figured over in the same manner, but with figures properly reduced in size.

Exp. 3.—Place two identical pictures of the same flower on the base-board, say they are an inch in diameter, and two and a half inches apart; place also on the edge of the index area, a picture of a small flower pot or vase, with flower stems as an index; then form the phantom image as before, and the flowers will appear in the vase so long as you contemplate the stems at the index screen, but the moment the eyes are directed to the flowers themselves, the phantom vanishes.

Exp. 4.—Let one of the above flowers be red and the other blue; the phantom will be purple. Sometimes however it will appear nearly red and then again blue. This and some other experiments, convince me that the attention of the mind even when we are looking with both eyes, is often directed exclusively to the image in one eye, and perhaps after that tires, the image in the other is contemplated. If this be true, then the two eyes serve in the first place to fix the distance of an object by the amount of convergence, and in the next place to relieve each other by turns.

Exp. 5.—Let there be a horizontal heavy line placed to the left and a vertical one to the right on the base-board, thus: — |, then adjust the screen and superimpose the images to form a phantom. That phantom will be a cross and the whole will appear thus: — + |

Exp. 6.—Do the same with any other parts of a figure of which one shall be the complement of the other; the phantom will be the complete figure. Thus take the picture of a person, cut it out of the paper, and cutting off the head, place the body on one side of the base-board, and the head upon the other, the converged phantom will be the complete figure, the head coming in from one side and the body from the other. It is perhaps unnecessary to say that each part must be placed in its true elevation, though displaced horizontally. It was in repeating this experiment, that I discovered that my eyes did not appear to be mates, for I saw the body clearly but the head obscurely. After a little time however, these conditions interchanged, and I saw the head clearly and the body obscurely. Nor did I seem to have any voluntary control over these conditions, but my eyes continued to relieve guard according to some rule of their own. This is rather an amusing experiment: the figure being beheaded, the phantom ghost appears between the two parts of the body, and from a little unsteadiness of the optical convergence, the ghost's head is inclined to attitudinize, and will sometimes start off a little from the body, and in returning, will go a little too far and will break the neck in the opposite direction. If the head of the experimenter be a little inclined, then the head of the phantom will come on too high or too low.

Exp. 7.—I placed a card having two perpendicular parallel lines about two inches in length and three inches apart. On converging them in an attempt at superposition, I found the converged lines were not parallel but came in contact at the upper end first, and diverged a little downward. Standing with my head erect, I repeated this experiment by converging voluntarily and without the aid of any index, the parallel sides of a window; the same want of parallelism was exhibited, but on throwing my head backward and looking horizontally over my cheeks, the converged perpendiculars coincided throughout. I learned by this that both of my eyes do not rotate in one and the same horizontal plane. I got another person to repeat the same experiment, and he found the error of his eyes to be in the opposite direction, the converged perpendiculars meeting first at the bottoms. This proves a moral adage to be physically true, "we don't all see alike."

This instrument and the researches into binocular vision, serve to extend considerably our knowledge of the anatomy and physiology of vision, nor is the subject by any means exhausted. I have not time to investigate the matter fully, and shall be happy to see fair and honorable competitors enter the field. The verifications and variations of the experiments by your correspondent, Dr. Lathrop, were gratifying to me.

This apparatus will illustrate many important points in optics, and especially the physiological point of "single vision by two eyes." It shows also that we do not see an *object* in itself, but the mind contemplates an image on the retina, and always associates an object of such a figure, attitude, distance, and color as will produce that image by rectilinear pencils of light. If this image on the retina can be produced without the object, as in the Phantascope, then there is a perfect optical illusion, and an object is seen where it is not. Nay, more, the mind does not contemplate a mere luminous image, but that image produces an unknown physiological impression on the brain. It follows that if the nerves can, by disease or by the force of imagination, take on this action, a palpable impression is made without either object or picture. As this would be most likely to occur when actual objects are excluded, as in the night, we have an explanation of the scenery of dreams, and the occasional "apparitions" to waking persons. The murderer, too, has a picture stamped on the sensorium by the sight of his victim, which ever wakes into vibration when actual pictures are excluded by darkness.

Art. XVIII.—*The condition of Trap dikes in New Hampshire an evidence and measure of Erosion;* by Oliver P. Hubbard, M.D., Prof. Chem., Min. and Geol., in Dartmouth College.

In New Hampshire, whose geology is characterized chiefly by primary rocks and metamorphic slates—trap dikes are exceedingly numerous, and they have an evident relation both in position and character to those of the adjoining states. Among them all, none have yet been described, (perhaps not observed,) that are eminent at all above the rocks enclosing them; and there is only one place where the bulk and prominence of the trap is such as to indicate a center of elevation, or greater resistance to erosion, than in the adjacent rock. This is the most northern of the peaks of Ossipee Mountain, east of Lake Winnipisiogee; it is described as "an isolated, bare, precipitous range of bluish greenstone rock," and abundant fragments are found on the adjoining peak, covering the gneiss. From this point as a center, series of dikes seem to radiate in various directions; one group east of Red Hill, ranging north 60° or 70° west, and varying from one to three or four feet in width; another similar one, west of Red Hill, near Squam lake, from one inch to ten feet wide, ranging east and west. "These dikes are distinctly marked over the surface of the granite including them. They have been worn and polished by the action of diluvial currents, so that a level and smooth surface, comprising many thousand square feet, lies entirely bare of soil."*

In volume xxxiv. of this Journal, (p. 105,) I have described a number of trap dikes, presenting the same relations to the enclosing rock, and without doubt there are hundreds of instances of the kind in New Hampshire and Vermont; and they are found at all levels, and continuous for considerable distances. The present condition of these dikes is, obviously, evidence of more or less erosion. I propose to cite in this paper, examples of trap dikes in New Hampshire and vicinity, which shall show how far they are *evidences and measures of erosion*, whether ancient or recent.

The trap in New Hampshire occurs in relation to the surrounding rocks either—1. *Worn off smooth and plane with the adjacent rock*, whether the surface be horizontal or inclined—2. *Below the surface*, when in a state of decomposition and forming, it may be, the channel of a stream—3. *Prominent above*, as at the Peak of Ossipee, and when forming an occasional barrier of a stream, where the surrounding rock has been removed.

There are believed to be very few instances of the third condition. Bear Camp river is crossed by a dike one to two feet

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* Geology of New Hampshire, p. 72.

wide which forms a barrier, the granite having decayed away. There may possibly be an instance in Red Hill, where the dike is exposed on one (the lower?) side by the removal of the granite.*

(*a.*) Of the second kind, there is an example in the rear of† the Willey house, referred to by Mr. Lyell in his second tour, and described by me previously in volume xxxiv. of this Journal. The trap is the bed of a small mountain torrent, in some parts decomposing, in others very hard. This dike was traced this season by some members of our party,‡ along a continuous and deep channel far up the mountain, and it is there found to divide into two parts, which again meet a considerable distance above, and thus enclose a large elliptical area. This area is distinctly observable from the house below, as it is fringed with a vivid green of deciduous shrubs, which mark the water courses in the mountains. As there must have been a time when the channel had no existence, and the trap filled it, up to the plane of the mountain, the formation of the water course may fairly be attributed to the decomposition of the dike, and the *depth* of the channel is evidently a measure of the erosion.

(*b.*) The "Flume," in the "Franconia Notch," is a deep chasm ten to sixteen feet wide, "having mural precipices of (very hard) granite on each side," forty to sixty feet high, while a mountain torrent rushes through it at high water. I saw it last June, after a severe drought of some weeks; there was but little water, and no difficulty in ascending it with occasional wading, and climbing over the large angular and rounded rocks in the way. The direction of the channel is north 80° east. At its lower end on the right hand is a trap dike, in several distinct lines each a few inches wide, mounting high in curved plates in the side of the cliff; farther on they decline and coalesce into *one* dike twenty inches wide, which passes under the water.

The dike crosses the fissure obliquely at about N. 75° E., and is seen some rods farther up the stream in a vertical section extending to the top of the opposite bank.

The trap where constantly wet is softened and decomposing, and above on the sides, is compact, very much fissured and stained deep with oxyd of iron. This fissure, like the former, must be admitted to have been filled by the intrusion of trap, and to have become a water channel by the removal of the dike; the channel, therefore, is some measure of the erosion of the trap and its rocky enclosures by existing agency.

(*c.*) The description given in the Geology of New Hampshire of the beautiful Dixville Notch, in the northern part of the state, suggests similar conclusions.

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* Am. Jour. Sci., vol. xxxiv, p. 113. † Ibid, p. 111.

‡ Members of the Senior Class in Dartmouth College.

"The summit of the (new) road (passing through the Notch to Portland, Maine,) is 835 feet above the plain of Colebrook. The direction of the pass is N.E. and S.W., and it is walled on both sides by towering ledges and pinnacles of mica slate, which stand nearly vertical, dipping to the N.W. 80°, and attain an elevation of 600 to 800 feet from the road"—of course about 1600 feet above Colebrook; and the Notch is parallel to the direction of the strata, which clearly have been removed on this line. Can we discover any disturbing agency or predisposing cause for this depression, from the summit of which the streams flow either way into the Androscoggin and the Connecticut? We learn that "dikes of basaltiform trap intersect the strata near the middle (summit?) of the Notch, and large loose blocks of it are seen in abundance on its northwest side. It contains very large crystals of basaltic hornblende and glassy white feldspar." The course of these dikes is not given. "On the north side of this road, forty or fifty rods back in the forest, is a ravine called 'the Flume.' It was formed by the decay of a large trap dike." "The chasm is twenty feet deep and from ten to twenty feet wide, and is the channel of a stream of water, from whence it received its name. The trap dike runs N. 30° E., and S. 30° W., and is six feet wide. It is slightly porphyritic with feldspar crystals, and is of a dark brown color. It divides into large cubical blocks which form a series of steps, so that when there is but little water a person may walk a considerable distance up the flume upon them. The principal ledge at this spot is granite, which protrudes through the mica slate."

Here we find a gorge through a mica slate range parallel with its direction N.E. and S.W., the slate dipping N.W. 80°, intersected by trap dikes—and near, another trap dike in a fissure, having the course N. 30° E., which is a variation of only 15° from the direction of the Notch, and all coincide in direction with the slate. But whether the different dikes are connected or not, erosion would seem to be indicated, down to the present level of the dikes, to the amount of 800 feet.

(*d.*) To cite one more case where the agent is still acting. The Waterqueechy river at Queechy village, (Hartford, Vt.,) makes a high fall of twenty feet over a dam of ten feet, and its rocky channel and sides are covered with pot-holes, and the gravel banks are here some eighty feet above with several terraces extending down a mile or more, where the narrow valley becomes a *cul de sac* from which the water could not have escaped before the present outlet existed, *except at a much higher level.** At this point the

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* I am informed by the Rev. Mr. Dudley of the village, that between the gulf and the village there are two distinct deserted channels parallel to the present one, but much higher, where in all probability, the river once ran.

river enters a rocky channel, called "The Gulf," at a large angle with its previous course, and runs S.S.W. with a rapid descent for nearly a mile. The left bank (in the descent) is nearly vertical, though receding at top, and by estimate one hundred feet high, and the opposite bank, with various irregularities, is *in part* and in some places *entirely* made up of a *trap dike* from three to six and ten feet thick, whose course is N.N.E. and dip 58° southeasterly, and *coincident in these respects with the mica slate enclosing* and underlying it and parallel of course to the stream. It has here and there been crossed by the stream and extensively removed with the slate below it, and a channel has been made on both sides which is filled at high water; and again the dike is found enclosing the slate and is extremely hard and compact.

Passing off at right angles to this dike, as lateral branches, and crossing under the stream, are two other large vertical dikes which are very distinctly seen in section in the perpendicular wall of slate opposite, and they may be traced some distance easterly from the top of the bank, but are soon concealed by gravel and soil. One of these is twelve feet wide, of light blue color, and beautifully amygdaloidal, with numerous white crystallized balls.

These last dikes do not seem to have been injected subsequently to the first, but are so blended at their union with it, as to leave no doubt of their being one system, and a part of the trap network which extends through the region.

The pot-holes and troughs or elliptical holes, are very numerous throughout the channel as may be seen at low water, and they occur where there is no fall. They are produced by the action of a very rapid stream over an irregular surface. There can hardly be found a more satisfactory case of erosion by existing agencies. At the same time the trap dikes whose perpendicular section measures the extent of the specific action, indicate in their easterly extension, level with the surface of the enclosing rock of the bank above, the prevalence of earlier and more general superficial causes of denudation.

(*e.*) At the termination of the Mass. and Vt. Railroad near the Connecticut river bridge at Brattleboro, Vt., it was necessary to remove by blasting a large amount of slate rock, which was graded down about thirty feet to the level of the track, which is about thirty feet above the river. The whole of the surface of the rock laid bare, was very smooth, and worn into curves and channels and then scratched every where with strong marks, of varying north and south directions, parallel and crossing each other in groups. In this bank was a large trap dike thirty and more feet wide, whose surface was coincident with that of the slate and showed the same marks, continuous from one to the other.

The direction of the dike is about N.N.E. in a line with the bridge across the river, and it is quite probable the dike extends a long distance either way and was once a barrier to the river. The Connecticut river is here bounded on the east by a high rocky mountain, and the position and appearances of the dike in relation to the river, suggest the inference that the removal of the trap is a fair measure of the erosion at this place, and, at least in part, of that produced by the action of the river (sixty feet).

A small stream from the west in a deep rocky channel just north of the bluff removed, seems to have had its course deflected so as to empty into the Connecticut river just *north* of the intersection of the latter river and the dike, and their joint force has continued to reduce the level of the latter so as to afford the free passage of the river.

(*f.*) We may mention here, before proceeding, a few facts brought to light by the different railroad surveys in New Hampshire and Vermont. The Rutland and Burlington Railroad crosses the Green Mountains at Mount Holly gap, at a level of 1350 feet above the Connecticut river.* In this place a cut was made through a muck swamp, which exhumed some remarkable elephantine remains.† The White Mountain Railroad survey from the Connecticut up the Ammonoosuck, passes the summit in or near Whitefield, at six hundred and fifty feet above the Connecticut, and this within twelve miles of Fabyan's in the White Mountains. The Passumpsic Railroad overcomes the summit in Sutton at about nine hundred feet above the Connecticut at West Lebanon. The Central Railroad of Vermont passes the summit between the White and Winooski rivers near Montpelier, nine hundred and thirty feet above the Connecticut at West Lebanon. The Northern Railroad from Concord, New Hampshire, to the Connecticut, passes the summit between the Merrimack and Connecticut valleys, in Orange, with high grades of 52·80 feet in a mile on both sides, at an elevation of eight hundred and thirty feet above the Merrimack at Concord, and only six hundred and eighty-two feet above the Connecticut river on the west.

If at any time, by reason of the difference of level of these valleys of Connecticut and Merrimack rivers, water were discharged from one to the other for a long period through the lower passes, we should expect to have evidence of it engraved upon the rocks. If such evidences were discovered as we know from our running streams to be the effect of water, we shall be justified in referring them to a similar agency, i. e., water in motion. Should we observe phenomena like what are frequently seen, in the less rapid

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* See profiles and reports of these roads.

† Agassiz. Proceedings Am. Assoc. for Adv. Science, held at Cambridge, September 1, 1849.

parts of a river and above dams in a rapid stream, we may refer their production to a similar cause.

The original features of this Orange summit were remarkable, but they have been very much altered by the cut for the railroad, which has however added, by the new features developed, very much to its geological interest. The facts have an important bearing on problems which are now arising with reference to the geological history of New England, and are therefore worthy of record. A description in part, is given by Dr. C. T. Jackson in the Geology of New Hampshire, p. 113.

The turnpike from Canaan on the northwest, passes some miles along the edge and on the sides of sand and gravel hills on the borders of an extensive swampy, peaty meadow, with a sandy bottom, which has long ramifications into the lateral valleys, then near a shallow pond of a few acres, which is fed by a rivulet coming from the hackmatac swamp at the base of the summit. The valley narrows rapidly, and towards the summit we find numerous long sand and gravel hills, shaped like an inverted boat, twenty to thirty feet high, parallel nearly to each other and to the general trend of the valley, with channels for surface water between them.

The depression or gap is several hundred feet below the general height of the range, and the old road formerly passed the summit at an elevation about forty feet above the swamp, and was made in the lowest channel cut by the waters formerly running here, and directly by the side of the "well"* made a slight descent across soft ground on a log causeway, then over a rocky ridge and down into Grafton valley.

This well or pot-hole, as figured, appears worn down on the side next the road three feet lower than on the opposite; its depth is eight feet; its diameter is between four and five feet at top, and about two feet at bottom. A large number of small, smooth rounded stones from this well, are in my possession, and in the Dartmouth cabinet is a plum shaped smooth mass of granite, which weighs two hundred and ninety pounds.

The surface of the rock wherever seen, even high above the road track is water-worn into cavities and channels descending to the southward, and great numbers of pot-holes have been uncovered, which have a tendency to a linear direction nearly north and south. In laying out the railroad, soundings were made between the two rocky barriers to the depth of near forty feet, in a peat bog, and the rock cutting was considerably diminished by laying the track about north and south, and obliterating wholly or in part many pot-holes of large and small size. Through the kindness of my friend, R. Bakewell, Esq., I refer to his drawing of the section made by the railroad on its west side.

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* Figured, Geol. N. H., p. 114.

The cut is north and south about 1600 feet long, and thirty-five feet deep; the railroad is at the base, and the former carriage road at the top.

A, granite, presenting two rocky barriers *s*, *s′*, the latter somewhat the highest:—these to the eastward rise more rapidly into ridges than on the west. The course of the channels in the granite is diagonal from the east side and descends south, showing certainly the direction of the stream. (*q*) Quartz veins from one to four inches thick, dipping from 35° to 42° S.E., intersecting the granite. These are cut off in barrier (*s′*) by two large veins (*f*) (*f′*), of whitish green feldspar with mica, and in some parts is handsome graphic granite, and all much harder and more difficult to excavate than the granite;—(*f*) is fifty-six feet wide and (*f′*) twenty-one feet. Their course is N. 18° E., and dip westerly 66°, and by the light color of the feldspar, they may be traced by the eye in a tortuous course far up the hills. B B′ B″ are deposits without stratification, of fine and coarse gravel with large and small rounded pebbles covering the granite and extending somewhat lower than the track of the railroad; the portion B″ was made up chiefly of pebbles of the larger size, even one foot by one and one half foot. C is a bed or deposit of swamp muck, filling to the brim the excavation in the gravel and covering it from *s* to *s′*. This extends below the track, and east and west, and is some two hundred feet wide, in the line of section between B′ B″. The draining of this swamp on the south, caused it to settle and tear apart in large patches, and to prevent its filling the track as fast as the excavations went on, a close row of piles thirty feet long was driven on each side and braced apart at top. Coniferous trees of considerable size, eighteen inches diameter, are found in this at all levels, prostrate and with roots attached, and also lying on stumps that were still in a vertical position; when cut they were found in the interior quite sound and of bright color. (*t*) Is a dike of gray amygdaloidal trap, three and one half feet wide. Its course is N. 30° E.; it was traced southwesterly up to the top of the ridge some hundreds of feet above

A, Granite.—B B′B″ Gravel, pebbles and sand—C, Peat containing trees and stumps—*f*, *f′*, Feldspar veins—*q*, *q*, Quartz veins—*s*, *s′*, Summits. *t*. Trap dike.

the road, for a distance of near half a mile, where it is only one foot wide; it may also be traced some way on the eastward side of the road.

In my note-book are memoranda of pot-holes measured here, some of which (the last three) have been since in part removed.

1. 16 inches diameter and 4 feet deep.
2. 4 feet " and 4 " "
3. 3½ and 4 ft. " and 10 " "
4. 4½ feet " and 8 " "
5. 13 " " and 12 " " now less than a semicircle.
6. 5 " " and 8 " " a semicircle.
7. 8 " " and 10 " " in two curves, as if two holes had been worn into one.

No. 1, was filled with peat, and discovered by sounding with an iron bar; at a single blow the bar struck on the bottom a flattened, rounded smooth stone, of about four pounds weight, which was the last agent in the excavation of the hole. There is also a rocky channel some rods in length, oblique from the northeast, which is cut off by the railroad at its lower end; it is twelve feet wide and eleven feet deep, and contains near its mouth large rounded granite boulders from one to seven feet diameter. Such masses as these, with the great number of similar ones, large and rounded, in the portion of the gravel bed at B″, are proofs of the tumultuous action of a great body of water, by whose agency they were carried along into this whirlpool and revolved till they were rounded and often reduced to pebbles and powder, and thus removed to give place to others. At various stages in the process, some may have escaped from the excavations and were carried over the south summit (*s*), or were lodged on its north side.

The phenomena here presented, indicate a long continued discharge of a large current of water through this gap, from north to south, which has worn down the mountain range, hundreds of feet, as shown by the feldspathic veins, and especially by the *trap dike*, which was injected since the veins, as it cuts one of them. Similar circumstances must have been often repeated at higher levels, while this erosion was in progress. "The well" beside the road has been lowered three feet on one side, so as to form a channel in which the early road was made, while below this level it was perfect and eight feet deep. We may suppose, with reason, that these wells had been of similar dimensions through a long period while the action was going on, and that excavation below kept pace with the removal of the upper portion.

Between these two remarkable barriers on the north and south, the excavation in granite of this longitudinal valley is more than forty feet deep and six hundred feet wide; it has a very uneven surface, with rounded hummocks rising from the bottom, as shown on the E. and W. side of the railroad, in a section from eight to eighteen feet high above the track. On the north side it is filled with the accumulations of gravel, and on the south side the basin in this gravel is filled with a deposit of peat, containing abundance of prostrate trees apparently of successive generations.

The configuration of the excavated gravel shows the last result of moving water; the accumulation of the swamp muck and the growth of trees in this cavity are of course of subsequent date. The violence of the current which has here acted, may be inferred from the wearing effects exhibited on the rocks of the valley, S. and E., where they are smoothed and rounded at elevations far above the stream now flowing there; also from the great depth of Tewksbury Pond, and from the extensive beds of pebbles washed clean of all fine materials, sand and soil, in Danbury, about ten miles southeast.

Again—we see no evidence at present that these excavations and irregularities were produced by water *falling from a very great height;* they are rather the effect of a uniform though violent current; the same marks are seen in the slate and hard trap of the bed of the Queechy, where pot-holes and channels and capacious excavations long and deep are abundant as the effects of a rapid stream.*

If we may safely conclude that where numerous dikes, and these it may be in groups of six or eight, are found crossing in a valley a river channel, as at Campton Falls, N. H., and reduced to a level with its bed, with occasionally one harder than the rest forming a barrier of slight elevation, we have before us a present agency which in time past, may have been sufficient for the production of the degradation indicated by the extent of the valley. So when there are large, elevated areas yet far below the peaks and ridges of the country intersected in many directions by trap dikes and the whole surface worn smooth, we hesitate not to admit that a general denuding or erosive force has acted with energy and during a long period. When we find a mountain ridge cut at right angles by one or more trap dikes, and these reduced to an even surface with the crest and sides of the mountain, and continuous across the valleys, it is not easy for the mind to forbear concluding that the valleys are valleys of erosion, although they may be narrow and some thousands of feet deep. This is illustrated by the following cases.

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* In connection with these effects of larger currents, and in proof of their former existence in the channel of our present streams, I mention that a cut was made in West Hartford, Vt., on the Central Railroad, across the angle of a slate spur, about sixty feet above the White River, that opened a pot-hole to its bottom, seventeen feet deep and between three and four feet diameter. In this were found two beautifully rounded and smooth spheres of granite, one of which unfortunately was buried in the track, and the other, almost a perfect sphere, two feet four inches in diameter, and weighing over nine hundred pounds, is preserved for science at the University of Vermont at Burlington.

(*g.*) Moose Mountain is a part of a north and south range of mica and hornblende slates with quartzite. It is situated about eight miles east of Dartmouth College, and may be 1000 feet high. Between the granite knobs just east of the College and the range, there is a synclinal valley and axis, and the slates on Moose Mountain dip westerly at a high angle. In passing along the ridge some years since, I observed a depression eighteen feet wide with perpendicular sides twelve feet high, and this singular interruption of the line of the ridge led to an examination of the rock in this space. It proved to be a dike of columnar porphyritic trap running east and west, which was traceable some way down the declivity, but of a uniform surface with the sides of the mountain.

On the opposite side of the valley, and crossing it and the road obliquely and following exactly the undulating and channeled surface of the slate, is another very compact, hard, blue trap dike, with crystals of glassy feldspar, and fourteen feet wide. These dikes if produced must intersect each other, and the latter is cut down many feet by a small stream.

A few miles south where this ridge is interrupted by the valley of the Mascomey River or Enfield Pond, the precipitous bluff presents a dike some feet in width which is made up of flattened and rounded masses of trap in columns side by side, and rapidly decomposing. This is one hundred feet and more above the level of the lake, which is at the base of the ridge, and whose bed must be intersected by the dike.

(*h.*) Mount Washington, as I showed in the American Journal, xxxiv, in 1838, is covered or capped with mica slate *in place*—and as there is no evidence from diluvial scratches, boulders or rounded and smooth surfaces, of erosion or denuding forces, we infer that its peak ever has been above the reach of those agencies which have operated upon its flanks and upon the surrounding peaks.

If a fissure should occur through one of these granitic peaks from valley to valley, (it would probably be much farther extended,) and if molten lava were to fill this fissure, it could never reach the apex or remain consolidated there, unless it were supported at the *limits* of the fissure on the flanks of the mountain. It is contrary to physical laws that as the lava rose in the fissure, it should not gravitate and run into the lower places, the valleys on the sides of the mountain, and only as these were filled would it rise in the fissure, and equally in both. This must follow whether the surface be submarine or subaerial.

1. If the existing valleys were filled to the height of the peak with *diluvium* or *drift*, like the conglomerate hardpan of this region, which is so consolidated that when excavated it must be blasted, this would seem sufficient to repress or hold up the col-

umn of lava and secure a uniform dike to the full height of the peak. The hardpan would be fissured and the dike found continuous through it; but this supposition implies a *previous excavation or erosion of the valleys.*

2. If existing valleys were formerly filled with *trap* by an overflow from the fissure, they are now clear of it and have been reduced to their former condition, i. e., they have been excavated a *second time as in the former case.*

3. If the present valleys were formerly occupied by continuous rock, such as constitutes the mountains, then a support is had for the molten lava when injected to the height of the peak, so as to allow the filling of the fissure and to form a dike; and the present configuration is the result of a subsequent erosion or excavation. Whether these valleys, therefore, were ever filled with diluvium or trap, need not be shown, as we must in that case, at a previous time introduce the latter supposition, involving as it does only a single excavation.

There is a possible supposition that the valleys of the White Mountains are the result of fracture and subsidence of their areas —or of fracture and elevation of the ridges—but I know of no evidence of this, and where the rock can be traced across from side to side of a valley, the continuity is complete. To sustain the third view above, I cite the following facts.

Mount Pleasant, the third peak south of Mount Washington, is about 4500 feet high. Its top is a plain of five or six acres, so even and level that a horse may be galloped all about upon it.

It is intersected near its center by a dike of very hard, bluish trap three feet wide, whose course is east and west, which is worn off entirely smooth and level with the enclosing rock, and may be traced entirely across the top. Circumstances did not allow an examination for its continuance beyond these limits, where the sides of the mountain are covered; but by telescopic examination from Fabyan's, which showed distinctly the little column of trap fragments piled upon the dike of two feet in height, I was led to infer a probable relation between the dike and the slides on the west side of Mount Pleasant, which seemed to be in the range with it. However this may be, the dike must be considered for the reasons already given, as of much greater length than the crest of the mountain and of course extending down into or across the valleys.

Though the positive evidence may be wanting of this latter point, yet from a party of our students who, in the autumn of 1848, descended into the valley on the east side of Mount Pleasant, from directly opposite the "Lake of the Clouds," and followed the mountain stream throughout its course of falls and rapids, &c., to the valley of Dry river, and down this to its junction with the Saco in the Notch, two or three miles below the

Willey House, and some twelve miles from where they began the descent—I learn that "two or three miles above the mouth of Dry river there are several remarkable trap dikes at right angles to, and crossing the stream, and running up into the mountain on the sides; one of them is five or six feet wide and is smooth and even with the rock enclosing it, and the stream makes a nearly perpendicular plunge at this point, of eight or ten feet,"—thus presenting such phenomena as are common in other similar places, and as ought to be found constantly existing or repeated in a process of excavating a valley by a running stream.

The facts which I have recorded, showing the relations between trap dikes, which have been denuded and eroded to considerable depths by running streams, will need no comment or illustration.

In regard, however, to such cases as Mount Pleasant and Moose Mountain, where no running water is found, we must recur to the periods when the relations of land and water were very different from the present.

We are too much disposed to look upon the great features of this group of mountains as fixed so long ago as to have no connection with the minor ones now presented, and which are in process of increase. The agencies of decomposition are now at work on a scale of sufficient magnitude to produce great changes in a generation, and the accumulation of debris since August, 1826, at the gorge back of the Willey House, and in the outlets of the two below it, if we could add also the large amount of fine materials carried down stream by the Saco from these sources, are well calculated to prevent our underestimating their importance.

The gorge ½ a mile below the Willey House being in the line of some trap dikes cutting the mountain, is already a very considerable depression, and in imagination we may anticipate the time when it has become a separating valley two or three thousand feet deep, like the one east of Mount Pleasant. We have only to extend this view to the thousands of precipitous torrents, and the more advanced channels, to provide for the future intersection of these ranges, and, as the valleys are deepened and widened, for their more rapid destruction by undermining and slides. It is not my object to exclude by any means the general operation of any or all of the authentic agencies, whether marine or freshwater or others subordinate, that by future observation may be shown to have left their impress on this region—but while observation shows a very considerable erosion of these valleys and mountains now going on, I wish to present other facts which lead to the conclusion, that these *deepest valleys are but valleys of erosion.*

The examination of the valleys of the state of New York, as at the Little Falls, &c., and of its lakes in different parts, shows a difference of level and a depth of erosion of 1200 feet to 2000 feet. So also the observations on the sandstone of the Connecticut valley in Massachusetts and Connecticut, indicate its erosion to the extent of 1200 feet. This erosion of the sandstone is only consistent with a similar one in the northern portions of New England, and requires its occurrence if we would provide the constituents of the sandstone in the first place and its continuance and increase subsequently. Whether this result is referable to one period or another is not now a question.

The following facts are cited from the Report of the Geology of New Hampshire, to sustain the general proposition, and which is also strengthened by the evidence afforded by metallic veins in positions similar to that of the trap.

1. The Lower Patuccoway Mountain of syenite in Nottingham is cut, through its summit, into two nearly equal parts by a dike of columnar greenstone trap from six to twelve inches wide, and which can be traced for a quarter of a mile till concealed by the soil. This mountain is 780 feet high above the sea.

2. In Piermont the mica slate is intersected by numerous dikes of greenstone trap; and from Piermont to Haverhill Corner, nine dikes are found, some of them porphyritic, and one so filled with magnetic iron pyrites as to affect the compass.

3. Red Hill, of syenite, and 2000 feet above the level of the sea, is crossed at about one-third its height by a large dike of porphyritic trap, N. 30° W.

4. On the declivity of the westerly peak of Gunstock Mountain, which is 1561 feet above lake Winipissiogee, is a vein of magnetic oxyd of iron, the pieces of which have polarity, and large dikes of trap occur on the southerly peak.

5. Baldface Mountain, in Jackson, of granite, is cut through its midst by a few trap dikes, and at a height of 1404 feet above its base, and in other places is cut by veins of peroxyd of iron of great width, which are traced down its flanks.

6. Several trap dikes in Jackson contain carbonate of lime, and cut through mica slate, granite and a granite vein, one of which is fifty feet wide.

7. At Hampton Falls, and on to the sea, the hard flinty rock is cut by dikes of trap.

8. In Eaton, dikes of porphyritic trap from ten to sixteen feet wide cut through a hill of granite, and again in another place a trap dike four feet wide cuts a hill of granite.

9. On the east flank of the White Mountains, on the Pinkham road in Jackson, the mountain ledge of mica and chiastolite slate

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1. p. 50.—2. p. 65.—3. p. 71.—4. p. 72.—5. pp. 78, 79.—6. p. 80.—7. p. 93.—8. pp. 95, 98.—9. p. 99.

is cut by two large trap dikes, and Town's hill in Lancaster, is intersected by trap dikes in limestone.

10. Trap dikes, porphyritic and dark brown compact, occur at Berlin Falls, and are also found in passing from Berlin to Lancaster.

11. In Littleton are trap dikes cutting mica slate.

12. Thorn Mountain, in Jackson, consisting of a porphyry, is cut through at top by veins of magnetic oxyd of iron descending its flanks, and by a dike of basalt.

These examples of trap are at very various heights above the sea, and are a fair illustration of the amount of erosion of the rocks in their several localities. I know of no more valid objection to the conclusions based on the evidence afforded by the relations of the trap in New Hampshire, than would lie against those derived from the trap in other formations, whether in the mountains of northern New York or in the coal formation, or in the sandstones of all countries; and future examination in the very instructive geological field of the White Mountains will doubtless furnish much more similar evidence.

Art. XIX.—*Contributions to the Mycology of North America*; by Rev. M. J. Berkeley, of England, and Rev. M. A. Curtis, of South Carolina.

61. **Agaricus Antillarum**, Fries.—In fimetis. May–Nov. Society Hill, S. Carolina.

62. **Coprinus tergiversans**, Fr.—Ad terram. Dec: Santee Canal, S. C. Mr. Ravenel.

63. **Paxillus porosus**, Berk.! in Lea's Catalogue.—Ohio! Mr. Lea. S. Car.! In sylvis humidis. Aug.–Oct.

64. **Hygrophorus mucilaginosus**, Berk. and Curt.;—pileo valde mucilaginoso lætecolori convexo demum plano striato; stipite fragili subconcolori fistuloso; lamellis decurrentibus crassis carneis. In paludosis. July. Society Hill.

Cap 6–9 lines broad, of a bright pale reddish yellow, darker in the centre. Stem ½ inch high, a line or more thick, composed of longitudinal fibres, subpellucid, pale yellow or carneous. Gills distant, unequal, fleshy. Allied to *H. Cantharellus*, Fr., from which it is readily distinguished by its very mucilaginous pileus and thick gills; and from *H. lætus*, Fr., by its brittle stem.

65. **H. luridus**, Berk. and Curt.;—pileo campanulato umbonato pallide fusco viscosissimo; margine striato crenato; stipite

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10. p. 104.—11. p. 109.—12. p. 145.

fistuloso concolori; lamellis crassis venoso-connexis adnexis albis. In paludosis. July. Society Hill.

Cap 7–9 lines broad, pale brown, darker in the centre. Stipe 1½ in. long, about a line in thickness, composed of longitudinal fibres. Gills ventricose, shortly adnate. Not very closely allied to any species described, except perhaps to *H. unguinosus*, which is however more robust and of different habit.

66. H. COCCINELLUS, Fr.—In terra arenosa humida. Aug. Society Hill.

67. H. CHLOROPHANUS, Fr.—Ad terram inter folia. June. Hillsborough, N. Car.

68. LACTARIUS INSULSUS, Fr.—Ad terram in sylvis. Aestate. Hillsborough, N. C.

Agaricus fuliginosus, *vellereus*, and *camphoratus*, enumerated in a previous paper, belong to this genus.

69. CANTHARELLUS UMBONATUS, Fr.—In sylvis. Oct. R. Island. Mr. Olney.

70. MARASMIUS OPACUS, Berk. and Curt.;—gracilis; pileo convexo ruguloso opaco pulverulento albido; stipite insititio elongato pulverulento-subfurfuraceo pallido; lamellis ventricosis distantibus adnexis. Ad ramulos et folia dejecta in sylvis. Aestate. Society Hill and Santee Canal, S. Car.

Cap about 2 lines broad, sometimes slightly depressed around a central umbo, dirty-white, scarcely striate or sulcate. Stem 1–1½ inch. high, ⅓ of a line thick, of the same color with the cap, furfuraceous toward the base. Gills moderately broad, slightly adnate, with the interstices nearly even. Nearly allied to *M. ramealis*, but, like *M. synodicus*, is far more elongated. From the latter it differs in its rather broad, not vein-like gills; and from *M. candidus*, in its opake pileus.

71. M. PITHYOPHILUS, Berk. and Curt.;—pileo e convexo plano-umbilicato sulcato-striato brunneolo; stipite insititio solido concolore pulverulento-furfuraceo; lamellis fusco-carneis subdecurrentibus. Ad folia Pinea dejecta. July. Society Hill.

Cap 4 lines broad, impressed-striate, dry, submembranaceous, whitish-brown. Stipe ½ in. long, scarcely ½ line thick, firm, subequal, pale or brownish pulverulent, clothed toward the base with minute furfuraceous scales. Gills unequal, forked, undulated. Agrees in habit with *M. fœtens*, but the stem is more opake, and the gills are by no means annulato-adnexed.

72. M. SPONGIOSUS, Berk. and Curt.;—pileo plano albido-fusco; stipite pulverulento basi incrassato spongioso fulvo-villoso; lamellis albidis subconfertis. Inter folia putrescentia in humidis. June, July. Hillsborough, N. C. and Society Hill, S. C.

Cap 4–6 lines broad, darker in the centre, obtuse. Stem 1½ in. long, brown, often much twisted, thickened toward the base and clothed with a tawny villus. Has much the aspect of *M. plancus.*

73. M. SIMILIS, Berk. and Curt.;—pileo membranaceo plicato opaco albido; stipite gracili elongato nitido fusco; lamellis paucis latis adnexis venoso-connexis albidis. Ad terram. July, Aug. Society Hill.

Gregarious. Cap 2–3 lines broad, dull white, smooth, covered with minute wrinkles. Stem 2 in. long, very slender, hardly pulverulent. Gills ventricose. Allied to *M. hæmatocephalus*, Fr., from which it is easily distinguished, at least by color.

M. hæmatocephalus, (No. 2 of these Contributions,) I find also at Society Hill, S. C.; sometimes having a stem 3 in. long with a cap 12–15 lines broad. Mr. Olney has also sent it from Rhode Island.

74. M. GRAMINUM, Berk.!—Ad folia graminum, herbas, etc. in hortis. June. Society Hill.

75. M. VAILLANTII, Fr.—Ad cortices emortuos, e. g. Vitis. Aug. N. and S. Car.

76. M. PLANCUS, Fr.—In sylvis acerosis. R. Island; Mr. Olney.

77. LENTINUS RAVENELII, Berk. and Curt.;—pileo umbilicato submembranaceo striato squamuloso maculato; stipite curto tenui furfuraceo-squamoso; lamellis tenuibus subdistantibus dente-decurrentibus venoso-connexis. Ad lignum putridum in humidis. April. Santee Canal, S. C. Mr. Ravenel.

Scattered. Cap 1–1½ in. broad, plano-convex, white, clothed with minute rufous velvety scales which are crowded and confluent in the centre. Stem 1 in. long, 1 line thick, solid, white, with rufous scales. Gills white, slightly erose. A very pretty species allied to *L. tigrinus*, but much more delicate. The pileus is thin, and in consequence when dry it has an hygrophanous aspect.

78. L. CESPITOSUS, Berk.! in Lea's Catalogue.—Very abundant in N. and S. Car: from July to Nov.; at the base of stumps and on buried roots. When dry it has a kind of acid-sweetish odor not unlike that about a cider-press.

79. PANUS DORSALIS, Fr.—Ad lignum mortuum Pini [et Liquidambaris?] Autumno, Hieme. N. and S. Car.

80. XEROTUS DEGENER, Fr.—Ad terram argillaceam inter muscos. June. Hillsborough, N. C.

81. LENZITES UNGULÆFORMIS, Berk. and Curt.;—albida lignea subtriquetra inæquabilis glabrata nitida; lamellis ligneis latis poroso-ramosis.—Ad lignum aridum. Wilmington, N. Car.

Cap 2 in. broad, 1¼ in. long, ¾ thick, rather elongated, villous when young but becoming smooth and shining; surface unequal, once or twice sulcate, with some trace of almost obliterated villosity towards the margin. Gills broad, thin but woody, branched, and here and there forming sinuous pores.—Allied to *L. betulina*, but more rigid. It also resembles *L. aspera*, but has not the scabrous surface of that species, nor has it the same habit.

82. L. TRICOLOR, Fr.—Ad ramos dejectos in sylvis humidis.—N. and S. C. Item, R. Island. Mr. Metcalf.

83. L. KLOTSCHII, Berk.!—Ad truncos dejectos. Oct.–March. N. and S. Car. Item, R. Island. Mr. Bennett.

84. L. STRIATA, Fr.—Ad lignum aridum. Society Hill and Santee Canal, S. Car.

85. L. CORRUGATA, Fr.—Ad ramos Castaneæ. R. Island. Mr. Metcalf; Mr. Bennett.

86. BOLETUS ELEGANS, Schum.—Ad terram. Aestate. Hillsborough, N. C.

87. B. VERSIPELLIS, Fr.—Ad terram. Aug. Hillsborough, N. C.

88. B. RUBIGINOSUS, Retz.—Ad terram in sylvis. Sept. Hillsborough. N. C.

89. POLYPORUS ARCULARIUS, Fr.—Ad ramos dejectos in humidis. May. Raleigh, N. C.

90. P. BOUCHEANUS, Fr.—Ad ligna. July, Aug. Hillsborough, N. C. Item, Ohio! Mr. Lea; and Penn Yan, N. Y.! Dr. Sartwell.

91. P. CURTISII, Berk.;—pileo excentrico molli-suberoso sulcato zonato ochroleuco hic illic sanguineo-laccato; stipite elongato rugoso sanguineo-laccato; hymenio ex albo ochraceo; poris punctiformibus.—Ad basin truncorum. N. and S. Car.

Cap 3–5 in. broad, convex, more or less grooved and zoned, of a rather soft corky texture, covered with an ochraceous often opake laccate crust which in parts is sometimes sanguineous. Substance toward the tubes cinnamon, above ochraceous, not zoned, traversed with laccate lines parallel to the surface. Margin obtuse. Stipe 2–5 in. long, ½–1 in. thick, uneven, shining. Hymenium white becoming ochraceous and brownish-cinnamon, sometimes partly laccate. Pores not angular, cinnamon colored, stratose within.—This fine species is closely allied to *P. lucidus*, but differs as above. It has also some resemblance to *P. ochreolaccatus*. Mont.

92. P. ELEGANS, Fr.—Ad terram. Aug. R. Island. Messrs. Metcalf and Bennett.

93. P. PES-CAPRÆ, Pers.—Ad terram in montosis. Hillsborough, N. C.

94. P. LOBATUS, Fr.—Ad lignum in terra. Hillsborough, N. C. Item, Santee Canal! S. C. et in Georgia! Mr. Ravenel.—Habet odorem fortem farinæ recentis.

95. P. (Anodermei) CAROLINIENSIS, Berk. and Curt.;—pileo molli-suberoso reflexo postice effuso inæquabili ochraceo-albido subsericeo strigis innatis asperulo subzonato; poris mediis dentatis acie plus minus lacerata.—Ad truncos emortuos Quercus [et Liriodendri?] Autumno, Hieme. S. Car.

Pileus 2–5 in. broad, ½–2 in. long, much effused behind, sometimes nearly resupinate, of a soft corky texture, rugose, slightly silky with innate or raised strigæ which sometimes project from the surface, sometimes nearly smooth with innate fibrillæ; margin acute. Pores of the same color with the cap, middle sized, $\frac{1}{36}$ of an inch broad, dissepiments thin and often broken up; sometimes the edge of the pores is obtuse.—Resembling *P. borealis*, Fr., and *P. Symphyton*, Schwein., of a looser texture than either, and with larger pores than the former.

96. P. (Placodermei) PALUSTRIS, Berk. and Curt.;—pileo carnoso-suberoso dimidiato obtusissimo cute tenui rivulosa nitidiuscula vestito; poris niveis non stratosis minutis angulatis.—Ad Pinum palustrem. Santee Canal. Ravenel.

Pileus 2 in. broad, 1 long, ½ thick, subungulate, clothed with a thin rather shining cracked ochraceous cuticle. Substance white uniform. Pores about two lines long, minute, white within and without, not at all stratose, slightly angular, with thin dissepiments and rather irregular edge.—Nearly allied to *P. officinalis*, but the pores are smaller, pure white, and not at all stratose; nor is the flesh bitter when dry or easily reduced to powder.

97. P. SALICINUS, Fr.—Ad truncos putridos. Santee Canal. Ravenel.

98. P. CARNEUS, Nees.—Ad palos. June. Society Hill.

99. P. (Placodermei) CUPULÆFORMIS, Berk. and Curt.;—pileo pezizæformi e vertice elongato stipitato albido cinnamomeo puberulo; hymenio plano-excavato cinnamomeo; poris minutis.—Ad corticem Rhois copallinæ; S. Car. Castaneæ; R. Island! Mr. Olney. Vere.

Gregarious. Cap 1–1½ line broad, attached by the vertex which is elongated into a short stem, cinnamon clouded with grey, slightly downy. Hymenium sunk below the swollen margin. Pores very minute.—Allied to *P. pullus*. Mont. and Berk.

100. P. (Inodermei) XALAPENSIS, Berk.;—pileo flabelliformi membranaceo zonato sericeo glabrescente; poris parvis dissepimentis tenuibus membranaceis hydnoideo-laceratis.—Ad ramos dejectos cariosos. Oct. Society Hill.

Cap thin, variously lobed, 2–4 in. long, pale, silky, at length nearly smooth and shining, repeatedly but delicately zoned. Hymenium white; dissepiments becoming soon torn and toothed so as to give the appearance of a Hydnum.—Closely allied to *P. elongatus*, Berk.—This species was first discovered in Xalapa by Mr. Harris.

Art. XX.—*Connection between the Atomic weights and the physical and chemical properties of Barium, Strontium, Calcium and Magnesium, and some of their Compounds;* by E. N. Horsford, Rumford Professor in the University at Cambridge.

Read before the Cambridge Scientific Association.[*]

The great discovery of isomorphism by Mitscherlich,[†] and the affiliated one by Kopp,[‡] of the identity of the specific volumes of isomorphous bodies are among the brilliant points in the progress of the chemistry of this century.

The latter seems to have had its origin in a conviction that in the atomic weight of a body—all its attributes have what may be denominated a *product expression*. The factors are *form*, *volume* and *density*. Each may vary, and with it the atomic weight will vary; for example:—the volume and form being constant, increase of density will be accompanied by increase of atomic weight: or form being constant, increase of density will be accompanied by increase of atomic weight, or, density and volume being constant, modification of form will influence the atomic weight.

The object of the following paper is to show that the properties of the metals, barium, strontium, calcium and magnesium, and of their compounds generally, are, in their intensity, in the order of their atomic weights. It will be seen that the law is more true of the first three than of these taken in connection with the fourth.[§]

The signification of the term intensity, as used above, may be thus illustrated. Sulphate of baryta requires 43000 parts of water for its solution. Sulphate of strontia 15029 parts at 11° C.[‖] Sulphate of lime ($CaO, SO_3, 2HO$) in 380 parts of cold water, and 388 parts of hot water,[¶] and sulphate of magnesia with seven atoms of water, 0·799 parts at 18·75°.[**]

	Solubility.	At. W.
BaO, SO_3	43000·00	116·5
SrO, SO_3	15029·00	91·7
CaO, SO_3	460·00	68·
MgO, SO_3	0·79	60·7

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[*] A summary of some of the conclusions arrived at by the author were communicated to the American Association of Geologists and Naturalists, at their meeting in Boston in 1849.

[†] Ann. Chim. Phys., xiv, 172; xix, 350; xxiv, 264, 265. Pogg. Ann., xii, 137; xxv, 300; xlix, 401.

[‡] Pogg. Ann., xlvii, 132; lii, 243–262. Ann. Chem. u. Phar., xxxvi, 1.

[§] It is to be regretted that so little is known of the properties of the compounds of magnesia. Their eminent solubility in water, and the difficulty with which any of the salts of this base may be made to crystallize, have made this field of investigation less inviting than many others.

[‖] Brandes u. Silber, Br. Arch., xxxiii, 61.

[¶] Giese. According to Bucholz, 480 parts cold or hot.

[**] Gay Lussac. The anhydrous sulphate is soluble at 0° C. in 3·885 parts of water.

Here *intensity* is the same as *degree of solubility.* In other words, the solubilities of the above salts are in the order of their atomic weights.

The truth of the general proposition will be apparent from considering the following facts.

I. Barium unites with two atoms of oxygen, and is stable in this state of combination at ordinary temperatures.[*]

Strontium and calcium peroxyds are only known in combination with water.[†]

Magnesium combined with two atoms of oxygen is unknown.

II. Barium, strontium and calcium all oxydate at ordinary temperatures in the air.

Magnesium does not.

III. Barium thrown into water causes decomposition with a stormy evolution of hydrogen gas.

Strontium and calcium are both dissolved with escape of hydrogen.

Magnesium may be washed in water that has been thoroughly freed from air by boiling, without diminution of its lustre.

IV. Baryta moistened with water enters into combination with it, attended by such evolution of heat as melts the hydrate formed.[‡]

Strontia falls with water to a white pulverulent hydrate, with the production of intense heat. Lime similarly treated yields a heat that will fire sulphur.[§]

Magnesia in uniting with water is but slightly heated.[‖]

V. Hydrate of baryta loses none of its water under intense red heat.[¶]

Hydrate of strontia, by long continued red heat, melts, and by higher heat loses all its water.[**]

Hydrate of lime, by moderate red heat without melting, loses its water.

Hydrate of magnesia loses its water below the red heat.

VI. Carbonate of baryta, an hour and a half exposed to the most effective blast furnace heat, loses its carbonic acid.[††]

Carbonate of strontia, loses its carbonic acid in the strong heat of an open fire.[‡‡]

Carbonate of lime is decomposed at a red heat.

Carbonate of magnesia loses its carbonic acid at a moderate red heat.

VII. Selenite of baryta and selenite of strontia are insoluble in water.

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[*] Thenard. Ann. Chem. Phys., viii, 308. Rammelsberg, Pogg., xliv, 558.

[†] Thenard. Ann. Chem. Phys., viii, 313.

[‡] Döbereiner. Schw., vi, 367.

[§] Ann. Chem. Phys., xxiii, 217.

[‖] H. Davy.

[¶] Bucholz u. Gehlen, iv, 258.

[**] Denham Smith. Phil. Mag., ix, 87. Pogg., xxxix, 196.

[††] Abich, Pogg., xiii, 314.

[‡‡] Ibid, 315.

Selenite of lime and selenite of magnesia are slightly soluble in water.

VIII. Biselenite of baryta dissolves with difficulty in water.

The same is true of the corresponding salts of strontia and lime.

Biselenite of magnesia is a doughy deliquescent uncrystallizable salt.

IX. Selenate of baryta is as little soluble as the sulphate.*

Selenate of magnesia is equal in solubility to the sulphate.†

X. Iodid of barium crystallized with an atom of water, is readily soluble in water, but does not deliquesce upon exposure to the air.‡ It is deliquescent.§ It is not fusible.

Iodid of strontium is readily soluble in water.‖ It is fusible below red heat.

Hydrated iodid of calcium may be crystallized. It deliquesces on exposure to the air,¶ and fuses below red heat.

Hydrated iodid of magnesium crystallizes with difficulty, and deliquesces readily.

All decompose, when heated by access of air, into metallic oxyds.

XI. Iodate of baryta with one atom of water is soluble in 1746 parts of water at 15° C. and in 600 of boiling water.**

Iodate of strontia with six atoms of water is soluble in 342 parts of water at 15° and in 110 of boiling water.††

Iodate of lime with five atoms of water dissolves in 253 parts of water at 15° C. and in one hundred and ten parts of boiling water.‡‡

Iodate of magnesia is soluble in water, but has not been further examined.

XII. Bromid of barium with two atoms of water is unaffected by exposure to air.

Bromid of strontium with six atoms of water loses its water at a feeble heat.§§

Anhydrous bromid of calcium deliquesces rapidly in the air. That with one atom of water crystallizes with difficulty from the solution of bromid of calcium.

XIII. Bromates of baryta, strontia, lime and magnesia crystallize with water, the first three with a single atom.

Bromate of baryta loses its atom of water not below 200° C.

Bromate of strontia by 120° C., bromate of lime by 180° C. and bromate of magnesia at ordinary temperatures.

XIV. Bromate of baryta dissolves in 130 parts of cold water.

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* Berz. Pogg., xxxii, 11.

† Berz. Schw., xxiii, 454.

‡ Gay Lussac.

§ O. Henry.

‖ Gay Lussac.

¶ Berthemot. J. Pharm., xiii, 416.

** Rammelsberg.

†† Ibid.

‡‡ Ibid.

§§ Löwig.

Bromate of strontia in three parts; bromate of lime in 1·1 parts, and bromate of magnesia in 1·4 parts.*

XV. When chlorid of barium is formed by leading the vapor of hydrochloric acid over heated baryta, the decomposition is attended with the evolution of heat and a red light. The same phenomena occur in the similar production of chlorid of strontium.

That of chlorid of calcium is attended with heat only.

Chlorid of magnesium cannot be formed in this manner.

XVI. The specific gravity of anhydrous chlorid of barium is 3·7037, of chlorid of strontium 2·8033, of chlorid of calcium 2·0401.†

XVII. When heated in dry air, chlorids of barium, strontium and calcium become alkaline; while chlorid of magnesium remains unchanged.

XVIII. Crystallized chlorids of barium and strontium do not change upon exposure to the air.

The chlorids of calcium and magnesium deliquesce rapidly upon exposure to the air.

XIX. Chlorid of barium is soluble in from 8108–6885 parts of cold alcohol, of 99·3 per ct., and in 4875 parts of boiling alcohol.

Chlorid of strontium is soluble in from 116·4–111·6 parts of cold and in 262 parts of boiling alcohol of 99·3 per ct.‡

XX. Chlorate of baryta requires four parts of water for its solution.

Chlorates of strontia, lime and magnesia deliquesce in the air.

XXI. Chlorate of baryta is insoluble in alcohol.

Chlorates of strontia, lime and magnesia are soluble in alcohol.

XXII. Fluorid of barium is readily soluble in hydrochloric and nitric acids.

Fluorid of calcium is slightly soluble in boiling acids, and fluorid of magnesium scarcely at all in cold or hot acids.

XXIII. Fluorid of barium is soluble in aqueous hydrofluoric acid; fluorid of strontium less; fluorid of calcium a mere trace, and fluorid of magnesium not at all.

XXIV. Nitrites of baryta and strontia do not change in air.

Nitrites of lime and magnesia deliquesce upon exposure to the air.§

XXV. Nitrate of baryta requires 20 parts of water at 0° for solution. Nitrate of strontia 5 parts of cold water. Nitrates of lime and magnesia deliquesce most rapidly in the air.

XXVI. Nitrates of baryta and strontia are not soluble in alcohol. Nitrates of lime and magnesia are soluble.

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* Rammelsberg. Pogg. Ann., lii, 81.

† Karsten.

‡ Fresenius. Liebig's Ann., Bd. lix. 117–128.

§ Mitscherlich.

XXVII. Carbonate of baryta is soluble in 14137 parts of cold, in 15421 of boiling water. Carbonate of strontia in 18045 parts cold water. Carbonate of lime in 10601 of cold and 8834 of boiling water.[*]

XXVIII. Oxalate of baryta with one atom of water is soluble in 200 parts of cold or boiling water.[†]

Oxalate of strontia with one atom of water is insoluble in water[‡]—even in boiling water.[§]

Oxalate of magnesia with two atoms of water only very slightly soluble in water.[‖]

XXIX. Formiate of baryta is soluble in 4 parts of cold water.[¶]

Formiate of lime in 8 parts of cold and in 10 parts at 19° C.[**]

Formiate of magnesia is soluble in 13 parts of cold water.[††]

XXX. Sulphovinate of baryta is soluble in 0·92 parts of water at 17° C.[‡‡]

Sulphovinate of lime is soluble in 0·8 parts of water at 17° C.[§§]

XXXI. Acid urate of baryta is insoluble in water. That of strontia somewhat soluble in hot water. That of lime of difficult solubility. That of magnesia, is soluble in 3500–4000 parts of cold and 150–170 parts of boiling water.[‖‖]

XXXII. Neutral alloxanate of baryta is less soluble than the corresponding salts of lime and magnesia.

XXXIII. The above salts of lime and magnesia are somewhat soluble in alcohol. The salt of baryta is not.[¶¶]

XXXIV. Ferrocyanid of barium ($Ba_2Fe\ Cy_3$) dissolves in 584 parts cold,[***] 1800,[†††] and in 116 parts of boiling water.[‡‡‡]

Ferrocyanid of strontium dissolves in 2 parts of cold and 1 of boiling water.[§§§]

Ferrocyanid of calcium deliquesces in the air.[‖‖‖]

Ferrocyanid of magnesium with 12 atoms of water dissolves in 3 parts of water.[¶¶¶]

It is to be regretted that other properties, including specific gravity, specific heat and light-refracting and heat-conducting power have been so little studied. Still, enough of correspondence and gradation among the properties of the compounds of this group has been shown to establish the general proposition that the intensities of their chemical attributes are in the order of the atomic weights of the metals, and lead to the conviction that other attributes might be found to be in similar gradation of intensity.

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[*] Fresenius. Liebig's Ann., Bd. lix, s. 117–128.

[†] Bucholz. Taschenbuch, 18. 18.

[‡] Scheele.

[§] Wackenroder.

[‖] Graham.

[¶] Arvidson.

[**] Gobel.

[††] Arvidson.

[‡‡] Magnus.

[§§] Marchand.

[‖‖] Bensch. Liebig's Ann., liv, 189–208.

[¶¶] Schlieper, Liebig's Ann., Bd. lv, s. 272-279.

[***] Duflos.

[†††] Porret.

[‡‡‡] Duflos.

[§§§] Bette. Ann. Pharm., xxviii, s. 54.

[‖‖‖] Ittner.

[¶¶¶] Bette. Ann. Pharm., xxii, s. 152; xxiii, s. 115.

The resistance to the passage of an electric current through the fluid solutions of these bodies might, it was conceived, be in the order of their atomic weights.

To ascertain if this supposition were founded, an apparatus was employed an account of which has been published in my paper upon the resistance of fluids to electric conduction,* and may be referred to here, as a perusal of this description will be necessary in order to the appreciation of the application of the law.

The fluids employed were nitrates, hydrochlorates and acetates of baryta, strontia, lime and magnesia.

The baryta and strontia salts were prepared from the sulphids (derived from the native sulphates by reduction with charcoal and rye meal); the lime salts from the hydrate, and the magnesia salts from magnesia alba.

The barium and strontium sulphids were dissolved in the several acids with slight excess of acid filtered, neutralized by addition of hydrates of baryta and strontia to the respective solutions, concentrated by evaporation, crystallized, and the crystals washed and dissolved.

The hydrate of lime was dissolved in the several acids, the solutions kept alkaline by excess of lime to precipitate the iron, filtered, and accurately neutralized.

The magnesia alba, with the aid of heat, was dissolved in the several acids and carefully neutralized.

A saturated solution of chlorid of barium, the least soluble of the salts employed, at 16° C., had a specific gravity of 1·042. The solutions of the other chlorids and remaining salts were with great care brought to the same degree of dilution. Two series of results were obtained with the solutions of chlorid of barium and chlorid of strontium. The series in column I. were with solutions of the specific gravity above mentioned. The series in column II. with these solutions diluted with equal measures of distilled water, presenting in an equal length and breadth of liquid, twice the depth. It will be seen that the resistance was very nearly the same.

The solutions of 1·042 specific gravity were then successively placed within the galvanic circuit, and a constant length, breadth and depth of the liquid maintained, and the obstruction they presented to the electric current replaced by windings of German silver wire. The windings correspond to and express the resistance the liquids severally presented.

Table I. presents the results obtained under the following conditions.

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* Pogg. Ann., Bd. lxx, s. 238, and Amer. J. Sci., vol. v, ii ser., 1848, 343.

Specific gravity of liquid, ... 1·042
Cross section of liquid, ... 0·00172 M.
Length of layer, ... 0·4 M.
Strength of battery, 5 Bunsen's pairs.

The exceptions in relation to the results under II. and III. have already been alluded to.

Column A contains the number of experiments; column B, the degrees of deflection of the magnetic needle as indicated by the galvanometer; column C, the windings and decimal fractions of windings of German silver wire, as indicated by Wheatstone's Regulator.

TABLE I.

		BaO, HCl		BaO, HCl		SrO, HCl		SrO, HCl		CaO, HCl		MgO, HCl
		I.		II.		I		II.				
A	B	C	B	C	B	C	B	C	B	C	B	C
1	14°	37·42	14°	36·04	14°	24·07	15°	28·68	16°13′	22·98	16°15′	23·18
2	11	39·60	12	38·10	13	27·91	12	27·04	15	22·90	19	21·87
3	12	35·50	..	....	15	26·62	12	26·78	15 30	22·95	16	22·80
4	13	34·00	..	....	13	26·88	..	....	15 30	23·84	14	23·71
5		....	..	....	12	27·34	..	....	14	21·75	....	22·89
Average,		36·63	..	37·07	..	26·56	..	27·50	....	22·88	....	22·89

The subsequent experiments were made with the platinum diaphragms ·25 M asunder, the specific gravity 1·042 and the remaining conditions the same as in the experiments above recorded.

It will be observed that the resistance is pretty nearly in the ratio of the diminished length of the layer of liquid in the case of the hydrochlorates. The want of precise correspondence was ascribed to the presence of chlorine upon the platinum plates producing the effect of so-called polarization. The odor of chlorine was remarked in the experiments with the hydrochlorates.

TABLE II.

		BaO, HCl		SrO, HCl		CaO, HCl		MgO, HCl
No. of experiment.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.
1	13°	20·36	12°	17·09	16°	15·12	18°	14·90
2	"	20·73	14	17·38	"	15·19	"	14·60
3	"	21·93	14 ·30′	17·36	"	15·15	"	14·92
4	"	20·45	"	17·81	"	14·70	"	14·72
5	"	20·98	14	17·97	"	15·10	"	14·45
6	"	21·75	"	17·89	"	15·30	"	14·49
7	"	20·75	"	17·65	"	14·54	"	14·99
8	"	20·28	"	17·70	"	15·03	"	13·90
9	"	20·04	"	16·93	"		"	14·05
10	"	20·18	"	17·00	"		"	14·14
11	"	20·94	"	17·03	"		"	14·94
12							"	14·38
Average		20·76		17·34		15·01		14·54

TABLE III.

		$BaO\ NO_5$		$SrO,\ NO_5$		$CaO,\ NO_5$		$MgO,\ NO_5$
No. of experiment.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.
1	14°	31·25	14°	29·31	17°	20·29	16°	17·66
2	"	31·15	"	29·47	16	21·41	"	17·97
3	"	30·25	"	29·26	"	20·47	"	17·90
4	"	31·78	"	28·90	"	21·10	"	17·34
5	"	30·00	"	29·10	15	21·39	"	17·99
6	"	31·20	"	28·76	"	20·81	"	17·72
7	"	30·23	"	28·50	"	20·02	"	17·28
8	"	30·07	"	28·12	"	21·57	"	17·85
9	"	30·37	"	29·22	"	20·45	"	17·01
10	"	30·00	"	28·40	"	20·20	"	17·90
11	"	30·08	"		"	20·10	"	17·21
					"	20·00	"	17·62
					"	20·01	"	17·57
					"	20·15		
					"	20·58		
Average		30·58		28·90		20·57		17·62

TABLE IV.

		$*BaO,\ \overline{A}$		$SrO,\ \overline{A}$		$CaO,\ \overline{A}$		$MgO,\ \overline{A}$
No. of experiment.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.
1	9°·30′	34·48	12°	36·33	12°·30′	36·42	12°	35·26
2	"	34·02	"	36·00	11	36·12	"	34·60
3	"	34·00	12 ·30′	36·97	9 ·30	36·62	"	35·08
4	"	34·50	"	36·00	9	35·00	"	35·29
5	"	34.90	"	36·55	8 ·30	35·31	"	35·69
6	"	34·26	"	37·39	"	35·00	"	35·45
7			"	36·13	"	35·25	"	35·04
8			"	37·25	"	35·39	"	35·09
9			"	36·27	"	35·60		
10			"	37·02				
11			"	37·00				
12			"	36·03				
13			"	36·04				
14			"	37·15				
Average		†42·95		36·50		35·63		35·18

SUMMARY OF RESULTS.

I.

Salts.	Atomic weights.	Results. I.	II.	III.
$BaO,\ HCl$,	152·0	36·63	37·07	20·76
$SrO,\ HCl$,	88·3	26·56	27·50	17·34
$CaO,\ HCl$,	64·5	22·88	. .	15·01
$MgO,\ HCl$,	56·7	22·89	. .	14·54

II.

$BaO,\ NO_5$,	130·5	30·58
$SrO,\ NO_5$,	105·8	28·90
$CaO,\ NO_5$,	82·0	20·57
$MgO,\ NO_5$,	74·2	17·62

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* Length of liquid section ·20 M.

† ·20 gave 34·36, ·25 would give 42·95.

III.

$BaO, \bar{A}$,	127·5	42·95
$SrO, \bar{A}$,	102·8	36·50
$CaO, \bar{A}$,	79·0	35·63
$MgO, \bar{A}$,	71·2	35·18

The above results led to the conviction that all the attributes of these metallic bases and their compounds would probably be found intense in the order of their atomic weights, a conviction which I expressed after presenting a summary of the foregoing results, to the meeting of the American Association in 1847.

I had then projected the scheme of decomposing the several salts of these bases by transmitting steam over them while subjected to heat. Circumstances prevented my realizing this intention, and in the following year, Mr. Tilghman of Philadelphia, to whom my researches could not have been known, as they had not been published, announced the results of a series of most important experiments—under the head of "Decomposing power of water at high temperatures."[*]

Mr. Tilghman found that, while a moderate heat was required to decompose sulphate of magnesia with the aid of steam, a higher one was necessary for sulphate of lime, a still higher one for sulphate of strontia, and the highest of all for sulphate of baryta. Thus, their susceptibility to decomposition is in the order of their solubility, viz.—

1. MgO, SO_3
2. CaO, SO_3
3. SrO, SO_3
4. BaO, SO_3

This research fulfilled my expectations, and it would seem that there can be little hazard in considering the above facts as illustrations of a natural law applying to the group of the alkaline earths.

ART. XXI.—*On the American Prime Meridian;* by Professor J. LOVERING, of Harvard University.

As extensive circulation has been given in the pages of this valuable Journal and otherwise to the views and arguments of those who advocate the adoption of an American prime meridian, it is incumbent on those who entertain serious objections to this important measure to state them fully and frankly; and, if possible, in season to prevent the consummation of a change which they consider uncalled for by the necessities of science and disastrous to commerce. The remarks which I propose to make, at this time, are substantially the same as were prepared in reply

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[*] Chem. Gaz., 1848, p. 181.

to a printed circular addressed to me; which, as it expresses the history of the measure so far as it has yet proceeded, more felicitously than I can hope to do, I take the liberty of introducing here as the preface to what I have to say.

"Cambridge, Mass., Sept. 17, 1849.

Dear Sir,—At the late meeting of the American Association for the Advancement of Science, held at this place, a Committee was appointed upon the subject of an American Prime Meridian, of which you were elected a member.

This committee had its origin in the following circumstances:—

Having been charged by the Hon. William Ballard Preston, Secretary of the Navy, with the duty of preparing for publication the American Nautical Almanac, provided for by the Act of Congress, approved March 3, 1849, I addressed to him a letter concerning the prime meridian to be adopted in the calculation of this work, the selection and determination of which form the first step in my progress.

Mr. Preston, in his reply (dated August 7) to this communication, directed me "to bring the subject of an 'American Prime Meridian' before the American Association for the Advancement of Science, to convene at Cambridge, Mass., on the 14th instant, for the purpose of soliciting the opinions of the principal mathematicians and astronomers upon that highly interesting subject."

In compliance with these instructions, I submitted to the Association a paper,* the same in substance as my letter to the Hon. Secretary, which, upon motion of Professor A. D. Bache, Superintendent of the U. S. Coast Survey, was referred to a committee, consisting of twenty-two members, (whose names are subjoined,) with instructions 'to send a copy of their Report to the Hon. William Ballard Preston, Secretary of the Navy.'

A meeting of as many of this committee as were then present was held, and a sub-committee, consisting of Lieut. Davis, Prof. Bache, and Lieut. Maury, was appointed to conduct the correspondence, and to execute the instructions of the Association.

The persons composing the whole of this committee are so remote from each other as to preclude the possibility of a general meeting to discuss this question, and agree upon any common report; it has been determined, therefore, as the best means of obtaining their views, to address each member of the committee separately.

Accordingly, I have the honor, as chairman of the sub-committee, to transmit to you a copy of the paper presented to the Association by myself, and also of another paper on the Prime Meridian, by Professor Holton, referred to the committee, and to ask your early attention to this communication.

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* See this Journal, viii, 394, November, 1849.

These papers will serve to suggest the principal topics to which your attention is invited, and will, I hope, lead to a free communication of your views and reflections. It is not impossible that the letters of the committee may be hereafter officially called for; you are requested to state, therefore, whether you object to having your letter printed, and, if no objection is given, I shall feel authorized to make it public, if required.

Very respectfully, Your obedient servant,

Charles Henry Davis,
Lieut. U. S. Navy, Sup't Nautical Almanac.

Prof. Joseph Lovering, University at Cambridge, Cambridge.

List of the Committee on the Prime Meridian.

Prof. A. D. Bache, Sup't U. S. Coast Surv'y.
Lieut. M. F. Maury, Sup't Nat. Observat'y.
Prof. F. A. P. Barnard, Univ. State of Ala.
Prof. Lewis R. Gibbes, Charleston, S. C.
Prof. Edward W. Courtenay, Univ. of Va.
Prof. Stephen Alexander, Princeton Coll.
Prof. John F. Frazer, Univ. of Penn.
Prof. H. J. Anderson, New York.
Prof. O. M. Mitchell, Cincinnati.
Prof. A. D. Stanley, Yale College.
Hon. Wm. Mitchell, Nantucket.
Prof. Joseph Lovering, Cambridge.
Prof. William Smyth, Bowdoin College.
Prof. Joseph Winlock, Shelby Coll., Ky.
Prof. Geo. W. Coakley, St. James's Coll., Ky.
Prof. Curley, Georgetown College.
Prof. J. S. Fowler, Franklin Coll., Tenn.
Prof. James Phillips, Univ. of N. Car.
Prof. Wm. H. C. Bartlett, West Point.
Prof. Ebenezer S. Snell, Amherst Coll.
Prof. Alexis Caswell, Brown University.
Lieut. C. H. Davis, Sup't Nauti'l Almanac."

In reply to this circular, I addressed the following remarks, in substance, to Lieut. C. H. Davis, the chairman of the sub-committee of the Committee of the American Scientific Association on the American prime meridian.

Engagements which could not be postponed have prevented me from giving a more prompt reply to the circular addressed to the committee of the American Scientific Association to whom the subject of the American prime meridian was referred. Having read with interest and attention the papers on this subject communicated to the Association by Lieut. C. H. Davis and Professor Holton, I desire to submit the following remarks.

No other matter presented to the Association at its recent meeting seems to me to compare in practical importance with this. Every one must wish to see the influence of the Association, whose opinion on this subject has been solicited, exerted in the right direction, so as at the same time to promote the interests of science and secure the respect and confidence of the community. It is, therefore, with a feeling of responsibility which I would willingly transfer to those worthier to bear it, that I undertake to offer an opinion upon a subject which involves considerable interests, affects the comfort and safety of a large class of citizens, and perhaps also the honor and prosperity of the country through much of her future history.

The real question I have to consider is whether, after having continued to count our longitudes from Greenwich since we have had a political existence, we shall now abandon that prime meridian and substitute an American one in its place. The Committee of Congress to whom was referred, on the 25th January, 1810, the memorial of William Lambert, recommended that "in order," as they say, "to lay a foundation for the establishment of a first meridian in this western hemisphere," it is expedient to make provision by law for determining the longitude of Washington and procuring the necessary instruments for this purpose. No action appears to have been taken by Congress on this report of the committee. Although the subject for many sessions was pressed upon the two houses and various reports were made upon it, it was not until the 3d March, 1821, that a joint resolution was passed, authorizing the President to employ means for determining the longitude of Washington. The arguments used on the occasion represent the measure as the preparatory step for the establishment of an American prime meridian, passing through Washington. Nothing, however, was done by Congress at that time which committed it on the latter question. After the resolution just referred to had been carried partially into effect, repeated efforts were made, during the administrations of Monroe and of Adams, to prosecute the subject farther and establish a National Observatory, but without success.

The good sense of the people has kept them in the right track thus far. Occasionally, in our school atlases, the longitudes in the United States are counted from Washington. In these cases, we generally find on the opposite side of the map the corresponding longitudes as measured from Greenwich. In more important matters, as the regulation of chronometers, the construction of sea-charts and whatever relates to geography and astronomy as well as to navigation, the custom is universal of counting our longitudes from Greenwich. Lieut. Maury has followed this custom in his charts of winds and currents, and Professor A. D. Bache has done the same in his maps of the coast, although he also gives the longitudes as measured from some one of the American meridians.

In 1810, the late Dr. Bowditch declared the meditated change of the first meridian from Greenwich to Washington to be inexpedient, as well as extremely difficult if not impossible unless the government incurred the expense of founding an Observatory and publishing a Nautical Almanac. Dr. Bowditch did not object to a Nautical Almanac or a National Observatory, but he considered a good survey of the coast more necessary than either. The liberality of the government has provided in turn for all three. Because in 1810 Dr. Bowditch urged, in addition to other arguments against an American prime meridian, its impracticability for want of a National Observatory and an American Nautical Almanac, and because he declared the establishment of such an Almanac and such an Observatory to be the only effectual way of bringing an American meridian into use even by our own countrymen, advantage has been taken of this language to prove that, at the present day, this high authority must be considered in favor of an American prime meridian. Such an inference is based on the presumption that whenever any change becomes practicable it is therefore to be desired; and, in the present case at least, it is wholly unwarrantable. Whoever will consult the papers of Dr. Bowditch on this subject in the ninth and tenth volumes of the Monthly Anthology, will be convinced that the principal force of his argument against an American prime meridian, is just as pertinent in 1850 as it was in 1810. With or without an American Nautical Almanac, Dr. Bowditch condemned an American prime meridian as an innovation which would not be "attended with one real advantage."

In a Nautical Almanac, the principal object of which is to give the places of the sun and moon among the stars and planets, at frequent intervals during the whole day, it becomes necessary to select some spot on the earth as the origin of absolute time and the first meridian for longitudes. The superintendent of the American Nautical Almanac is now called on to make his selection. But the establishment and perfect success of an American Nautical Almanac will in no degree be promoted by the selection of an American first meridian, as the basis of its calculations. Lieut. Davis observes: "Our National Observatory at Washington must have existed half a century before it will be able to furnish independent observations sufficient for the determination of a correct theory of the moon or primary planets. But these theories are already calculated from the observations (begun long since and uninterruptedly continued) at the old established observatories of Europe. In preparing new tables I shall avail myself of the Washington observations to the utmost extent of their utility."

Thus it appears that the materials and whatever is most valuable and indispensable for the calculation of an American Nautical Almanac will be and must be borrowed from Europe for many years. I see no reason why we should scruple to reckon from our old prime meridian, even if it do intersect countries to which we lie under such heavy scientific obligations. Certainly, if the British Nautical Almanac is calculated for Greenwich, the American may be also. If both are based on the same identical observations, it can make no difference, either in the dispatch or accuracy of the work, whether the calculations are made at Greenwich or at Washington. Indeed, I think it will appear hereafter that a Nautical Almanac, wherever calculated, which relies on European observations, can be calculated more accurately for an European prime meridian than for an American meridian.

Let us next consider the chief aim contemplated in the establishment of a Nautical Almanac. There can be no doubt that the British Nautical Almanac, at least, was designed for the benefit of seamen exclusively. Before its foundation in 1767, each navigator calculated the places of those bodies which he used in his reckoning for longitude directly from the tables. Thus he was liable to an error of a degree or about sixty geographical miles, in assigning his position at sea. Then it was proposed that the places of the moon and other useful bodies should be calculated from the tables by able astronomers: that these places, corresponding to short intervals during the day, should be published; and that easy means should be furnished for interpolating the place of any one of them at any moment between the hours for which the places are given. As much as possible of the business of navigating the ship was to be anticipated; and as little as possible was to be left to the navigator himself, to be done by him in the hurry and anxiety of the moment. It was supposed, that calculations made under the most favorable circumstances and tested in manifold ways by expert computers, must vastly transcend in accuracy the best that could be made by the most skilful sailor amid the other duties, vexations and perils incident to his profession. Such I believe to have been the design of Nautical Almanacs, whenever and wherever they have been instituted.

The same considerations dictate that no innovations, such as the change of an established prime meridian, whereby fresh perplexities and dangers may be entailed on a profession already too much exposed to uncertainty in every form, should be made without the most clear exhibition of their necessity. I do not suppose that an American sea-captain, qualified to navigate a ship across the Atlantic, is incapable of understanding the relations of different meridians, and of allowing, whenever he compares his reckoning with that kept on board a British vessel, for any difference which may hereafter exist in the established prime meridians of Great Britain and the United States. I only say that this labor, which might generally be done with accuracy, would occasionally lead to mistakes and ought not to be required of the navigator, unless there is some uncontrollable necessity for it. Otherwise, the very class of men for whose benefit an American Nautical Almanac should be designed, will be the most injured by it. I object, therefore, to any change in the prime meridian to which our navigators are accustomed, on the ground that it furnishes new occasion for error, which no one, however careful and however accomplished, can always avoid, and that it introduces a daily inconvenience into the life of every American navigator, and subjects him daily to one new chance of disaster.

Other countries, we are told, in the development of their resources and their science, have established a prime meridian in their own territories: why should not the United States? The example of the European governments can have little value for us in a nautical point of view. Their commerce on the ocean is comparatively circumscribed; and even did they adopt the prime meridian of Greenwich, they are debarred from a free intercourse with each other and with British and American vessels by a strange language. Besides, in countries where the people, from their habits or their landlocked position, are so much more withdrawn from maritime pursuits than we are, we should expect that their almanacs would consult more the want of astronomers and less the convenience of navigators. There is not one of these countries which is not obliged, as soon as it comes out into the ocean, to defer, to some extent, to the meridian of Greenwich in its use of chronometers and charts; and some, having learned by experience the folly of an assumed independence which worked for them real mischief, have already begun to retrace their steps back to Greenwich.

But our own experience and judgment are worth more than the example of any foreign nations. We speak the same language as the British navigator: why should we be at pains to learn a different scientific dialect? Why should we endeavor to forego all the innumerable advantages we derive from our common origin, and discard an existing agreement in regard to scientific standards which other nations have striven so long and hopelessly to consummate? The communication of Lieut. Davis does ample justice to the importance of an universal prime meridian. There is no reason to believe that a single first meridian can ever be established by the common consent of nations. All desire it, but how many will agree upon the choice? Let us not, in the pursuit of this chimera, adopt the temporary expedient of an American prime meridian, and thus renounce an inheritance to which we were born; throw the whole of this great good to the winds: and postpone, as we must for centuries, the realization of the grand desire of all hearts for a universal meridian. So long as America and Great Britain continue to use a single prime meridian, they alone can make that meridian, for all important nautical purposes, a universal prime meridian, and we at least shall enjoy, not in prospect but in immediate fruition, all the substantial advantages of such a meridian.

The foregoing remarks are designed to show that the adoption of an American prime meridian will violate the spirit in which other governments have established Nautical Almanacs, and will entail upon the commerce of the country, for several generations if not forever, an amount of daily inconvenience and danger which, in the aggregate, cannot be overestimated.

I now propose to consider the reasons that are urged in favor of an American prime meridian. The only reason of a scientific character which has been given for the proposed change is founded upon the slight error which still affects the best determined American longitudes as reckoned from Greenwich, arising from our ignorance of the exact breadth of the Atlantic ocean. Assuming the uncertainty which still exists in the corrected longitude of Boston to amount to two seconds of time, as stated by Lieut Davis, this is equivalent to an error of about half a mile in longitude. Half a mile, under the circumstances, is a large error for the astronomer; but to the navigator, who will compare it with other errors to which he is exposed, it will appear quite insignificant. The best chronometers, transported in the British steamers between Liverpool and Boston, are liable to vary four seconds. The errors incidental to the lunar method of calculating a ship's longitude, originating either in errors of the tables or errors of observation, are sufficient to produce an uncertainty, to the amount of ten miles at least, in regard to the position of a ship. The lingering error of half a mile, which still disturbs the longitudes of those American ports whose distance from the continent of Europe is most accurately measured, is small when compared with the fluctuations of chronometers or the doubts which beset the ordinary methods of fixing a ship's position at sea. Whether the error is large or small, important or unimportant, the proposed change of the prime meridian from Greenwich to some spot in America will not contribute in the least to release the navigator from the effects of it. I will suppose a ship which counts its longitude from Greenwich to leave Boston, with its chronometers set at Boston to Greenwich time. These chronometers may differ from true Greenwich time by two seconds, and there may exist an uncertainty to that amount, on arriving upon the European coast, in regard to the precise position of the ship. But when the same ship returns, its chronometers may be set to true Greenwich time. Still the homeward voyage of the navigator will be no surer nor safer than his outward voyage. For, though his chronometers may be correct, he knows not within half a mile the longitude of the port for which his ship is destined. Suppose, the same ship to start again upon another voyage with its chronometers arranged to an American prime meridian. The same difficulties will reappear, though in an inverted order. The captain leaves home with his chronometers set to true American time, but he cannot tell within two seconds the longitude of his European port, and on this account, when he is homeward bound, his chronometers must be stamped by the same error of two seconds. In other words, if we do not know the exact distance from Liverpool to Boston, neither do we know any better the distance from Boston to Liverpool. If the longitudes of American ports as counted from Greenwich cannot be accurately given, neither can the longitudes of any foreign port as counted from an American prime meridian. The importation of a prime meridian from Europe to our own territories will not, I conclude, operate for the improvement of our navigation.

Neither do I believe that our knowledge of American geography will be advanced by an American prime meridian. The longitudes of a large number of places in the United States have already been determined with great accuracy by the usual astronomical methods or by the transportation of chronometers; and the relative differences of longitude between the principal spots on our coast and those cities and observatories whose longitudes are best known will be assigned through the operations conducted by the excellent superintendent of the U. States Coast Survey. Were all our longitudes to be calculated from observations of eclipses, occultations or transits, so rapidly is the number of observatories and observers increasing over the whole country, there is reason to believe that the capital places in all the states and territories would be determined in this way, if not with absolute precision, with all the accuracy that is wanted for the construction of a correct geographical map of the United States. In this case, however, not only might the absolute distances from Greenwich slightly fluctuate, but the relative distances from each other also. For we could hardly expect that the longitudes of all these places, as measured independently from Greenwich, would be determined with equal precision. We should rather suppose that the meridians most remote from Greenwich and less crowded by population would not, in general, be projected so carefully as the nearer and older meridians. But the transportation of chronometers from place to place will give our relative longitudes independently of any uncertainty as to the exact distance between the eastern and western continents. Thus not only will the relative longitudes be known as accurately as they could be with an American prime meridian, but the absolute longitudes of each and all from Greenwich will be known as accurately as the best; so that, hereafter, though the absolute numbers might change by infinitesimal quantities, the relative numbers will be permanent and our map will be permanent. Moreover, the superintendent of the U. States coast survey has applied with triumphant success the admirable telegraph of Professor Morse to the determination of the longitudes of places intersected by the telegraphic wires. The country is already traversed, in every direction, by the grand telegraphic lines, and these will be crossed in a few years, at a multitude of points, by a finer network. If we wait this short time, our relative longitudes will be ascertained with a precision, a simplicity and an economy wholly unprecedented as yet in the scientific history of any country in the world; and without any reference to our first meridian, whatever it may be. The map and the meridians upon it will never fluctuate. The floating error to the extent of half a mile in regard to the exact distance between Greenwich and Washington, or any other spot in America, this error or uncertainty in regard to the breadth of the Atlantic ocean on which so much stress is laid, can produce no more derangement in a map of the whole or any part of the United States, than when we push a map from one side to the other of our table. If we desire to unite a map of the United States with a map of Europe so as to form a map of the world, then the uncertainty in question will manifest itself. But no alteration in our prime meridian from one place to another will remove or diminish it; it is absolutely insurmountable. After we have made our map of the United States and drawn the meridians upon it, the selection of numbers to describe these meridians is a question of convenience rather than of scientific accuracy. If we count these meridians from Greenwich, the difference of two numbers will give the relative difference of longitude between the two meridians to which they are affixed. These differences will be permanent, though the absolute numbers may change by some constant quantity, and the differences as well as the absolute numbers may be placed upon our maps and charts if the convenience of those who use them requires it.

I am not able to see that any other scientific operations will be materially affected by the substitution of an American prime meridian for that of Greenwich. I do not see that the details of the American Nautical Almanac or the calculations of those who use it, whether astronomers, navigators or engineers, will be ensured any greater accuracy by the establishment of an American prime meridian. The uncertainty to the amount of two seconds of time in relation to the distance which separates American from European meridians must vitiate, and, as I believe, to the same extent, all our calculations for practical and scientific purposes, until either the uncertainty itself is removed, or we are prepared to make American science in spirit as well as in form, wholly independent of those precious results which centuries of labor have garnered up at the venerable observatories of Europe. If we use an astronomical ephemeris, calculated in Europe for an European prime meridian, or calculated in our own American almanac from European observations and for an European prime meridian, the uncertainty of which I speak, though it does not affect the ephemeris itself, will affect the application of it to our own meridians. On the other hand, if we undertake to calculate an ephemeris for an American first meridian, this ephemeris, though it may be as good when applied to one American meridian as another, will be inaccurate for all, because it has been calculated from European observations. An astronomical ephemeris, calculated exclusively from a long series of American observations would, I doubt not, be better adapted to the wants of American astronomers and serve more effectually the purposes of

American science than any arrangement which can be made under existing circumstances. No one looks more confidently to the future to realize this maturity of American astronomy than I do; and no one, certainly, will more gladly hail it when it shall have arrived. Long before the advent of that happy day, the principal difficulty which American astronomers now experience will have vanished of itself. For it cannot be that the costly and elaborate operations which the government are now conducting under the supervision of the superintendent of the coast survey, with the object of ascertaining with greater nicety the difference of longitude between Cambridge, U. S. and Greenwich, will be of no avail.

I am aware that an American prime meridian would be of some convenience to the single observatory through which it might pass. It is possible that an ephemeris, calculated for that observatory, could be corrected for other observatories on neighboring meridians with a little more dispatch than an ephemeris calculated for so distant a meridian as that of Greenwich. I presume, however, that a little more time and care will ensure as much accuracy in the latter case as in the former. At any rate, if it should appear that the astronomers of the country and others whose pursuits, scientific or practical, require them to handle such an ephemeris, would be essentially accommodated by one which is calculated for an American first meridian, or if it should appear that, in the opinion of those who have charge of our principal observatories or are otherwise most competent to judge, the interests of astronomical science would be materially advanced by such an ephemeris, it may deserve consideration whether one ought not to be provided for their peculiar benefit and that of the science which they cultivate. But, in our desire to promote the science of astronomy, let us not lose sight of the grand aim contemplated in every nautical almanac; but let us make that in fact what it professes to be in name, *a manual for the advantage and security of seamen.*

In conclusion, I must deprecate any attempt to bring about a change in the first meridian used in this country, by a misplaced appeal to our national pride. This is a question, partly of science, but much more of common prudence; into which, if national honor enter at all, it can only be to forbid the contemplated change. Politically, we are independent of all other nations. But in science, literature, and the arts, we must look to the old world for the most perfect models, and long continue to draw from its rich storehouse much that we prize most highly, in thought and action. We are dependent on the old world, and England particularly, as the child is dependent upon the parent, as each generation is dependent upon those which have preceded it and have contributed to its own greatness and glory. No ingratitude or denial on our part will relieve us from this dependence. By the encouragement which we give to the cultivation of true science in this land, and by the bright example which we hold up to the world of a just as well as a free government, we may hope to pay back a part of the great obligation under which we stand to the older nations of the world and the time-hallowed institutions of Europe.

An American prime meridian will make American science independent in name only, and such an independence can deceive no one but ourselves. Certainly, we shall not be so blind as to be deceived by it. Every thing around us must remind us of our relations with the old world. Our ships are furnished with the chronometers and sextants of Great Britain and France. Our observatories are adorned with masterpieces of art imported from Munich. Our libraries are luminous with the great works of Leibnitz and Newton, Galileo and Laplace. We must wait half a century before we shall have created a fund of observations at our own observatories which will make us independent of similar institutions abroad. How much longer must we wait before we shall have American observations made by American instruments? This is a real dependence. Let us not be humiliated by it, but rather let us take courage from it to imitate, in due season, the honorable achievements in science of the older nations of the world.

But the use of a foreign meridian involves no dependence whatever. We do not hesitate to reckon our latitudes from the equator, though this great circle does not, at present, lie within our own territories. Why should we refuse to count our longitudes from the meridian of Greenwich, even if it be a line intersecting some foreign country? We borrow nothing from Great Britain or any other country when we count our longitudes from Greenwich. It belongs to us and to whoever chooses to use it for this purpose, as much as to them. It belongs to us as much as the English language belongs to us and whatever else that is valuable which we have inherited from our parent of the old world. It belongs to us, for all scientific purposes, as much as the earth's magnetism or the sun's light and heat; as much as the moon, planets and stars; as much as the common atmosphere which warms and feeds us all. There is no property in any of these things. They are the common property of all who think, all over the world; and he most possesses who most uses them.

Should Great Britain and America ever agree to adopt an American prime meridian, it would be a misfortune to us. Should the nations ever agree upon a universal first meridian, the prayer of these United States ought to be that it might not pass across this western continent. Of all nations in the world, we can least afford to sacrifice our coasters to the perpetual annoyance they must experience in crossing it. The meridian of New Orleans, which is recommended by Lieut. Davis as the first meridian of this country, will only furnish a partial remedy for this inconvenience, especially when we consider the new channels opened to our commerce by our enlarged sea-coast on the Pacific. The old maritime nations of the world shifted their first meridian farther and farther westward as their geography and navigation enlarged, that all their commerce might be conducted on one side of it. In this respect also, the meridian of Great Britain is better adapted to the wants of this country than an American prime meridian.

But we cannot expect that Great Britain or any other foreign nation will adopt the American prime meridian. Indeed, it is to be feared that American navigators will not adopt it. They will prefer the British Almanac, calculated for the meridian of Greenwich, to an American Almanac calculated for any other meridian. History declares how difficult it is to effect a revolution in the daily habits of a large class in the community, even where the change is confessedly an advantage to those who adopt it. The change of the prime meridian from Greenwich to America promises no good to any class in the community; it certainly will be attended by great sacrifices and can contribute nothing to our honor or our independence.

The following memorial to Congress, has obtained a large number of signatures in Boston and other seaports of the United States, and been transmitted to Washington.

"The subscribers, merchants, underwriters, and shipmasters of Boston and its vicinity, understanding that a communication has been made by Lieut. Charles H. Davis, of the United States Navy, now charged with the preparation of an American Nautical Almanac, in which it is proposed to change the reckoning of the longitude from the meridian of Greenwich to some place within the United States, beg leave respectfully to submit to you our opinion of this proposed change, and its probable effects upon the navigation of the country.

"The advantages that would result to all commercial nations from marking their longitude from one common prime meridian are too obvious, and have been too often stated, to require any new recital. The evils, however, which might be supposed to result from the great diversity of prime meridians have been of no considerable practical importance to the United States: our navigators have hitherto computed from Greenwich, which, being thus common to them and Great Britain, forms the basis of the longitude of four-fifths of the commerce of the world. This meridian of the English tongue, as it may be called, which is fixed upon all the maps, charts, and books known to our service, it is now proposed to change. We are not possessed, in our own knowledge, of a single good reason for this change; nor can we find any such in the elaborate and ably-drawn argument of Lieut.

Davis. In no single case will the labor of the navigator be abridged, or his knowledge of his place upon the ocean rendered more certain; but, on the contrary, the confusion, incident to the introduction of a new meridian into his books, his charts, and his memory, will be attended with constant perplexity, miscalculation, and mistake, which must cause a serious increase in the hazard of all the lives and property under the American flag.

"Permit us to specify a few of the evils thus predicted:—*1st*, We shall have introduced upon our own coast the east and west reckoning; and although, by making the first meridian at New Orleans, most of the coasting trade will be upon one side of the meridian, yet all vessels passing to the coast of Texas must change their longitude from east to west, and be subject to all the perplexities of that change. *2nd*, It is now the common practice for navigators at sea to communicate to each other their longitude. This practice is exceedingly useful, and has often led to the correction of errors which must otherwise have been fatal. But this is done in the haste of passing, often in storms and partial darkness,—conditions very unfavorable to hearing and understanding with accuracy even the simple numbers that express the degrees and minutes of longitude. But, if the proposed change of meridian is adopted, another element must be introduced in all communications between English and American vessels, and for a long time between American vessels with each other; and the failure to give the reckoning as from Greenwich or New Orleans, or to hear and understand it rightly when given, may involve ship, cargo, and navigators in one common ruin. *3d*, A portion of the charts used by United States navigators are, and must continue to be for an indefinite period, of English construction, and consequently marked with the longitude of Greenwich. To reduce this to the American standard upon a sudden emergency, and when perhaps surrounded by danger, cannot be effected, however simple the operation, by all persons, without occasional error; and it must be remembered, that, in these cases, life and death may hang upon the error of a single mile. Some of these evils may be of a temporary nature, which will pass away in a few generations, with the loss of a limited amount of life and property: others, however, must remain, even after the universal adoption of the new reckoning by all the navigators of the United States, and the substitution of books and charts, for all parts of the world, adapted to the new meridian.

"Against all this perplexity and mischief, which must attend the proposed change, its advocates have not *pointed out a single countervailing practical advantage;* but it is suffered to rest, by Lieut. Davis, upon a *supposed* scientific necessity, and upon considerations in some way connected with our national independence.

"Waiving all observations upon the assumed scientific necessity, save the single one that we are unable to perceive that it is affected in the least degree by the proposed change, we beg leave to add a few words regarding an American meridian, as connected with our national honor or independence. Did we believe it true that the honor or independence of the United States were in the least degree affected by counting our longitude from a meridian line passing through an English Observatory, we would readily encounter all the evils of a change; but we do not believe that any such taint rests upon this practice. We received this mode of counting our longitude, as we received our language, our arts, our names, our very blood, from England, our parent state. The meridian of Greenwich belongs to us, in common with the English nation, by right of inheritance from our fathers, who helped to rear and support the observatory first established there. Our property in this is more clear than in the compass, the chronometer, and many other instruments of navigation; and the same principle of an ideal independence, which shall require us to abandon the meridian of Greenwich, must require us to abandon most of our instruments of art, science, literature, and even our language, for we hold them all by the same tenure; and the question will come to be, not what we shall resign, but what we shall have left. Permit us further to observe, that this state of ideal independence, in marking the longitude, will not be at all attained by the change proposed. It is intended by Lieut. Davis to make the prime meridian *completely dependent upon Greenwich.* It is not to be the meridian of any point arbitrarily assumed at New Orleans, but a line as near as possible to 90 degrees west of Greenwich, which, by a coincidence purely accidental, passes through or near New Orleans. Indeed, the necessities for a continued dependence upon foreign observatories for observations for half a century is distinctly avowed. Without this foreign aid, the proposed almanac could not be prepared. The change, then, will be merely nominal. We shall not reckon our longitude really from New Orleans, but from a point 90 degrees west of Greenwich; and the longitude of Washington, for example, will not be so completely described by saying that it is 12 degrees 56 minutes east of New Orleans, as by calling it 12 degrees 56 minutes east of a meridian 90 degrees west of Greenwich.

"In conclusion, and after a review of the whole subject, we can perceive no reason for abandoning the meridian of Greenwich, or any other of the common property of civilization. If the use of the instruments of art or the methods of science, introduced by other nations, be beneficial to us, the most high-minded and truly independent and national spirit would seem to dictate, not that our practice and usages should be changed, but that we should, by the cultivation and advancement of branches of knowledge, where our efforts can be useful, repay to mankind the advantages which we have received from the common stock of civilization."

ART. XXII.—*On Perfect Musical Intonation, and the fundamental Laws of Music on which it depends; with remarks showing the practicability of attaining this Perfect Intonation in the Organ;* by HENRY WARD POOLE, Worcester, Massachusetts.

(Concluded from page 83.)*

28. THE opinion has been very generally entertained among musicians, that there is a peculiar character belonging to each of the keys. We should not have considered this opinion worthy of notice in this connection, but for the reason that many have attributed this real, or supposed, peculiar character to temperament; for if this peculiarity exists in nature, and is inherent in music itself, it will be especially manifest in a system, or on an instrument, of Perfect Intonation. If, however, temperament is the source of a *variety* which is so highly appreciated by some, it is certainly an argument in favor of temperament, and against Perfect Intonation.

29. We have before us a musical work, of no small reputation, from which we copy the characters, or "complexions," of several of the keys. "C, Bold, vigorous, commanding. D, Ample, grand, noble. D♭, Awfully dark (!) E, Bright, pellucid, feminine. F, Rich, mild, sober. G, Gay and sprightly. A, Golden, warm, sunny. A♭, The most lovely of the tribe; unassuming, gentle, soft, delicate and tender, having none of the pertness of A in sharps. B, (in sharps) keen and piercing. B♭, the least interesting of any, &c., &c." These ideas have been formed and perpetuated by a sort of musical creed, and is said to have for its authority, "the common consent of musicians." It is not so much our purpose to oppose this beautiful theory, as to show, that no argument can be drawn from it to sustain temperament. If temperament be assigned as the cause why the key of A differs in character from the key of A♭, the difference must be found in the fact that one is tempered differently from the other. If tempera-

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* In our article in the last No. of the Journal, we gave a brief account, so far as we were informed, of all the attempts that have been made to attain *Perfect Intonation.* Since the January No. was issued, our attention has been called, with no little surprise, to a recent No. of the Westminster Review, vol. 50, page 253, Am. ed., in which an allusion is made to an improvement in the organ, similar to ours, which has recently been brought out in London, by Col. P. Thompson. Of the details of Col. Thompson's invention we know nothing, as our knowledge is entirely confined to the notice referred to, and there it is alluded to, simply to illustrate some truths, of which we are now endeavoring to convince the American public. It might have appeared remarkable that the same invention should have been made at the same time, after the subject had been reposing so quietly for forty years—the parties being so remote and knowing nothing of what the other was doing—if the history of science did not furnish even more remarkable instances of the kind. If the invention in England is as successful as ours, it will illustrate this simple truth, that, in the course of human events, the time for *Perfect Intonation* has arrived.

ment was adjusted in any uniform manner, through the different classes of instruments, and by different tuners, there would be a show of argument, in the fact, for temperament. But we find no such uniformity; different instruments are tempered in a widely different manner; and on one instrument the key of A is tempered like the key of A♭ on another. If an instrument be tuned in the *equal temperament*—which is the more common and popular—every key is tempered *precisely alike*, and consequently all peculiarity from the cause assigned will disappear. If an alteration of *pitch*, either, be the cause, as some have supposed, of this peculiarity in the different keys, as instruments often vary from one another, in pitch, a semitone, it will often be difficult to decide which is the "soft and tender" key of A♭, and the "pert" key of A. If an organ be tuned correctly in the key of A♭, (or four flats,) and the temperature of the room rise a few degrees, the relative pitch of the whole organ will rise a comma, and the music played in the key of *four flats* will have the *character* (if this theory be correct) of the key of *eight sharps!**

30. Undoubtedly, in perfect intonation, a certain key is frequently more appropriate for a given composition than any other key; but that a certain key gives to music performed in it, any such peculiarity as we have quoted, is (in our opinion) as fanciful as to suppose that the size of the canvas determines the character of the painting. We will suppose a composer has an idea which he would express in a soft and gentle air; thinking that the character of A♭, renders it the most appropriate key for the expression of his idea, he writes his music in that key and arranges it for a quartette. He executes the music, thus arranged, on his piano-forte, and the soft and gentle effect desired is produced. He then gives it to a quartette to perform, without any accompaniment. They take their pitch a semitone higher than his A♭, that is, exactly in his "pert" key of A. Would the composer

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* There is something so very imaginative in this theory of the different keys having different characters, that one might reasonably doubt whether such a theory had any supporters. Such however, we are compelled to say is the fact—it is found in the books, and is taught at the present day, by many teachers of reputation. If any one still doubts the fact, we would refer him to a recent number of the London Quarterly Review, vol. 83, p. 274, Am. ed., where, in an elegantly written article on "Music," the characters and complexions of the several keys afford the writer a theme for many sublime remarks, as if the theory had never been questioned. "A whole Bridgewater treatise" this writer says, "might have been not unworthily devoted to the wonderful varieties of keys alone. He [the composer] knows whether he requires the character of triumphant praise given by two sharps, as in the Hallelujah Chorus of Handel, or the Sanctus and Hosanna of Mozart's Requiem; or the wild demoniac defiance (!) of C minor, as in the allegro of the Freischütz overture; or the enthusiastic gladness of four sharps, as in the song of *Di Piacer;* or the heart-chilling horror (!) of G minor, as in Schubert's Erl King, and all the Erl kings that we have known." A very proper reply to this writer in the Quarterly, can be found in an article on "Greek and Modern Notation of Music," in the volume of the Westminster, to which we have already referred in a previous note.

himself perceive any difference in the effect of his music? We think not; and say moreover, with confidence, that no one, in listening to an instrument, to the pitch of which he is not accustomed, can, with any degree of certainty, decide in what key the music is played. A flute-player may judge correctly as to the key, when listening to an air performed on his own flute—perhaps a flute to which he is not accustomed—for different tones on the flute have different qualities; the high E, for instance, has a different quality from the E♭; but this is admitted to be an imperfection in that instrument, which art has endeavored to obviate. The character of music depends on other things than the *key* in which it is written in. Many "soft and tender" compositions have been written in A♭, and many of an opposite character.

One key is more appropriate for a composition than another, for the reason that there will be employed in that key, a range of sounds which are best adapted to the quality and compass of the voices, or instruments, for which the music was composed. Thus if a melody of this compass, (an octave and a fifth,) were written for a soprano or tenor voice, it would not probably be placed in the key of C, as in that key the highest notes would be too high, and the lowest notes too low for convenient execution. Such a melody would more appropriately be placed in a key in the vicinity of F. Assuming F to be the *best* key for it, we believe that the nearer the key is brought to F, the better will be its effect; that is, the key of D will be better than C, E♭ than D, and E better than E♭. Melodies of small compass may be adapted to several keys. In different collections of music before us, the Hundredth Psalm—whose melody is contained in the compass of an octave—is written in four different keys, viz., F, G, A♭ and A.

31. It is necessary to examine more particularly than we have yet done in this paper, the subject of TEMPERAMENT, if we would fully understand how far the scale of the common organ, with twelve notes in the octave, when arranged in the best possible manner, falls short of fulfilling the requirements of music. As we shall have frequent occasion to refer to a table we gave in the January No. of the Journal, (25.) we reinsert that table, (see next page,) for the convenience of those who may not have that No. at hand. It was shown in (11.) that *four prime intervals* are employed in music, viz., the *octave*, *fifth*, *major third* and *perfect seventh*. It

appears from the table that notes which vary by smaller intervals than a semitone, result from combining these four prime chords. In temperament, these four chords are disposed of in the following manner. The *octave* is tuned perfect. For the *perfect seventh*, no provision is made, and it is rejected altogether. The *thirds* and *fifths* remain, to which alone temperament is applied.

Signatures.	KEY NOTES.	Major Seconds.	Major Thirds.	Dominant Sevenths.	Perfect Fourths.	Perfect Fifths.	Leading notes, Minor scales.	Major Sixths.	Perfect Sevenths.	Major Sev-enths.	Octaves.
5 Sharps.	B^3	$C\sharp^3$	$D\sharp^2$	E7	E^3	$F\sharp^3$	F^{+1}	$G\sharp^2$	A7	$A\sharp^2$	B^3
4 Sharps.	E^3	$F\sharp^3$	$G\sharp^2$	A7	A^3	B^3	$B\sharp^1$	$C\sharp^2$	D7	$D\sharp^2$	E^3
3 Sharps.	A^3	B^3	$C\sharp^2$	D7	D^2	E^3	$E\sharp^1$	$F\sharp^2$	G7	$G\sharp^2$	A^3
2 Sharps.	D^2	E^3	$F\sharp^2$	G7	G^2	A^3	$A\sharp^1$	B^2	C7	$C\sharp^2$	D^2
1 Sharp.	G^2	A^3	B^2	C7	C^2	D^2	$D\sharp^1$	E^2	F7	$F\sharp^2$	G^2
Natural.	C^2	D^2	E^2	F7	F^2	G^2	$G\sharp^1$	A^2	$B^{\flat 7}$	B^2	C^2
1 Flat.	F^2	G^2	A^2	$B^{\flat 7}$	$B\flat^2$	C^2	$C\sharp^1$	D^1	$E^{\flat 7}$	E^2	F^2
2 Flats.	$B\flat^2$	C^2	D^1	$E^{\flat 7}$	$E\flat^2$	F^2	$F\sharp^1$	G^1	$A^{\flat 7}$	A^2	$B\flat^2$
3 Flats.	$E\flat^2$	F^2	G^1	$A^{\flat 7}$	$A\flat^2$	$B\flat^2$	B^1	C^1	$D^{\flat 7}$	D^1	$E\flat^2$
4 Flats.	$A\flat^2$	$B\flat^2$	C^1	$D^{\flat 7}$	$D\flat^2$	$E\flat^2$	E^1	F^1	$G^{\flat 7}$	G^1	$A\flat^2$
5 Flats.	$D\flat^2$	$E\flat^2$	F^1	$G^{\flat 7}$	$G\flat^2$	$A\flat^2$	A^1	$B\flat^1$	$C^{\flat 7}$	C^1	$D\flat^2$

The principle on which it is applied will be seen by the following example. In the table there appear two E's, one obtained by turning a major third from C^2, viz., E^2, and the other, E^3, a comma higher than the first, obtained by tuning a series of *fifths* from the same C^2. It is proposed in temperament to use *one* E for these *two*. It is evident that if E be tuned truly as a major third it will be a comma too flat, in a series of fifths; and also, if it be tuned truly in a series of fifths, it will be a comma too sharp, as a major third. As the error of a comma is *intolerable*,* if occurring in one place, it is usually divided among the four fifths, and

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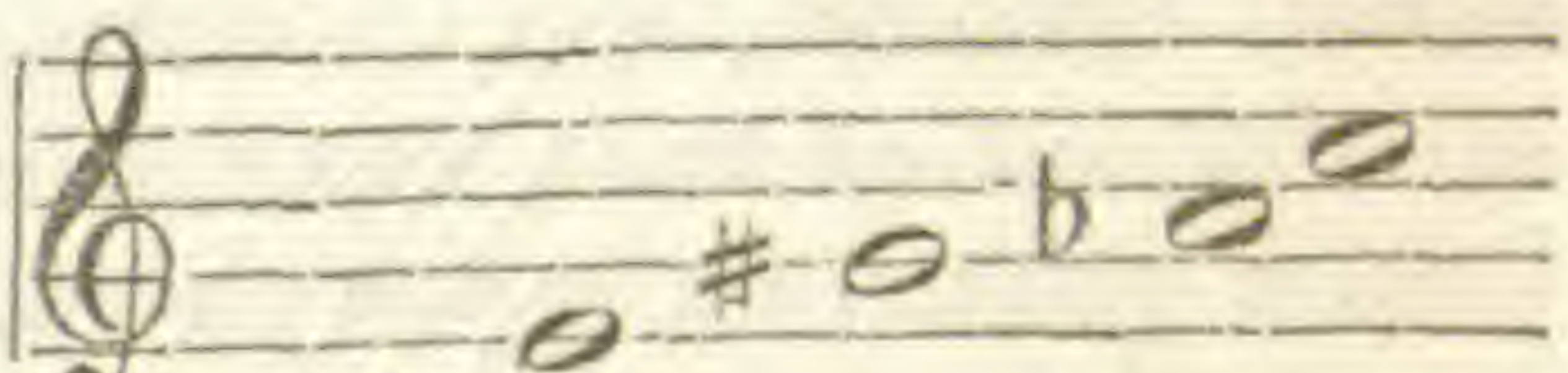
* In correcting opinions on this subject, which, we think, are erroneous, we have already, and shall again refer to Prof. Peirce's treatise "on Sound;" not because the views, to which we take exception, are peculiar to, or original with him. They are also found in other works of the kind of high authority. We have referred to Prof. Peirce's treatise because it is more common, and the learned Professor is at hand to correct us if we err. In treating *Temperament*, in § 108, he says, "The principle on which the reduction of notes is made, is, that if the notes differ from each other by only one vibration in eighty, [or a comma,] the ear can hardly perceive the difference between them, and the substitution of one of them for the other. will not be fatal to harmony." This is another point which the *ear* must decide, and we must set against the Professor's authority not only our own, but the experience of every tuner. Instead of the error of a *comma* being an interval so small that "the ear can scarcely perceive the difference," *a twelfth of a comma* can be, and is, perceived by every intelligent tuner, as this is the interval by which he leaves the fifth flat, in the equal temperament. But a fifth a *whole comma* flat, or sharp, is probably as *discordant*, and "fatal to harmony" as any possible interval.

the major third. By flatting the fifths, the third is prevented from being so sharp, as it would otherwise be; and sharping the third, will, in like manner, benefit the fifths. Temperament, therefore, is a compromise between the thirds and the fifths, in which each gives up more or less of its purity, in order to favor the other series of intervals.

32. Although temperament may be adjusted in many different ways, yet every possible adjustment can be classified under one, or both, of two general systems, called the MEAN-TONE SYSTEM and EQUAL TEMPERAMENT. The first aims to preserve the perfection of the thirds; while the latter sacrifices the thirds, and gives preference to the fifths.

33. The first is called the MEAN-TONE SYSTEM, for the reason that, instead of preserving the distinction between the major tone of *nine commas*, and minor tone of *eight commas*, it averages the two, and makes a MEAN-TONE, of *eight and a half* commas. Consequently the sum of two *mean-tones* equals the sum of a major and minor tone, or a perfect major third. In tuning the E in this temperament, it is tuned a perfect major third from C, or E^2, as we express it, in the table. This E not being high enough, by a comma, for the E in the series of fifths, the error is divided equally among the four fifths, viz., C to G, G to D, D to A, and A to E, and each is left flat by a *quarter of a comma*. The tuning is continued until *eight* notes have perfect major thirds, and fifths that are a quarter of a comma flat. These are all the chords that can be used in an instrument of *twelve* notes in the octave. In this system, a *sharp* cannot be used as a *flat*, as it will be false by the *enharmonic diësis*, or about two commas. This is the interval by which three major thirds fall short of the octave, and it is obtained in this manner. Commencing with C, we tune E, a perfect major third, from this E, tune G♯, a major third; and from C, an octave above the first, tune downward a major third to A♭. This A♭ is not as low as G♯, by the *diësis*, and G♯ will not answer at all for A♭. When common organs, which have but one sound for G♯ and A♭, are tempered on this system, one of these notes, usually A♭, is left so false that it cannot be used. Some organs have an A♭ supplied by a different pipe. The Temple organ, in London, has two notes thus supplied, A♭ and D♯, by the aid of which, that instrument is enabled to play in two scales more than those, tuned in this temperament, which have but twelve sounds in the octave. The mean-tone system bears, in many respects, more resemblance than any other temperament, to the perfect scale. It recognizes a distinction between sharps and flats, diatonic and chromatic semitones, has perfect major thirds, and has its minor thirds nearer to perfection, than in any



other temperament. With these advantages, however, it is justly censured for its discordant fifths, and its "wolfishness" when the modulation is carried into keys, where it is not prepared to play.

34. The EQUAL TEMPERAMENT preserves the fifths nearer to perfection than the mean-tone system, and consequently throws the discord, or "wolf," (as it is termed by tuners,) into the thirds. The fifths, however, although they are favored, are yet not given in perfect tune. It is found in perfect tuning, that a series of twelve fifths will end a comma[*] higher than the note commenced with. In equal temperament, it is designed to make the series meet, and consequently this comma is equally divided among the twelve fifths, leaving each a *twelfth of a comma* flat. If this be accurately done, the octave will be divided into twelve equal parts, and one fifth will be equally as good (or bad) as another. To set this temperament, it is only necessary to temper the fifths carefully, as has been stated, without regarding the thirds at all. The major thirds will be found sharp, by an interval eight times as large as the error in the fifths, that is, *two thirds* of a comma. The minor thirds will be flat *three fourths* of a comma, or the sum of the temperament of the fifth and the major third. As it is designed, in the equal temperament, to have every chord of the same name, equally tempered, the necessity of leaving the thirds in this condition will be further made obvious. The third part of the octave must be used as a major third, and as three *perfect* major thirds do not equal the octave by the *diësis*, each third must be sharped, by one third of the *diësis*, or *two thirds* of a comma. Again, the minor thirds must be each, one fourth of an octave; but four *perfect* minor thirds overrun the octave by *three* commas; this excess therefore is equally divided among the four minor thirds, and each is left flat, by *three fourths* of a comma.

35. The Equal Temperament has this great advantage over all others—its twelve keys can all be used, they are all tempered alike. The ear, too, is better satisfied when all the chords are *equally out of tune*, than when it listens to constant transition from a better to a worse chord. It can also be demonstrated that in equal temperament, the *sum* of the temperament of all the chords—if the instrument be used in the twelve keys—will be less than in any other. Any other than the equal system, is simply an attempt to improve part of the thirds, by sacrificing, not only the fifths, but the remaining thirds.

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[*] This comma, which is called the *Pythagorean comma*, results from combining the octave and fifth, which are derived from the primes 2 and 3; and consequently cannot be mathematically the same as the *comma* before mentioned, resulting from the fifths and thirds, or the primes 3 and 5. The ratio of the last, as before stated, is 80:81; the ratio of the *Pythagorean comma* is 524288:531441 or 80:81,091463091068+. It will be seen that the two commas are very nearly the same, and to consider them the same, will greatly simplify the subject of temperament, while it will not involve any material error.

36. The following table will exhibit the temperament of the principal chords and intervals in the two systems.

	EQUAL TEMPERAMENT.	MEAN-TONE SYSTEM.
Fifths,	$\frac{1}{12}$ of comma Flat.	$\frac{1}{4}$ of comma Flat.
Fourths,	$\frac{1}{12}$ " " Sharp.	$\frac{1}{4}$ " " Sharp.
Major Thirds,	$\frac{2}{3}$ " " Sharp	Perfect.
Minor Sixths,	$\frac{2}{3}$ " " Flat.	Perfect.
Minor Thirds,	$\frac{3}{4}$ " " Flat.	$\frac{1}{4}$ of comma Flat.
Major Sixths,	$\frac{3}{4}$ " " Sharp.	$\frac{1}{4}$ " " Sharp.
Perfect Sevenths,	$1\frac{5}{12}$ " " Sharp.	$1\frac{3}{4}$ " " Sharp.
Major tones and Ninths,	$\frac{1}{6}$ " " Flat.	$\frac{1}{2}$ " " Flat.
Minor Tones,	$\frac{5}{6}$ " " Sharp.	$\frac{1}{2}$ " " Sharp.
Diatonic Semitones,	$\frac{7}{12}$ " " Flat.	$\frac{1}{4}$ " " Sharp.
Chromatic Semitones,	$\frac{5}{12}$ " " Sharp.	$1\frac{1}{4}$ " " Flat.
Grave chro. Semitones,	$1\frac{5}{12}$ " " Sharp.	$\frac{1}{4}$ " " Flat.

37. If we extend the science of music and musical ratios beyond the limits referred to in (8.) the errors from temperament, in the mean-tone system, will be increased by the addition of the diësis. As no provision is made in either system of temperament for the chords of "perfect sevenths," it will be seen from the table that they will be extremely harsh, being false by about a comma and a half. These two systems embrace every advantage that can be found in any, and every intelligent tuner knows that no mixed system embraces advantages beyond either of the original temperaments. It is the quack and pretender only, who professes to unite in one system the advantages of both; in other words, to favor the fifths, as they are in the *equal*, and the thirds, as they are in the *mean-tone* system. It is certain that no new system of tempering twelve sounds, so that they will perform correctly the office of several times that number, has been discovered during the last century, and we think we have shown that such a system never will be discovered, while the laws of nature and the mathematics continue the same.

38. In whatever manner the temperament is set, the best chords are given imperfect, and this imperfection is so obvious that the common ear, entirely unskilled in music, can most readily distinguish between chords that are tempered, and those that are *tuned perfectly*. We are so constituted, however, (and wisely so, of course,) that we can get accustomed, in time, to almost any amount of discord, so that it will not be, to us, disagreeable. It is said that men, whose whole lives are spent in riveting the plates of steamboat boilers, perceive no discord in the harsh clangor of their business. Such artists would probably *prefer* a tempered organ. It is for the natural and uncontaminated, as well as for the cultivated, ear to appreciate fully the beauty and perfection of pure harmony. The best tuners, in our large manufactories are free to confess that there is but little musical satisfaction in leaving

an instrument, which has been constructed carefully in all its parts, *out of tune.*

Notwithstanding the evidence of our senses, that the perfect scale is most pleasing to the ear—notwithstanding the sure deductions from the mathematics, there are those who speak and write against perfect intonation. "Why," it is asked, "if it was intended, in nature, that music should be in *perfect tune*, has a tempered scale been used for so many centuries?" Admit such an objection, and there is an end of all invention and discovery, in this, and every other science. Against the greatest invention of the age—the electric telegraph—the same objection has equal force. So long as no mechanism had been invented, by which more than twelve sounds could be conveniently managed by the performer, we should naturally suppose that organ-builders would manufacture such instruments as we have, and give to them the best tune they could, even if it was somewhat imperfect; but we might *not* have expected, that learned and professedly scientific writers should have attempted to prove, from this fact, that the *nature of music* does not permit its chords to be in *perfect tune.** It has *not* been customary, so far as our information extends, for those

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* Prof. Peirce again says, §115, "It is a mistake to suppose, as some have done, that temperament applies only to instruments with keys and fixed scales. Singers, violin-players and all others who can pass through every gradation of tone, must all temper, or they could never keep in tune with each other, or with themselves."

"Any one, who should keep on ascending by perfect fifths, and descending by octaves and thirds, would soon find his fundamental pitch grow sharper and sharper, till he could at last neither sing nor play; and two violin-players accompanying each other and arriving at the same note by different intervals, would find a continual want of agreement."

With regard to the statement in the first paragraph, we shall now take occasion only to say, that the reverse we believe to be true; and it appears to us contradictory, to assert that singers, to sing *in tune*, must sing *out of tune*, (for this is precisely the meaning of temperament.) If the learned Professor will visit our instrument in Boston, we will satisfy him that, with our instrument as an accompaniment, which does not *temper* in the least, singers find no difficulty in keeping *in tune.*

The second paragraph probably refers to a case like the following, which has often been quoted by those who advocate temperament. "If from C we ascend by four perfect fifths and descend by two octaves and a major third, we find the last note a comma higher than the C commenced with." This is entirely true. Neither can we multiply a number by $\frac{2}{3}$'s, and divide the product by $\frac{1}{2}$'s and $\frac{4}{5}$'s, and reach at length the original number; for this reason, nevertheless, the Professor does not advocate a *temperament* in the mathematics. The supposed trouble with the violin-players who arrive at the same note, by different intervals, is, that they will *not* arrive at the *same note*, but different ones; for if one ascends from C, by *four fifths*, he will arrive at a different note from the other, who ascends from C, by a major third. The first would find himself in four sharps, while the other would be in the natural scale. The first would be playing (as we express it) E^3, the second E^2. The trouble is of the same nature as if two players should attempt to reach the same note, by ascending, one a fourth, and the other a fifth, from the same key-note. But no music requires either of these impossibilities to be done.

It was perfectly proper to treat of *temperament*, in a scientific work of this kind, as showing the best that could be done with twelve sounds, but we think it is to be regretted that imperfections should have been attributed to *music as a science*, which pertain only to the construction of musical instruments.

who profess to treat the *natural sciences*, to charge *nature* with *imperfections*, but rather, if possible, to discover order and system, where only apparent imperfections were visible. Perhaps scientific writers on music are the only exception to this rule. These imperfections, however, belong entirely to their theories, and have no existence in the nature of music. No science—not even the mathematics—can be more *perfect* and harmonious than music, in the department which relates to intonation.

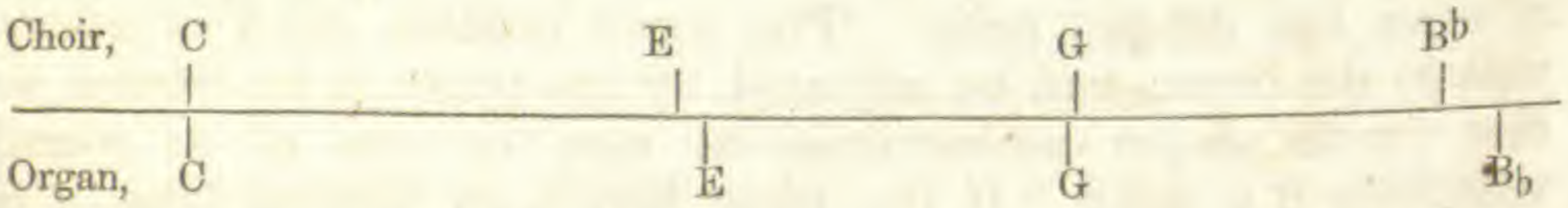
39. But melody and harmony do not produce all the effect of music, for much depends on the quality of tone, rhythm, expression, &c. It is therefore possible that tempered music may be pleasing, if good in these last particulars, although its melody and harmony be imperfect. But it is certain that, *cæteris paribus*, the more perfect the intonation, the more pleasing will be the music. The importance of absolutely perfect harmony is not equally felt in all kinds of music. In dance music, for example, the *rhythm* stands prominent, and although even here the music would be best if performed *in tune*, still, in quick movements, and in the rapid flight of notes, the attention is diverted from the imperfection in the intervals.

40. Church music, perhaps more than any other, depends, for its excellence, almost entirely upon its *harmony*. From church music, are necessarily excluded many qualities which add much interest and character to other kinds of music. As its movement is slow and regular, any excellence or defect in its harmony is most apparent. The instrument which has long been used, and is best adapted as a guide and accompaniment to voices in church music is *the organ*. For this purpose it is *the instrument* of all instruments, as its derivation (τὸ ὄργανον) also signifies. It is superior to all others, in the volume of sound and number of parts which can be brought under the control of a single player—it excels in keeping in tune, and can sustain steadily its sounds for any length of time—it will give its sounds, also, with a certainty which even violins cannot always attain. For although these stringed instruments admit of perfect intonation, yet it requires a skill, which very few artists possess, of always striking at once the desired note. The exact relative pitch of every pipe in the organ can be adjusted by the tuner at his leisure, so that (with proper precautions) he may be sure of its sound whenever it is used. If the tuner leaves an interval false, it is beyond the power of the organist to improve it; in this respect, the violin has an advantage over the organ, for if a string of the violin fall from its true pitch, skill of the artist, in execution, can overcome the difficulty.

41. *Perfect tune* has been for centuries the great desideratum in the organ and instruments of this class. In the tempered organ, the tuner leaves no chord, except the octave, in perfect tune, and

hence whatever the best organist attempts, must be imperfectly done. So long as the organ is used only as a solo instrument, as for a voluntary, a skillful performer is able in some degree to cover up the great imperfection in its tune. By great rapidity of movement, and incessant and startling transitions from key to key, he may divert the ear from criticising the imperfection of the chords. Temperament has doubtless done much to form a style, so prevalent at present among organ players and composers for that instrument—a style neither dignified nor scientific. Organists and composers are not to be blamed for this faulty style, (or a style which *would* be faulty, if their instruments could play in tune;) for being unable to obtain legitimate harmony, and satisfy themselves, or their hearers, with dignified compositions—which show most conspicuously the defects of a tempered instrument—they resort to other expedients to please, and they astonish their hearers with remote and wonderful modulations, and feats of execution.

42. When played with the choir the defects of the organ are most perceptible. As the organ usually plays the same parts which the choir sing, the singers must temper exactly like the organ—which probably no choir was ever trained to do accurately—or there will be a continued want of agreement between them. A *perfect* major third, a child, who has had no musical instruction, will strike most readily and almost unconsciously, for it is in the simple ratio of 4 : 5, and the ear instantly detects the coincidence of the vibrations; but a *tempered* major third, *two-thirds of a comma sharp*, he knows nothing about; it requires the skill of a scientific and well-drilled musician, to give it correctly. If the singers could learn to temper with the organ, it would be at the sacrifice of that pure harmony which they would make if they sung in tune without a tempered accompaniment. The ordinary agreement, (or rather *dis*agreement,) between a choir and organ accompaniment, can be illustrated to the eye by the following example. We will suppose that an organ, tuned in the equal temperament, is accompanying a choir, when it is singing the common chord of C.



The key-note of C will, of course, be the same in the organ and the choir. The fifth G, of the organ will be slightly, but percetibly, flat, viz., one twelfth of a comma. The third E, of the organ, will be very discordant with the choir, being two-thirds of a comma sharp. If B♭, in the chord of the seventh, be added, the discord will be much greater than in either the fifth or the third, the organ being a comma and a quarter too sharp.* The discord is more conspicuous when the organ plays the vocal parts, as above, than when it plays a separate accompaniment, as is sometimes done. A tempered instrument, as a piano-forte, may be properly used in this manner, as an accompaniment only, without impairing materially the perfection of a melody, which is sung by a voice.

43. For many reasons, some of which we have stated, it has long been believed by musicians, that if the organ could be constructed to play in *perfect tune*, and could be managed by the organist, it would be exceedingly valuable for aiding the songs of sacred praise in our churches. It would afford to singers a certain guide and test, and would harmonize perfectly with their voices, when they sing in a manner most satisfactorily to themselves and to all who hear. Having ascertained the notes which are necessary to perfect a requisite number of scales, it would not be difficult to construct an organ with pipes which will give all these sounds, and a wind-chest containing the proper number of valves. But these sounds must be under the ready control of the organist, or the instrument is impracticable. If we represent each sound, on the key-board, by a separate finger-key, an insuperable difficulty in execution presents itself; and it is useless to talk of what the key-board *might* have been made originally. Universal custom has fixed the key-board, and it would be as impossible now to change it, as to introduce a radical change in the orthography of our language. It remains, therefore, to invent such mechanism that the organist, with a common key-board, can conveniently control the sounds which are required to perfect every musical scale, in which the instrument plays. As these difficulties of mechanism have been successfully overcome recently in an instrument, to which allusion has already been made, a brief notice of it may be proper in this place.

44. This instrument, the EUHARMONIC ORGAN, invented and built by Joseph Alley of Newburyport, Mass., and the writer of this paper, is now set up in Boston, and will be exhibited, with pleasure, to all who may take an interest in the progress of musical science. It plays perfectly within the limits of five sharps and five flats, both inclusive. The theory of the instrument renders it perfectly practicable to construct one of any size, or compass of modulation, even to twenty sharps and twenty flats, if de-

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* Any one, who will notice the singing of a good quartette with a tempered organ, may perceive the variation and discord of the organ upon these thirds and sevenths, particularly the last. For this reason these notes are oftentimes omitted, as in chants, to the great improvement in the general effect. Good natural singers, who give their thirds and sevenths correctly, on first singing with an organ, have been accused by organists and conductors ignorant of the matter, of singing *flat*, because by temperament these notes on the organ were *too sharp*.

sired; but it is very rare that we meet, in church music, with a more remote modulation than is provided for in this instrument. The key-board, and the method of fingering, are the same as on the common tempered organ, and the only addition to the player's duties, is the management of certain pedals which must occasionally be pressed, when the music modulates into a different key. The object of these pedals is to enable one finger-key to open either of two or more valves. For example, if the C♯ (or D♭) finger-key be pressed when the music is in the scale of *one flat*, the note wanted is C♯^{1} the leading note to D minor, (see the table;) but if the music is in the scale of *four flats*, a different note, D♭^{2}, is wanted and is given by the same finger-key. The A finger-key opens, in the scale of C, the valve to A^2, and the same finger-key opens, in the scale of G, the valve to the pipe A^3. These pedals are equal in number to the scales or *signatures* in which the organ is designed to play—each pedal belongs to a certain signature, and they are arranged in their natural order, as follows:

MODULATION PEDALS,

&c., 5♭, 4♭, 3♭, 2♭, 1♭, ♮, 1♯, 2♯, 3♯, 4♯, 5♯, &c.

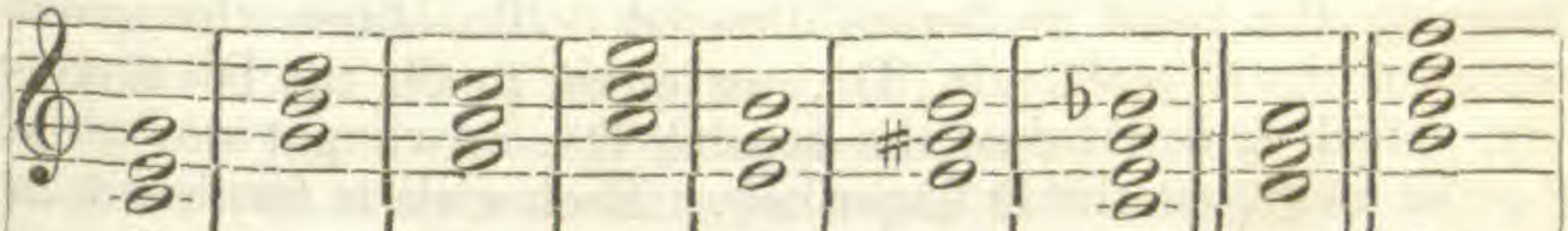
By pressing any one of these pedals, the action is brought into such a position, that the finger-keys will act on those valves (and no others,) which are required in the scale to which the pedal belongs. The act of putting down any pedal will always draw up any other which may be down at the time, and will detach from the finger-keys every valve not wanted in the scale required.

45. To illustrate the practical operation of the organ, we will take a tune, which is entirely in one diatonic scale, as the "Hundredth Psalm" in the key of G. On putting down the 1♯ pedal, the organ is in readiness to play. The valves of the pipes belonging to the scale of G, are connected with the proper finger-keys, and all others are detached; consequently, the playing of this composition on the euharmonic, will be the same as on the common organ. This however is a simple illustration, and before we explain a more complicated one, we must speak further of the plan of the instrument.

46. As but seven, of the twelve, finger-keys are employed to play the diatonic scale in each key, to the remaining five finger-keys are brought on and attached, by the same pedal and at the same time, five other notes, which are set down in the table as "leading notes of the minor scales" and "perfect sevenths," and three others which belong to the adjoining scales. In each pedal will be found the following chords, viz., the tonic, the dominant, and subdominant—the chord of the relative minor (the sixth of the scale,)—the chord of the mediant (the third,)—the major chord of the dominant of the relative minor—and the chord of the sev-

enth upon the tonic. So long as a composition uses no other chords than these, there will be no necessity, of course, to change the pedal. But most compositions either modulate into the adjoining key, (usually the dominant,) or at least pass into an adjoining scale, by using chords which belong to that scale. When a complete modulation is made, it is so apparent in the written music, that no musician of ordinary intelligence can fail to know it. But as certain chords are *borrowed* from an adjoining scale, without a complete modulation being made, and without the change being indicated by accidentals, the whole difficulty in playing the organ, will be in not understanding when these chords occur. A little attention to this point will make it perfectly clear.

47. The chords referred to are only two, viz., the *chord of the relative minor of the subdominant*, and the *chord of the dominant seventh.* The first chord will be found in the *subdominant* pedal—the first pedal to the left; the second will be found in the *dominant* pedal—the first pedal to the right. Examples of the chords we will write in the key of C, including the two last, which would be likely to occur in a composition in that key; we will write also the notes, which compose each chord, and the pedals in which each are found. The chord of the relative minor of the subdominant, is founded, *not* upon the *second* of the scale, but upon the *sixth of the subdominate scale*, which note is a comma lower than the second of the scale, and is called the *grave second;* and this chord is called, for brevity, the *chord of the grave second.* In the example, it will be seen that the only reason for pressing the F pedal is to change the second of the scale of C, viz., D^2, into the *grave second*, D^1, the sixth of the scale of F. Again, in the chord of the dominant seventh, the G pedal is put down to change the fourth of the C scale, F^2, into the perfect seventh of the G scale, F^7.



C	PEDAL	- - -	- - -	- - -	- - -	- - -	F PED	G PED.
						$B\flat^7$		F^7
G^2	D^2	C^2	E^2	B^2	B^2	G^2	A^2	D^2
E^2	B^2	A^2	C^2	G^2	$G\sharp^1$	E^2	F^2	B^2
C^2	G^2	F^2	A^2	E^2	E^2	C^2	D^1	G^2

48. All other chords, than these two, occurring in music, which require a change of pedal, are indicated in notation by *chromatics:* and it is believed that what has already been said is sufficient to enable any one, who possesses sufficient knowledge to play the common organ understandingly, to play the enharmonic organ.

That many who now assume to play the organ in our churches, would find difficulty in playing their music and making the requisite changes with the pedals, we have not the shadow of a doubt. To such we would recomend a course of study, on the scientific principles of music; but that any intelligent organist can readily make these changes, after a few hours' practice, has now been abundantly demonstrated. By practice, the organist will find that the music can be played with much fewer changes of pedals than he would probably make at first. He will find, for instance, that when the dominant seventh is followed by the tonic chord, it will not be necessary to change to the tonic pedal, as both chords are in the dominant pedal. It will be found, again, that the change of pedal, which would otherwise be requisite, to perfect the chord of *grave second*, can be dispensed with, by an arrangement in one action, provided for that purpose. As the first finger-key, below that used for the *second* in the scale, is unemployed, we have attached to it the *grave second*, which is a comma lower than the *second*. When therefore this *grave second* is required, it may be obtained, without touching the pedal, by placing the finger on the first key below the one which gives the *second*. It can be obtained also by the usual fingering—if the player prefers—by changing the pedal as before directed. To obtain the *grave second* of the C scale, viz., D^1, we either touch the D♭ finger-key, which is first below the second, D^2, or we put down the F pedal and touch the D finger-key. Each scale is furnished, in like manner, with its *grave second*.

49. The action—which is the chief mechanical peculiarity in the construction of the organ, and on which the patent is founded—is of such a nature, that it operates as perfectly in practice as we designed it in theory, and it is so substantial in its construction, that it will bear almost any amount of use, and stand almost any number of years, without getting out of order, or needing repairs. It can be applied to the largest instruments, as those which contain the four organs, viz., the Great, the Swell, the Choir, and the Pedal Organs; a single set of pedals will operate, as described, upon the whole at once.

Much of this paper we have devoted to considering, *what sounds are necessary to a certain number of perfect scales?* On these points we have asked not so much, what is *authority?* as, what is *truth?* We have been compelled to differ from teachers in this science, to whom we look up with veneration and respect. So far as our views on these points are original, we commit them, without anxiety, to the world, to share such a fate as their merits deserve. But a distinction must be made between our *theory*, and our *invention*. The value of our invention will not be endangered even if our theory of the musical scale should fail. Our instrument plays the scale which we believe to be correct.

Our mechanism, however, is as well adapted to play any other scale, as the one we have adopted.

The ostensible design of our invention is to produce harmony; but even those who delight in *discord*, can find, in our instrument, a source of attraction. By putting down the modulation pedal belonging, for instance, to the scale of E, and playing in the scale of A♭, they will be furnished with an amount of discord, to which our common tempered instruments bear but a faint approximation. To express the effect, the ordinary term of "wolf" is weak. If this effect be too severe, any less amount of discord, or *temperament*, can be obtained by putting down a less remote modulation pedal. Discords have their appropriate place in music, but their place is *not* in a common chord, or where the composer designed a concord. In such combinations many love *pure* HARMONY, and we are among that number; this can be obtained by putting down the modulation pedal belonging to the scale in which the music is written.

50. As reference has been made to the organ of the Rev. Henry Liston, and also to errors (as we consider them,) in his plan, we will now, as we promised in the early part of this paper, speak of his plan, and show also, in what particulars the two instruments resemble each other. They both had for their object PERFECT TUNE. Both Mr. Liston and ourselves investigated, independently, and *ab integro*, the phenomena of music, to ascertain what sounds were necessary to a requisite number of perfect musical scales. We necessarily arrived at many and the same truths; in several respects also we differed; indeed, our plan was perfected, and the instrument partly completed, before we saw Mr. Liston's Essay.* When we come to the mechanism for carrying into operation our separate plans, all resemblance ceases. In the theory of the two instruments, the great difference is found in the *perfect seventh*, 4 : 7, in the chord of the seventh, for which Mr. Liston made no provision, but used, in its place, the fourth of the scale, 9 : 16. This combination is very discordant, and, when the *ninth* is added, (17.) is so harsh, that in Mr. Liston's opinion, the ninth ought not to be used with the seventh in this manner. Again, he has the major and minor keys of the same letter—as C major and C minor—founded upon the *same key-note* (27.); and he makes the major third of C the key-note of *four sharps*, &c.—thus destroying the *series of perfect fifths* by which the keys should be connected together. In the mechanism

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* We take this opportunity to express our acknowledgment to Dr. Edward Hodges, Musical Director of Trinity Church, New York, for his kindness in voluntarily forwarding to us Mr. Liston's Essay, which is very rare; as it was published by subscription, and only a few copies were printed. We would moreover express to Dr. Hodges, and also to Prof. E. T. Fitch, of Yale College, our thanks for their sympathy and encouragement, when our plans had not so many friends as at present.

there is scarcely a point of resemblance, either in its internal structure or its management by the player. We cannot be expected here to give a description of our machinery, further than is necessary to understand the method of playing it, as it would require drawings to make it intelligible; and besides, we have already, we fear, exhausted the patience of our readers. On our organ, a single pedal will bring on an entire scale, extending through every set of pipes in the instrument, and the operation of the pedals is the same in every key. On Mr. Liston's organ, different keys required different combinations of pedals, with different degrees of difficulty. All the notes of some diatonic scales could not be brought on together by any combination of pedals, as for instance, in the scale of G, the organist could not obtain its second, A^3, and its sixth, E^2, at the same time; for when A^3 was brought on, E^3 always came with it, and A^2 always accompanied E^2.

51. The practicability, therefore, of building an organ which will give its chords in perfect tune, and can be easily managed for all music that is proper for the services of the church, is no longer a matter of speculation and doubt. The organ we have spoken of, has been in constant use for nine months, and has kept in perfect order. Good singers, whose ears have not been accustomed to a tempered accompaniment, agree with it perfectly, giving readily and naturally, all the intervals necessary to Perfect Intonation. Those who have been accustomed to sing with a common organ, require some practice before they have corrected their old habits, they are then prepared to appreciate the distinction between the pure harmony of nature and the discordant harmony of art.

52. Although we have not intended the organ for any music except such as *can be sung*, yet, if any one should write music very difficult, on account of its abrupt transitions from key to key, as for instance, from the key of C to four sharps, thence, straightway into four flats, &c., the music nevertheless can be played if the organist understands it. But probably no singers could sing such a composition without a guide, and any such music, (if any such there be) which cannot be played on the euharmonic organ, is certainly very far beyond the ability of singers to sing. In such music as a leader of good taste would select, the small addition to the duties of the organist is not sufficient to embarrass one of ordinary musical knowledge and skill, and for this extra care he will be richly repaid by the improvement in the harmony. Those who have *felt* the effect of perfect harmony, in the music of a quartette of natural and well drilled singers or violin-players, can form an idea of the harmony of the organ when in perfect tune. In training singers in correct intonation, this organ affords an aid which is invaluable; and to violin-players, it affords a certain guide for stopping their notes in tune.

53. We should not be treating the whole subject, if we did not speak of the relative *expense* of building the enharmonic organ. It can truly be said to be *more expensive*, at the same time, *more economical*, than the common organ. The extra machinery and pipes in this organ render it *more expensive;* its effect, and the musical satisfaction (which is the sole object of the organ, or any musical instrument) derived at a given outlay of money, renders it the *more economical.* The euharmonic organ of a given size and expense, would not contain as many sets of pipes or "stops," as each stop contains more pipes than the common organ, yet each set or *stop* is more effective, in power, than the same stop would be if tempered; for it is well known that musical sounds, which are in harmony, assist and strengthen each other, while discordant sounds neutralize and destroy each other. Besides, a great quantity of *mere sound* will no more afford musical pleasure, than mere painted canvas will satisfy the lover of painting. Church committees, who purchase organs, are not aware (as we organ-builders *could* inform them) that much which they pay for, is *mere trickery and trumpery.* There is, however, a desire, *in* the church, as well as *out* of it, to boast of an organ having as large a number of stops as possible, even if many of these furniture and reed stops, (having foreign names, which they do not understand,) are as inappropriate for the legitimate purposes of church music as a set of Chinese gongs. So long, however, as such a rivalry exists, and such instruments are ordered and paid for, they will be built; for this is the business of organ-builders. It is probable that any one who loves music at all, would prefer the music of a quartette of good singers, to a noisy chorus of fifty, singing no nearer in tune than the tempered organs play. As has been before stated, the theory of the instrument admits it to be of any size and power—the expense to be appropriated, must alone decide that point. This, however, can be stated with certainty, that a euharmonic organ in *perfect tune* and of sufficient size and power to perform satisfactorily the purposes of an organ in church, can be built for the expense which is usually appropriated to the larger class of instruments of *imperfect tune.*

54. Until it had been shown to be practicable by experiment, it was to be expected that a conservative portion of the public would view, with caution, a plan like the present, which proposes such a radical reformation in a system of so long standing as the organ scale. This feeling certainly operated against the plan when we proposed to undertake it two years since. It is with no little gratification that, since the completion of the instrument, it has had the favorable and unanimous opinion of the musical people who have examined it, and the scientific principles on which it is built. We believe it is certain that public musical opinion,

will ere long, among other improvements in the music of our churches, demand that it be given in *pure harmony*, and in accordance with the fixed and demonstrable principles of music.

That music may be investigated with something of the same learning and research which is bestowed upon almost every other science, is an end much to be desired. It will be gratifying to the writer—even if some of his opinions are shown to be incorrect—if his labors in this department of science, shall have the effect of calling to this subject the attention of those who are better qualified to make further investigations, and who can lay them before the public in a more interesting manner.

Note.—In the music example in (18.) page 77, the second lower note in the base clef, should be B♭ instead of D; and the ♭ also should have been placed on the second, instead of the third line. We would here also state that this and several other music examples in this paper were intended as theoretical illustrations, rather than as examples for actual execution.

ART. XXIII.—*On the new American Mineral, Lancasterite;* by Prof. B. SILLIMAN, Jr.

AMONG the minerals associated with the Serpentine of Texas, Lancaster Co., Pennsylvania, received through the kindness of Mr. L. White Williams of Westchester, one has close resemblance to Brucite. On chemical examination it has proved to be a new hydrous carbonate of magnesia, for which I propose the name *Lancasterite.* The following are its characters:—

Foliated like Brucite, affording thin pearly laminæ, inelastic and somewhat flexible. Also small crystals, which appear to be monoclinic (?) with an eminent pearly diagonal cleavage, H = 2·5. G = 2·33 according to my determinations; 2·35, according to H. Erni. Translucent. According to two analyses by H. Erni, it contains,

	1.	2.	Mean.	Oxygen.	
Carbonic acid,	27·07	26·85	26·96	19·61	1
Magnesia,	50·01	50·72	50·36	19·79	1
Protoxyd of iron,	1·01	0·96	0·99	0·21	
Water,	21·60	21·47	21·53	19·14	1
	99·69	100·00			

This gives the formula $\dot{M}g\,\ddot{C}+\dot{M}g\,\dot{H}^2$ = carbonic acid 27·11, magnesia 50·78, water 22·11 = 100. In two other trials the $\dot{H}$ and $\ddot{C}$ together equaled 49·83 and 49·86 after 1½ days drying in the water bath. In a matrass the mineral yields much water.

Before the blowpipe it exfoliates and becomes a little yellowish or brownish, and gives the reaction of magnesia. Dissolves with effervescence in acids.

We observe that Hermann has made a new mineral—which he calls *Pennite*—of the white and greenish incrustation of carbonate of magnesia accompanying Emerald nickel at Texas, Pa., and which, as we have remarked, appears to graduate into the Emerald nickel. He finds for its composition, carbonic acid 44·54, lime 20·10, magnesia 27·02, nickel 1·25, protoxyd of manganese 0·40, alumina 0·15, water 5·84 = 100, giving the formula $3(\dot{Mg}, \dot{Ca}, \dot{Ni})\ddot{C}+\dot{H}$. H = 3·5. G. = 2·86.

We have not yet had opportunity for trials to ascertain how far the water is a constant ingredient.

ART. XXIV.—*Table of Atomic Weights.*

THE recent investigations of science, while evincing the consummate skill of the Swedish chemist, are introducing changes from time to time in the Berzelian atomic weights. These changes are in part the result of *direct* experiment on the particular substances, and in part an *indirect* consequence of these new determinations;—a change of one element involving necessarily a change in those other elements which were determined by using that one in the data. The following table is here inserted as an exposition of the recent results, only a part of which have hitherto appeared in this Journal, and these at distant intervals. In order to render it useful and convenient to the chemist, there are added to it the more common oxyds and sulphurets, and also the oxygen or sulphur per-centage for these compounds.

Hydrogen is taken as a single instead of a double atom, as this appears to be becoming the accepted mode among chemists. In the same manner, chlorine, iodine, bromine, phosphorus, nitrogen, arsenic and antimony, are written as single atoms or equivalents, with double the Berzelian atomic weight.

The multiples of the atomic weights of many of the oxyds are also given, as they save time and trouble, besides rendering accuracy in calculations more certain.

Various authorities are annexed, and different determinations for many of the elements, in order to give the means of comparison and choice to such as would use them, and especially for comparison with the new determinations that may hereafter be made.

The number of elements as now recognized is sixty-two, forty-nine of which are metals. J. D. D.

ALUMINIUM, Al,	170·9	
Alumina, $\dddot{\bar{\text{A}}}\text{l}$,	641·8	(O, 46·74)
2 $\dddot{\bar{\text{A}}}\text{l}$	1283·6	
3 $\dddot{\bar{\text{A}}}\text{l}$	1925·4	
4 $\dddot{\bar{\text{A}}}\text{l}$	2567·2	
5 $\dddot{\bar{\text{A}}}\text{l}$	3209·0	
6 $\dddot{\bar{\text{A}}}\text{l}$	3850·8	
ANTIMONY (Stibium), Sb,	1612·9	
Sul. Antim., Sb S^3,	2212·9	(S, 27·12)
ARGENTUM (Ag) see *Silver.*		
ARSENIC, As,	937·50*	*Pelouze.*
Arsenic Acid, $\overset{\cdot\cdot}{\dddot{\bar{\text{A}}}}\text{s}$,	1437·5	(O, 34·78)
Sulphuret of A., As S^3,	1537·5	(S, 39·0)
AURUM (Au) see *Gold.*		
BARYUM, Ba,	856·8†	
Baryta, $\dot{\text{Ba}}$,	956·8	(O, 10·45)
2 $\dot{\text{Ba}}$	1913·6	
3 $\dot{\text{Ba}}$	2870·4	
4 $\dot{\text{Ba}}$	3827·2	
BERYLLIUM (Be) see *Glucinum.*		
BISMUTH, Bi,	1330·4	
Oxyd of Bismuth, $\dddot{\bar{\text{B}}}\text{i}$,	2960·8	(O, 10·13)
BORON, B,	136·2	
Boracic Acid, $\dddot{\text{B}}$,	436·2	(O, 68·78)
BROMINE, Br,	1000‡	
CADMIUM, Cd,	696·8	
CALCIUM, Ca,	251·49§	*Berz.*
Lime, $\dot{\text{Ca}}$,	351·49	(O, 28·45)
2 $\dot{\text{Ca}}$	702·98	
3 $\dot{\text{Ca}}$	1054·47	
4 $\dot{\text{Ca}}$	1405·96	
5 $\dot{\text{Ca}}$	1757·45	
6 $\dot{\text{Ca}}$	2108·94	
CARBON, C.	75	*Dumas.*
Carbonic Acid, $\ddot{\text{C}}$,	275	(O, 72·73)
2 $\ddot{\text{C}}$	550	
3 $\ddot{\text{C}}$	825	
4 $\ddot{\text{C}}$	1100	
5 $\ddot{\text{C}}$	1375	
6 $\ddot{\text{C}}$	1650	
CERIUM, Ce,	575‖	*Hermann.*
Protoxyd of C. $\dot{\text{Ce}}$,	675	(O, 14·82)
Peroxyd of Cerium, $\dddot{\bar{\text{C}}}\text{e}$,	1450	(O, 20·69)
CHLORINE, Cl.	443·3	
Hydrochlor. Acid, HCl,	455·8	
CHROMIUM, Cr,	328·4¶	*Berlin.*
Oxyd of Chrome, $\dddot{\bar{\text{C}}}\text{r}$,	956·8	(O, 31·35)
Chromic Acid, $\dddot{\text{Cr}}$,	628·4	(O, 47·74)
COBALT, Co,	368·65	
Oxyd of Cobalt, $\dot{\text{Co}}$,	468·65	(O, 21·34)
COLUMBIUM (Tantalum) Ta,	1148·4	
Columbic Acid, $\dddot{\bar{\text{T}}}\text{a}$,	2596·8	(O, 11·55)
COPPER (Cuprum), Cu;	396.6	
Oxyd of Copper, $\dot{\bar{\text{C}}}\text{u}$,	893·2	(O, 11·2)
Oxyd of Copper, $\dot{\text{Cu}}$,	496·6	(O, 20·14)
DIDYMIUM, D,	620 ?	*Marignac.*
ERBIUM, Eb,		
FERRUM (Fe) see *Iron.*		
FLUORINE, F,	237·5	*Louyet.*
Hydrofluoric Acid, FH,	250·0	(F, 95)
GLUCINUM (Beryllium), Be,	58·084**	*Awd.*
Glucina, $\dot{\text{Be}}$,	158·084	(O, 63·26)
GOLD (Aurum), Au,	2455††	
HYDRARGYRUM (Hg) see *Quicksilver.*		
HYDROGEN, H,	12·5‡‡	
Water, $\dot{\text{H}}$,	112·5	(O, 88·89)
2 $\dot{\text{H}}$	225·0	
3 $\dot{\text{H}}$	337·5	
4 $\dot{\text{H}}$	450·0	
5 $\dot{\text{H}}$	562·5	
6 $\dot{\text{H}}$	675·0	
7 $\dot{\text{H}}$	787·5	
8 $\dot{\text{H}}$	900·0	
9 $\dot{\text{H}}$	1012·5	
IODINE, I,	1586	
IRIDIUM, Ir.	1232	
IRON (Ferrum), Fe,	350§§	
Protoxyd of Iron, $\dot{\text{Fe}}$,	450	(O, 22·22)
2 $\dot{\text{Fe}}$	900	
3 $\dot{\text{Fe}}$	1350	
4 $\dot{\text{Fe}}$	1800	
5 $\dot{\text{Fe}}$	2250	
6 $\dot{\text{Fe}}$	2700	
Peroxyd of Iron, $\dddot{\bar{\text{F}}}\text{e}$,	1000	(O, 30)
KALIUM (K) see *Potassium.*		
LANTHANUM, La,	588‖‖	*Marignac.*
Protoxyd of L., $\dot{\text{La}}$,	688	(O, 14·55)
Peroxyd of L., $\dddot{\bar{\text{L}}}\text{a}$.	1476	(O, 20·33)
LEAD (Plumbum), Pb,	1294·6	
Oxyd of Lead, $\dot{\text{Pb}}$.	1394·6	(O, 7·17)

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* 938·8, *Berzelius.*

† 854·85, *Berzelius*, taking chlorine at 443·20, and silver at 1349·01.—858·08, *Pelouze;* 856·77, *Marignac.*

‡ 999·98, *Marignac.*

§ 250, *Dumas*, and *Marchand and Erdmann.* This gives for $\dot{\text{Ca}}$ 350 (O, 28·57).

‖ 572·8, *Rammelsberg;* 576·97, *Beringer;* more recent, (1849), 590·8, *Marignac*, which gives for $\dot{\text{Ce}}$ 690·8 (O, 14·48), and for $\dddot{\bar{\text{C}}}\text{e}$, 1481·6 (O, 20·25).

¶ More recently 334, *Moberg*, which gives for $\dddot{\bar{\text{C}}}\text{r}$ 968 (O, 31); and for $\dddot{\text{Cr}}$ 634 (O, 47·3).

** According to Kobell and Awdejew, glucina is a protoxyd. Yet some distinguished chemists still consider it a peroxyd, like alumina; making glucinum (Be) 331·26, and glucina ($\dddot{\bar{\text{B}}}\text{e}$) 962·52 (O, 31·17); or Be 87·12 and $\dddot{\bar{\text{B}}}\text{e}$ 474·24, *Berz.*

†† 1227·75, *Berz.*, corrected by Pelouze for the new atomic weight of quicksilver. *Pelouze* has recently obtained 1227·45. Most chemists now double this number as above.

‡‡ 12·48, *Berzelius.*

§§ 350·527, *Berzelius;* more recently, 349·8, *Svanberg* and *Norlin.*

‖‖ 554·88, *Rammelsberg;* 600, *Hermann;* 580, *Mosander.* The last is a mean of the different determinations, and gives for $\dot{\text{La}}$ 680 (O, 14·7), and for $\dddot{\bar{\text{L}}}\text{a}$ 1460 (O, 20·55).

LIME, see *Calcium.*		
LITHIUM, Li,	81·66	
Lithia, $\dot{\mathrm{L}}\mathrm{i}$,	181·66	(O, 55·05)
MAGNESIUM, Mg,	154·5*	*Svanb.*
Magnesia, $\dot{\mathrm{M}}\mathrm{g}$,	254·5	(O, 39·3)
2 $\dot{\mathrm{M}}\mathrm{g}$	509·0	
3 $\dot{\mathrm{M}}\mathrm{g}$	763·5	
4 $\dot{\mathrm{M}}\mathrm{g}$	1018·0	
5 $\dot{\mathrm{M}}\mathrm{g}$	1272·5	
6 $\dot{\mathrm{M}}\mathrm{g}$	1527·0	
MANGANESE, Mn,	344·7	
Protoxyd of M., $\dot{\mathrm{M}}\mathrm{n}$,	444·7	(O, 22·47)
2 $\dot{\mathrm{M}}\mathrm{n}$	889·4	
3 $\dot{\mathrm{M}}\mathrm{n}$	1334·1	
4 $\dot{\mathrm{M}}\mathrm{n}$	1778·8	
Peroxyd of M., $\dddot{\bar{\mathrm{M}}}\mathrm{n}$,	989·4	(O, 30·32)
2 $\dddot{\bar{\mathrm{M}}}\mathrm{n}$	1978·8	
3 $\dddot{\bar{\mathrm{M}}}\mathrm{n}$	2968·2	
4 $\dddot{\bar{\mathrm{M}}}\mathrm{n}$	3957·6	
MERCURY (Hg) see *Quicksilver.*		
MOLYBDENUM, Mo,	575·83†	*Svanb.*
Molybdic Acid, $\dddot{\mathrm{M}}\mathrm{o}$.	875·83	(O, 34·3)
NATRIUM (Na) see *Sodium.*		
NICKEL, Ni,	369·33	
Protoxyd of Nickel, $\dot{\mathrm{N}}\mathrm{i}$,	469·33	(O, 21·3)
NIOBIUM, Nb,		
NITROGEN, N,	175·06	
Nitric Acid, $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$,	675·06	(O, 74)
2 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$	1350·12	
3 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$	2025·18	
4 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$	2700·24	
NORIUM,		
OSMIUM, Os,	1242·6	
OXYGEN, O,	100	
PALLADIUM, Pd,	665·48	
PELOPIUM,		
PHOSPHORUS, P,	392‡	*Berz.*
Phosphoric Acid, $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$,	892	(O, 56·05)
2 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$	1784	
3 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$	2676	
4 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$	3568	
PLATINUM, Pt,	1232·08	
PLUMBUM (Pb) see *Lead.*		
POTASSIUM (Kalium), K,	488·86§	
Potassa, $\dot{\mathrm{K}}$,	588·86	(O, 16·98)
2 $\dot{\mathrm{K}}$	1177·72	
3 $\dot{\mathrm{K}}$	1766·58	
4 $\dot{\mathrm{K}}$	2355·44	
QUICKSILVER (Hydrargyrum), Hg,	1250‖	
RHODIUM,	651·96	
RUTHENIUM, Ru,	*undetermined.*	
SELENIUM, Se,	495·3¶	
SILICIUM, Si,	277·31**	*Berz.*
Silica, $\dddot{\mathrm{S}}\mathrm{i}$,	577·31	(O, 51·96)
2 $\dddot{\mathrm{S}}\mathrm{i}$	1154·62	
3 $\dddot{\mathrm{S}}\mathrm{i}$	1731·93	
4 $\dddot{\mathrm{S}}\mathrm{i}$	2309·24	
5 $\dddot{\mathrm{S}}\mathrm{i}$	2886·55	
6 $\dddot{\mathrm{S}}\mathrm{i}$	3463·86	
7 $\dddot{\mathrm{S}}\mathrm{i}$	4041·17	
8 $\dddot{\mathrm{S}}\mathrm{i}$	4618·48	
9 $\dddot{\mathrm{S}}\mathrm{i}$	5195·79	
SILVER (Argentum), Ag,	1350††	
Sulphuret of S., AgS,	1550	(S, 12·9)
SODIUM (Natrium), Na,	287·2‡‡	
Soda, $\dot{\mathrm{N}}\mathrm{a}$,	387·2	(O, 25·83)
2 $\dot{\mathrm{N}}\mathrm{a}$	774·4	
3 $\dot{\mathrm{N}}\mathrm{a}$	1161·6	
4 $\dot{\mathrm{N}}\mathrm{a}$	1548·8	
STANNUM (Sn) see *Tin,*		
STIBIUM, (Sb) see *Antimony.*		
STRONTIUM, Sr,	548§§	*Pelouze.*
Strontia, $\dot{\mathrm{S}}\mathrm{r}$,	648	(O, 15·43)
SULPHUR, S,	200‖‖	
Sulphuric acid, $\dddot{\mathrm{S}}$,	500	(O, 60)
TANTALUM (Ta) see *Columbium.*		
TELLURIUM, Te,	801·8	
TERBIUM, Tb,		
THORIUM, Th,	743·86	
Thoria, $\dot{\mathrm{T}}\mathrm{h}$,	843·9	(O, 11·84)
TIN, (Stannum), Sn,	735·3¶¶	
Oxyd of Tin, $\ddot{\mathrm{S}}\mathrm{n}$,	935·3	(O, 21·38)
TITANIUM, Ti.	314·7***	
Oxyd of Titanium, $\dddot{\bar{\mathrm{T}}}\mathrm{i}$,	929·4	(O, 32·28)
Titanic Acid, $\ddot{\mathrm{T}}\mathrm{i}$,	514·7	(O, 38·86)
TUNGSTEN (Wolframium) W,	1188·4	
Tungstic Acid, $\dddot{\mathrm{W}}$,	1488·4	(O, 20·16)
URANIUM, U,	750†††	*Peligot.*
Protoxyd of U., $\dot{\mathrm{U}}$,	850	(O, 11·76)
Peroxyd of U., $\dddot{\bar{\mathrm{U}}}$,	1800	(O, 16·66)
Protoperox. of U., $\dot{\mathrm{U}}\dddot{\bar{\mathrm{U}}}$,	2650	(O, 15·10)
VANADIUM, V,	856·9	
WATER, see *Hydrogen.*		
WOLFRAMIUM (W) see *Tungsten.*		
YTTRIUM, Y,	402·5	
Yttria, $\dot{\mathrm{Y}}$,	502·5	(O, 19·90)
ZINC, Zn,	406·6	*Erdmann.*
Oxyd of Zinc, $\dot{\mathrm{Z}}\mathrm{n}$,	506·6	(O, 19·74)
ZIRCONIUM. Zr,	419·73	
Zirconia, $\dddot{\bar{\mathrm{Z}}}\mathrm{r}$,	1139·5	(O, 26·3)

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* 158·14, *Berzelius;* 151·33, *Scheerer.*

† 596·1, *Berzelius,* revised.

‡ 400·10, *Pelouze.*

§ 488·856, *Berzelius;* 487·004, *Maumené.*

‖ 1247·33, 1248·21, 1249·27, *Svanberg;* 1250·6, *Erdmann and Marchand;* 1250, (nearly a mean of these determinations), *Millon;* 1251·29, *Berz.*

¶ 491, Sacc.

** 266·742, *Pelouze,* more recent; 277·778, *Berzelius* revised.

†† 1349·66, *Berzelius;* 1349·01, *Marignac;* 1350·32, *Maumené.*

‡‡ 287·17, *Pelouze;* 390·9, and later revision, 289·73, *Berzelius.*

§§ 545·93, *Berz.*

‖‖ 200·75, *Berzelius,* making sulphuric acid 500·75 (O, 59·91); 200·02, *Erdmann and Marchand,* considering 1250·6, the equivalent for quicksilver.

¶¶ Recently, 725, *Mulder.*

*** 301·55, *Berzelius;* 303·3, *H. Rose;* 295·8, *Mosander;* 314·69, *Pierre.*

††† 746·34, *Wertheim;* the earlier results give 2711·4, making $\dddot{\bar{\mathrm{U}}}$=5722·72 (O, 5·24).

ART. XXV.—*On the Isomorphism and Atomic Volume of some Minerals;* by JAMES D. DANA.*

HAVING perused recent statements by Prof. G. Rose respecting some anomalous cases of isomorphism, and also having remarked that the chemically unlike minerals chrysoberyl and chrysolite were essentially alike in form, I was led to a farther search for such singular anomalies among minerals in order to elicit the principle upon which they depend. The results of the investigation have proved interesting beyond what was expected, and are detailed in the following pages.

Before proceeding with them, the facts observed by Prof. Rose should be mentioned. He points out the relations of bismuth, arsenic and some other metals,† and also shows that specular iron and alumina are isomorphous with them, as seen in the following table.

Osmium,	R:R=84°52′	Bismuth,	R:R=87°40′
Iridium,	84 52	Palladium,	undetermined.
Arsenic,	85 04		
Tellurium,	86 57	Corundum (alumina) $\overset{\cdots}{\bar{\mathrm{A}}}\mathrm{l}$	R:R=86 4
Antimony,	87 35	Specular iron ($\overset{\cdots}{\bar{\mathrm{F}}}\mathrm{e}$)	85 58
		Titanic iron ($\overset{\cdots}{\bar{\mathrm{F}}}\mathrm{e}$, $\ddot{\bar{\mathrm{T}}}\mathrm{i}$)	85 59

Prof. Rose also gives the following parallel groups of isomorphs.‡

1. *Form that of Calc Spar.*

		R:R
a. Calc spar and isomorphs	$\dot{\mathrm{R}}\ddot{\mathrm{C}}$	105° – 107°40′
b. Nitrate of soda	$\dot{\mathrm{N}}\mathrm{a}\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$	106 33
c. { Dark red silver ore	$3\mathrm{AgS}+\mathrm{SbS}^3$	108 18
Light red silver ore	$3\mathrm{AgS}+\mathrm{AsS}^3$	107 36

2. *Form that of Arragonite (dimorph with the preceding).*

		M:M
a. Arragonite, white lead ore, &c.	$\dot{\mathrm{R}}\ddot{\mathrm{C}}$	116° – 118°30′
b. Nitrate of potash	$\dot{\mathrm{K}}\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$	119
c. Bournonite	$3(\bar{\mathrm{C}}\mathrm{u}, \mathrm{Pb})\mathrm{S}+\mathrm{S\acute{b}S}^3$	115 16

Many examples of this kind of isomorphism have come to light in the course of the research; and moreover an explanation is at hand in *the relations of atomic volume*—the same principle appealed to by Kopp for explaining the cases of ordinary isomorphism.

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* The atomic numbers adopted in the body of the preceding table have in a few instances been slightly changed, since this article was printed: in such cases, the numbers employed in the following pages will be found in the notes to the table.

† On the rhombohedral metals. Monatsb. der Königl. Preuss. Akad. der Wissenschaften zu Berlin, April, 1849, p. 137.

‡ In an article "on a remarkable analogy of form between certain sulphur and oxygen salts," Monatsbericht der Köingl. Preuss. Akad. d. Wissenschaften zu Berlin, Jan., 1849, p. 13. Pogg. Annal., lxxvi, p. 291.

Rammelsberg endeavored to apply this principle in accounting for the relations of epidote and different varieties of orthite.* As is customary in such investigations, he determined the atomic volume of the compounds and compared the ascertained numbers with one another. But the relation obtained was not sufficiently simple to be wholly satisfactory. One additional step seems to throw farther light on the subject, and leads to general conclusions not otherwise apparent. This step consists simply in *dividing the aggregate atomic volume of the compound by the number of atoms of the elements present.* Unlike compounds are thus reduced to a single standard. The correctness of such a step is proved by the general correspondence obtained between likeness of form and volume. The relations between the *aggregate* atomic volume of isomorphous compounds is in many cases necessarily complex; for we find that this relation is expressed most nearly by the proportional number of molecules of elements in those compounds. Between ryacolite and loxoclase, for example, this relation is that of 15 : 19, and between labradorite and anorthite, that of 15 : 37 (see page 233).

That the subject may be fully illustrated and the facts on all sides fairly exhibited, I have in the following pages given with equal detail, (A) the aggregate atomic volume; (B) this aggregate atomic volume divided by the number of atoms of acids and bases; and (C) the same divided by the number of atoms of the elements. The peculiar interest of each of these modes of viewing the atomic volume will thus be clearly shown: and while not underrating the ratios ascertained by the *first*, we think that an additional value will be found in the relations developed by the *third* method; and also that some importance may attach to the *second*. In some cases the (B) relation is singularly close and of interest. The atomic volumes of alumina and arsenic are almost identical (161·7 and 163); while if we divided by 5, the number of atoms in alumina, it gives, instead of a ratio of equality, the ratio of 1 : 5. These modes of viewing the subject of atomic volume appear to open the way for important conclusions bearing upon some of the most recondite points in chemical science.

Hermann has written at considerable length upon isomorphism among compounds of unlike atomic constitution.† He has confined himself almost exclusively to pointing out such well known cases as the chemically unlike varieties of epidote, scapolite, etc., (which the crystallographer has often united and the chemist as often pulled asunder)—besides some acknowledged instances of isomorphism. He has introduced for such cases the new term *heteromerism*, a term of indefinite signification, since all com-

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* Poggendorff's Annalen, 1849, No. 1, lxxvi, p. 80.

† Erdmann und Marchand's Journal für Praktischen Chemie, xliii, 35.

pounds of *unlike* atomic proportions are heteromerous, whether isomorphous or not.

Without farther introduction I proceed with the details of the observations—mentioning, first, some of the prominent cases of isomorphism among unlike compounds; and then giving the researches into the atomic volume of these and other species.

I. CHRYSOBERYL, $\dot{\mathrm{Be}}\,\dddot{\bar{\mathrm{A}}}\mathrm{l}$—CHRYSOLITE, $(\dot{\mathrm{Mg}}\,\dot{\mathrm{Fe}})^3\,\dddot{\mathrm{Si}}$—SERPENTINE, $2\dot{\mathrm{Mg}}^3\,\dddot{\mathrm{Si}}^2+3\dot{\mathrm{Mg}}\,\dot{\mathrm{H}}^2$—EPSOM SALT, $\dot{\mathrm{Mg}}\,\dddot{\mathrm{S}}+7\dot{\mathrm{H}}$—VILLARSITE, $4(\dot{\mathrm{Fe}},\dot{\mathrm{Mg}})^3\,\dddot{\mathrm{Si}}+3\dot{\mathrm{H}}$—PICROSMINE, $2\dot{\mathrm{Mg}}^3\,\dddot{\mathrm{Si}}^2+3\dot{\mathrm{H}}$.

The magnesian minerals, Chrysolite, Serpentine and Villarsite, are well known to be isomorphous, and have been the subject of recent remarks by Hermann.* We now add the totally unlike minerals, Chrysoberyl and Epsom salt.

A brachydiagonal prism in Chrysolite has the angle 80° 53′, a corresponding one in Chrysoberyl 119° 46′. The tangents of half these angles are nearly as 1 : 2; and a vertical prism of the former has the angle 49° 50′ and one of Chrysoberyl 70° 40′, giving the relation of 1 : 1½. The former planes, referred to the same fundamental form, are respectively $\breve{P}\infty$ and $2\breve{P}\infty$, and the latter ∞P and $\infty P\frac{3}{2}$. The crystallographic axes of these species as given by von Kobell are as follows:—

	a.		*b.*		*c.*
Chrysoberyl, ...	0·58	:	1	:	0·47
Chrysolite, ...	1·1733	:	1	:	0·93

The ·93 of Chrysolite it is seen is double of ·47 in Chrysoberyl, and 1·1733 is double of 0·58 showing a simple ratio. If we take for Chrysolite the vertical prism above alluded to (49° 50′) as the prism ∞P, it gives $b : c = 1 : 0{\cdot}465$; which is almost identical with that for chrysoberyl. We add farther, though other evidence is unnecessary, that the angles of the corresponding rhombic octahedrons in each of the above species, are given as follows:—

Chrysolite, ...	139°55′	85°15′	108°31′
Serpentine, ...	139 34	88 26	105 26
Villarsite, ...	139 45	86 56	106 52
Chrysoberyl, ...	139 53	86 16	

In Picrosmine, a brachydiagonal prism has the angle 117°49′, which is near that of Chrysoberyl, and a vertical prism the angle 53° 08′, the corresponding angle in Chrysolite being 49° 50′. This prism being the prism ∞P, it gives $b : c = 1 : 0{\cdot}5$, while it is 1 : 0·47 in Chrysoberyl, and 1 : 0·465 in Chrysolite.

Epsom salt has the same axes as Chrysolite, except that for the assumed fundamental form,† the vertical axis is about one-half the

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* J. f. Pr. Chem., 1849, xlvi, 229.

† It may not be understood by all my readers that the axes of crystals are not lines of fixed length for each crystal, but only the axes corresponding to a form or set of planes in the crystal *assumed* as the fundamental form—a form of frequent

above in length. The numbers given are 0·5703 : 1 : 0·9089, which on doubling the first term becomes 1·1406 : 1 : 0·9089.

II. QUARTZ, $\dddot{\text{Si}}$—CHABAZITE, $(\dot{\text{Ca}}, \dot{\text{Na}}, \dot{\text{K}})^3\dddot{\text{Si}}^2+3\bar{\dddot{\text{Al}}}\,\dddot{\text{Si}}^2+18\dot{\text{H}}$.

R : R in Quartz = 94° 15′; in Chabazite = 94° 46′.

III. CORUNDUM, $\bar{\dddot{\text{Al}}}$—PHENACITE, $\dot{\text{Be}}^3\,\dddot{\text{Si}}$, together with *Arsenic* and others of the group on page 220.

Taking the angle of the rhombohedron of phenacite at 115° 25′, the axis $a = 0·6958$. The axis a of Corundum = 1·3617, which is nearly double that of phenacite (2 × 0·6958 = 1·3916). The angle of the rhombohedron 2R of phenacite is 83° 12′; while R : R in corundum is 86° 4′; in Iridium 84° 52′; in Arsenic 85° 04′.

IV. SCHEELITE, $\dot{\text{Ca}}\,\dddot{\text{W}}$—(with TUNGSTATE OF LEAD, $\dot{\text{Pb}}\,\dddot{\text{W}}$ and MOLYBDATE OF LEAD, $\dot{\text{Pb}}\,\dddot{\text{Mo}}$)=FERGUSONITE, $\dot{\text{Y}}^6\,\bar{\dddot{\text{Ta}}}$.

Tungstate of lime and Fergusonite crystallize in square octahedrons which are hemihedrally modified in the same manner. In the former the angle of the octahedron is 100° 8′; in the latter a corresponding octahedron has the pyramidal angle 100° 28′. The axis of Tungsten is given at 1·05, and that of Fergusonite, (another pyramid being assumed as fundamental,) at 1·50; the latter is 1½ times the former—a simple relation. Tungstate of lead, a recognized pseudomorph of Tungsten, has A : A = 99° 43′, and Molybdate of lead, also so recognized, has A : A = 99° 40′.

We also observe that the vertical axis of *Idocrase* is about half that of Tungstate of lime.

V. ZIRCON, $\bar{\dddot{\text{Zr}}}\,\dddot{\text{Si}}$—RUTILE, $\ddot{\text{Ti}}$—TIN ORE, $\ddot{\text{Sn}}$.

Rutile and Tin ore are recognized isomorphs; the basal angle of the octahedral fundamental forms are 84° 40′ for the former and 87° 5′ for the latter. In Zircon, the same angle is 84° 20′. The axes of rutile, tin ore and zircon are respectively 0·655, 0·6743, 0·6405.

VI. CINNABAR, Hg S—EUDIALYTE, $2\dot{\text{R}}^3\,\dddot{\text{Si}}^2+\bar{\dddot{\text{Zr}}}\,\dddot{\text{Si}}^2$.

Cinnabar and Eudialyte are rhombohedral. In the former R : R = 71° 47′; in the latter, = 73° 40′.

VII. BORAX, $\dot{\text{Na}}\,\dddot{\text{B}}^2+10\dot{\text{H}}$—PYROXENE, $\dot{\text{R}}^3\,\dddot{\text{Si}}^2$—GLAUBER SALT, $(\dot{\text{Na}}\,\dddot{\text{S}}+10\dot{\text{H}})$.

In Pyroxene	M : M=87°6′;	0P : ∝P ∝=106°6′	axes 0·2867 : 1 : 0·9506
In Borax	" 87°	" 106°35′	0·2978 : 1 : 0·9489

Glauber salt is also near pyroxene. It has M : M = 86° 31′ and 0P : ∝ P ∝ = 104° 41′.

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occurrence being selected. They express only a relation of length, and constitute a measure for determining or designating all the other occurring forms. The form assumed for Epsom salt, would be the form ½P of Chrysolite. And if the planes ½P in Epsom salt were taken for the fundamental form then the axes would be the same (nearly) as for Chrysolite.

VIII. ANATASE, $\ddot{\mathrm{Ti}}$—HORN QUICKSILVER, $\mathrm{Hg\,Cl}$.

A pyramid in Horn quicksilver has the basal angle 136°; and the corresponding angle of anatase is 136° 22′.

IX. SULPHUR, S, and SCORODITE, $\dddot{\bar{\mathrm{F}}}\mathrm{e}\,\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{As}}+4\dot{\mathrm{H}}$.

The axes of sulphur are 1·9043 : 1 : 0·8108; and those of Scorodite 0·9539 : 1 : 0·8527. The vertical axis of sulphur is hence double that of Scorodite (2×0·9539=1·9078), while the other axes are nearly equal. (The planes of the vertical rhombic prism common on crystals of scorodite, belong to the form $\infty\breve{\mathrm{P}}2$.)

X. CELESTINE, $\dot{\mathrm{Sr}}\,\dddot{\mathrm{S}}$—WHITE IRON PYRITES, $\mathrm{Fe\,S^2}$—GRAPHIC TELLURIUM, $\mathrm{Ag\,Te+2Au\,Te^3}$.

The angle M : M of Celestine is 104°; of White Iron Pyrites 106° 2′; a brachydiagonal prism of the former has the side angle 103° 58′; of the latter 99° 58′. Graphic Tellurium has M : M =107° 44′; a macrodiagonal prism in Celestine is 101° 24′, in Graphic Tellurium 103°.

XI. CHROMATE OF LEAD, $\dot{\mathrm{Pb}}\,\dddot{\mathrm{Cr}}$—MONAZITE, $(\dot{\mathrm{Ce}}, \dot{\mathrm{Th}}, \dot{\mathrm{La}})^3\,\overset{\cdot\cdot\cdot\cdot\cdot}{\bar{\mathrm{P}}}$.

The forms are monoclinic. In Chromate of Lead, M : M = 93° 40′ and P : M = 99° 11′. In Monazite, M : M = 93° 10′ and P : M = 100° – 100° 25′. The forms of the crystals are similar in the occurring secondary planes.—Compare figure 2 of Chromate of Lead in the author's Mineralogy* with 2 of Monazite in the same work;† the general form is similar; and the planes M, ē, ĕ, ă, ĕ, *a*, *a*′, ($\infty\mathrm{P}, +\mathrm{P}, -\mathrm{P}, -\mathrm{P}\infty, \infty\mathrm{P}'\infty, \mathrm{P}'\infty, 2\mathrm{P}'\infty$) are the same in the two. ē : ē in the former is 119°, in the latter 119° 22′; ĕ : ĕ in the former is 107° 40′, in the latter 106° 36′.

XII. BERYL, $\ddot{\bar{\mathrm{B}}}\mathrm{e}\,\dddot{\mathrm{Si}}^4+2\dddot{\bar{\mathrm{A}}}\mathrm{l}\,\dddot{\mathrm{Si}}^2$, or $\dot{\mathrm{Be}}^3\,\dddot{\mathrm{Si}}^2+\dddot{\bar{\mathrm{A}}}\mathrm{l}\,\dddot{\mathrm{Si}}^2$—NEPHELINE, $\dot{\bar{\mathrm{R}}}^2\,\dddot{\mathrm{Si}}+2\dddot{\bar{\mathrm{A}}}\mathrm{l}\,\dddot{\mathrm{Si}}$.

In Nepheline, P on two planes on the basal edges is 134° 3′ and 154° 27′; in beryl, the corresponding angles are 130° 59′ and 150° 6′. The vertical axis of nepheline is 0·4629, of beryl 0·4993. These species are only approximately isomorphous.

The axis of *quartz* is a little more than double that of beryl, it being 1·0996 and 2×0·4993=0·9996.

We mention also, without particular remark, some of the admitted cases of isomorphism, among species that are alike in general constitution but different in atomic proportions.

1. Pyroxene, Acmite, Hornblende and varieties.
2. Scapolite, Meionite, Wernerite, Dipyre, Gehlenite.
3. Talc, containing magnesia and silica in different proportions.

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* Fig. 74, pl. x, Mohs's Naturg. des Min., ii.

† Also Am. Jour. Sci., xxxiii, p. 71, fig. 1, but with different lettering; and the same figure copied in Dufrenoy's Mineralogie, vol. iv, pl. 223, fig. 476.

4. Epidote, Zoisite, Orthite.
5. The Feldspar family.
6. Bucholzite, Kyanite.
7. Different groups among the monometric or tesseral species.

It is not my object in this place to mention the cases of isomorphism that conform to the ordinary law on this subject. With this brief enumeration of some of the groups, I proceed to the consideration of the atomic volumes of the species. The atomic volume is obtained by dividing the atomic weight by the specific gravity.

I present first an example of the atomic volumes of a group of acknowledged isomorphous minerals, as a measure of the degree of discrepancy to be expected. The carbonates of lime, lime and magnesia, manganese, iron, magnesia, and zinc, increase in the angle R : R from 105° 5′ to 107° 40′, and the atomic volumes, as determined by Kopp, are respectively as follows:

231·20, 202·36, 202·29, 188·50, 181·25, 175·33.

The range of numbers is quite wide in this series, amounting to ¼ the larger number, and exceeds what usually occurs among isomorphous species. Yet the extent of the variation, here shown to be possible, should be kept in mind, or we may be led into error by expecting too close coincidences.

In the following calculations, either the mean specific gravity, as nearly as it could be determined, has been taken, or the specific gravity corresponding to some analysis selected for comparison. The atomic weights used are from the table on pages 218, 219, of this volume. By way of distinction as well as brevity in the following enunciations, we number the statement of the aggregate atomic volume by A; that in which the aggregate atomic volume is divided by the number of atoms of bases and acid, by B; and that of the same divided by the number of atoms of the elements, by C.

I. *Chrysoberyl, Chrysolite, Serpentine, Villarsite, Picrosmine, Epsom Salt.*

1. Chrysoberyl.

1 $\dot{Be}$=158·084 *b.* atoms of acid and base, 2. *c.* atoms of elements, 7.
1 $\dddot{\bar{Al}}$ 641·80 A. 799·884÷3·7 (sp. gr.)=216·18

a. At. weight, 799·884 B. 216·18÷2=108·9 C. 216·18÷7=30·9

With the old atomic weight of Glucinum, making glucina 962·52, we have the formula $\dddot{\bar{Be}}\,\dddot{\bar{Al}}^6$, which gives

1 $\dddot{\bar{Be}}$ 962·52 *b.* atoms of acid and base, 7. *c.* atoms of elements, 35.
6 $\dddot{\bar{Al}}$ 3850·8 A. 4813·32÷3·7 (sp. gr.)=1300·9

a. At. volume, 4813·32 B. 1300·9÷7=185·8 C. 1300·9÷35=37·16

The formula $\dddot{\bar{Al}}^4\,\dddot{Si}+2\dddot{\bar{Be}}\,\dddot{\bar{Al}}^4$, which differs from the last only in including an atom of silica for 12 of alumina, gives the value of C equal to 37·29.

With von Kobell's atomic weight, which is for glucina one third the last mentioned, (320·98 for glucina), chrysoberyl is $\dot{Be}\,\dddot{\bar{Al}}^2$, and the atomic weight is 1604·58; A=433·7; B=144·6; C=36·14.

2. Chrysolite.
1 $\dddot{\mathrm{Si}}$=577·31 *b.* atoms of acid and bases, 4. *c.* atoms of elements, 10.
$2\frac{8}{11}\mathrm{Mg}$ 694·1 A. 1394·13÷3·35 (sp. gr.)=416
$\frac{3}{11}\dot{\mathrm{Fe}}$ 122·72 B. 416÷4=104 C. 416÷10=41·6

a. At. weight, 1394·13

3. Serpentine.
4 $\dddot{\mathrm{Si}}$= 2309·24 *b.* atoms of acid and bases, 19. *c.* atoms of elements, 46.
9 $\dot{\mathrm{Mg}}$ 2290·50 A. 5274·62÷2·55 (sp. gr.)=2068·5
6 $\dot{\bar{\mathrm{H}}}$ 674·88 B. 2068·5÷19=109 C. 2068·5÷46=44·9

a. At. weight, 5274·62

4. Villarsite.
4 $\dddot{\mathrm{Si}}$= 2309·24 *b.* atoms of acid and bases, 19. *c.* atoms of elements, 46.
12 $\dot{\mathrm{Mg}}$ 3054·0 A. 5700·68÷2·975 (sp. gr.)=1916·3
3 $\dot{\bar{\mathrm{H}}}$ 337·44 B. 1916·3÷19=100·86 C. 1916·3÷46=41·65

a. At. weight, 5700·68

5. Picrosmine.
4 $\dddot{\mathrm{Si}}$= 2309·24 *b.* atoms of acid and bases, 13. *c.* atoms of elements, 34.
6 $\dot{\mathrm{Mg}}$ 1527·0 A. 4173·68÷2·63 (sp. gr.)=1587
3 $\dot{\bar{\mathrm{H}}}$ 337·44 B. 1587÷13=122 C. 1587÷34=46·68

a. At. weight, 4173·68

6. Epsom Salt.
1 $\dddot{\mathrm{S}}$= 500· *b.* atoms of acid and bases, 9. *c.* atoms of elements, 20.
1 $\dot{\mathrm{Mg}}$ 254·5 A. 1541·86÷1·75 (sp. gr.)=881
7 $\dot{\bar{\mathrm{H}}}$ 787·36 B. 881÷9=98 C. 881÷20=44

a. At. weight, 1541·86

The result shows that these different substances have for atomic volume C, Chrysolite 41·6, Villarsite 41·65, Epsom salt 44, Serpentine 44·9, Picrosmine 46·7; and for Chrysoberyl 30·9, (adopting Awdejew's atomic weight,) which is to that of Chrysolite as 2 : 3; or with the old atomic weight 37·15, a little below that of Chrysolite. The B results are also nearly uniform; they are for Chrysolite 104, for Villarsite 100·86, Epsom salt 98, Serpentine 109, Picrosmine 122, Chrysoberyl 108·9, or with the old atomic weight, 185·77. It would seem from the result with Epsom salt, that it is more correct to consider the hydrogen in water as a single rather than a double atom.

We pass on with the other examples without special remark, the results being tabulated on a subsequent page.

II. *Quartz, Chabazite.*

1. Quartz.
$\dddot{\mathrm{Si}}$= 577·31 A. 577·31÷2·65 (sp. gr.)=218. C. 218÷4=54·5.

2. Chabazite.
8 $\dddot{\mathrm{Si}}$=4618·48 *b.* atoms of acid and bases, 32. *c.* atoms of elements, 89.
3 $\dddot{\bar{\mathrm{Al}}}$ 1925·4 A. 9622·99÷2·1 (sp. gr.)=4582·4
3 $\dot{\mathrm{Ca}}$ 1054·47 B. 4582·4÷32=143. C. 4582·4÷89=51·5
18 $\dot{\bar{\mathrm{H}}}$ 2024·64

a. At. weight, 9622·99

III. *Corundum, Specular Iron, Arsenic, Phenacite.*

1. Corundum. $\overset{\cdots}{\mathrm{\rlap{-}Al}}$=641·8÷3·97 (sp. gr.)=161·7 C. 161·7÷5=32·3

2. Specular Iron. $\overset{\cdots}{\mathrm{\rlap{-}Fe}}$=1000÷5·212 (sp. gr.)=192 C. 192÷5=38·4

3. Arsenic. As, 940·08÷5·75 (sp. gr.)=163, which equals 5×32·6. The specific gravity 5·88 gives for atomic volume 160.

4. Phenacite.

1 $\overset{\cdots}{\mathrm{Si}}$= 577·31 *b.* atoms of acid and base, 4. *c.* atoms of elements, 10.
3 $\overset{\cdot}{\mathrm{Be}}$ 474·25 A. 1051·56÷2·97 (sp. gr.)=354

a. At. weight, 1051·56 B. 354÷4=88·5 C. 354÷10=35·4

With the old atomic weight for glucinum, Phenacite has the formula $\overset{\cdots}{\mathrm{\rlap{-}Be}}\,\overset{\cdots}{\mathrm{Si}}{}^2$, which gives

A. 2117·14÷2·97 (sp. gr.)=713 C. 713÷13=55, which is 1½ times that of specular iron.

Antimony, Bismuth, Tellurium and Osmium are isomorphous with Arsenic.

5. Antimony, Sb, 1612·8÷6·702 (sp. gr.)=240·65
6. Bismuth, Bi, 1330·4÷9·8 (sp. gr.)=135·75
7. Tellurium, Te, 802·÷6·2 (sp. gr.)=129·36
8. Osmium, Os, 1242·6÷10 (sp. gr.)=124·26

The atomic volume of Corundum is to that of Arsenic as 1 : 5, to that of Antimony nearly as 1 : 8, and to that of each of the other metals following nearly as 1 : 4. The discrepancies, if considered such, it will be observed are among *acknowledged isomorphs;* and a more exact knowledge of the atomic weight may remove them.

IV. *Scheelite, Tungstate of Lead, Fergusonite.*

1. Scheelite.

1 $\overset{\cdots}{\mathrm{W}}$ =1488·4 *b.* atoms of acid and base, 2. *c.* atoms of elements, 6.
1 $\overset{\cdot}{\mathrm{Ca}}$ 351·5 A. 1839·9÷6·1 (sp. gr.)=301·6

a. At. weight, 1839·9 B. 301·6÷2=150·8 C. 301·6÷6=50·3

2. Tungstate of Lead.

1 $\overset{\cdots}{\mathrm{W}}$ =1488·4 A. 2882·9÷8·1 (sp. gr.)=355·9
1 $\overset{\cdot}{\mathrm{Pb}}$ 1394·5 B. 355·9÷2=177·9 C. 355·9÷6=59·3

a. At. weight, 2882·9

3. Fergusonite. *b.* atoms of acid and base, 7. *c.* atoms of elements, 7.
1 $\overset{\cdots}{\mathrm{\rlap{-}Ta}}$ 2596·8 A. 5611·8÷5·8 (sp. gr.)=967·5.
6 $\overset{\cdot}{\mathrm{Y}}$ 3015·0 B. 967·5÷7=138·2 C. 967·5÷17=57·0.

a. At. weight, 5611·8

We have introduced here the acknowledged isomorph of Scheelite, Tungstate of Lead, in order to afford a more satisfactory comparison with Fergusonite.

V. *Zircon, Rutile, Tin Ore* (acknowledged isomorph of rutile).

1. Zircon.

1 $\overset{\cdots}{\mathrm{Si}}$= 577·31 *b.* atoms of acid and base, 2. *c.* atoms of elements, 9.
1 $\overset{\cdots}{\mathrm{\rlap{-}Zr}}$ 1139·50 A. 1716·81÷4·636 (sp. gr.)=370·3

a. At. weight, 1716·81 B. 370·3÷2=185·15 C. 370·3÷9=41·15.

2. Rutile. $\overset{\cdot\cdot}{\mathrm{Ti}}$=514·7÷4·21 (sp. gr.)=122·3. C. 122·3÷3=40·7
3. Tin Ore. $\overset{\cdot\cdot}{\mathrm{Sn}}$=935·3÷6·96 (sp. gr.)=134·4. C. 134·4÷3=44·8

VI. *Cinnabar, Eudialyte.*

1. Cinnabar. Hg S=1450 1450÷8·1 (sp. gr.)=180. C. 180÷2=90.

2. Eudialyte.

6 $\dddot{\mathrm{Si}}$ 3463·86 *b.* atoms of acid and bases, 13. *c.* atoms of elements, 41.
1 $\dddot{\not{\mathrm{Z}}\mathrm{r}}$ 1139·50 A. 6909·33÷2·9 (sp. gr.)=2382
1 $\dot{\mathrm{F}}\mathrm{e}$ 450·00 B. 2382÷13=183·2 C. 2382÷41=58·1
2½ $\dot{\mathrm{C}}\mathrm{a}$ 878·72
2½ $\dot{\mathrm{N}}\mathrm{a}$ 977·25

a. At. weight, 6909·33

The relation of 58 : 90, is nearly as 2 : 3 (60 : 90.); of 180 :183·2=1 : 1

VII. *Borax, Glauber Salt, Pyroxene.*

1. Borax.

2 $\ddot{\mathrm{B}}$ = 872·4 *b.* atoms of acid and bases, 13. *c.* atoms of elements, 30.
1 $\dot{\mathrm{N}}\mathrm{a}$ 390·9 A. 2388·1÷1·716=1391·6
10 $\dot{\mathrm{H}}$ 1124·8 B. 1391·6÷13=107·0 C. 1391·6÷30=46·38.

a. At. weight, 2388·1

2. Glauber Salt.

1 $\dddot{\mathrm{S}}$ = 500· *b.* atoms of acid and bases, 12. *c.* atoms of elements, 26.
1 $\dot{\mathrm{N}}\mathrm{a}$ 390·9 A. 2015·7÷1·562 (sp. gr.)=1290·5.
10 $\dot{\mathrm{H}}$ 1124·8 B. 1290·5÷12=107·54 C. 1290·5÷26=49·6

a. At. weight, 2015·7

3. Pyroxene.—1st. var. $(\frac{1}{2}\dot{\mathrm{C}}\mathrm{a}+\frac{1}{2}\dot{\mathrm{M}}\mathrm{g})^3\,\dddot{\mathrm{S}}\mathrm{i}^2$. Color white.

2 $\dddot{\mathrm{Si}}$ =1154·62 *b.* atoms of acid and bases, 5. *c.* atoms of elements, 14.
1½ $\dot{\mathrm{C}}\mathrm{a}$ 527·23 A. 2063·60÷3·24 (sp. gr.)=637
1½ $\dot{\mathrm{M}}\mathrm{g}$ 381·75 B. 637÷5=127·4 C. 637÷14=45·5

a. At. weight, 2063·60

4. Pyroxene.—2nd. var. $(\frac{1}{2}\dot{\mathrm{C}}\mathrm{a}+\frac{1}{3}\dot{\mathrm{M}}\mathrm{g}+\frac{1}{6}\dot{\mathrm{F}}\mathrm{e})^3\,\dddot{\mathrm{S}}\mathrm{i}^2$. Color green or black.

2 $\dddot{\mathrm{Si}}$ =1154·62
1½ $\dot{\mathrm{C}}\mathrm{a}$ 527·23 A. 2161·35÷3·35 (sp. gr.)=645·2
1 $\dot{\mathrm{M}}\mathrm{g}$ 254·50 B. 645·2÷5=129 C. 645·2÷14=46·1
½ $\dot{\mathrm{F}}\mathrm{e}$ 225·

a. At. weight, 2161·35

5. Pyroxene.—3d var. $(\frac{1}{2}\dot{\mathrm{C}}\mathrm{a}+\frac{1}{2}\dot{\mathrm{F}}\mathrm{e})^3\,\dddot{\mathrm{S}}\mathrm{i}^2$. Hedenbergite.

2 $\dddot{\mathrm{Si}}$ =1154·62
1½ $\dot{\mathrm{C}}\mathrm{a}$ 527·23 A. 2356·85÷3·5 (sp. gr.)=673·4
1½ $\dot{\mathrm{F}}\mathrm{e}$ 675·00 B. 673·4÷5=134·7 C. 673·4÷14=48·1

a. At. weight, 2356·85

6. Pyroxene—var. *Hudsonite.* A recent analysis in the Yale Laboratory, New Haven, by Mr. W. H. Brewer,* gives nearly the results of Beck for this mineral, but makes

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* Mr. Brewer obtained the following for the composition of the Hudsonite; we add also Beck's results:—

	I.	Oxygen.		II.	III.	Beck.
Silica,	36·94	19·13	24·17	36·06	36·76	37·90
Alumina,	11·22	5·04		10·47	....	12·70
Peroxyd of iron,	*trace*	....		*trace*	....	....
Protoxyd of iron,	36·03	8·00	12·12	36·57	....	36·80
" manganese,	2·24	0·50		1·10	....	$\dot{\mathrm{M}}\mathrm{g}$ 1·92
Lime,	12·71	3·62		....	....	11·40
	99·14					100·72

Beck uses the term *oxyd of iron;* but we infer from his accompanying remarks that he meant protoxyd. G.=3·43—3·46, Brewer; 3·5, Beck.

the iron protoxyd, with but a trace of peroxyd. It affords very closely the formula $\dot{\text{R}}^3(\dddot{\text{Si}}, \ddot{\bar{\text{Al}}})^2$, or more precisely $\left(\frac{8}{12}\dot{\text{Fe}}+\frac{0·5}{12}\dot{\text{Mn}}+\frac{3·5}{12}\dot{\text{Ca}}\right)^3\left(\frac{6·33}{8}\dddot{\text{Si}}+\frac{1·66}{8}\ddot{\bar{\text{Al}}}\right)^2$. Multiplying by 4 throughout, the relation becomes $6\frac{1}{3}\dddot{\text{Si}}+1\frac{2}{3}\ddot{\bar{\text{Al}}}+8\dot{\text{Fe}}+\frac{1}{2}\dot{\text{Mn}}+3\frac{1}{2}\dot{\text{Ca}}$, which we here adopt, without farther reducing it, as the result will be the same.

$6\frac{1}{3}\,\dddot{\text{Si}}$ =3656·3 *b.* atoms of acids and bases, 20. *c.* atoms of elements, 57⅔.
$1\frac{2}{3}\,\ddot{\bar{\text{Al}}}$ 1069·6 A. 9778·4÷3·463 (mean sp. gr.)=2824, and 2824÷4=706
8 $\dot{\text{Fe}}$ 3600·0 B. 2824÷20=141·2 C. 2824÷57⅔=48·9
$\frac{1}{2}\,\dot{\text{Mn}}$ 222·3
$3\frac{1}{2}\,\dot{\text{Ca}}$ 1230·2

a. At. weight, 9778·4

7. Pyroxene—var. $\dot{\text{Fe}}^3\,\dddot{\text{Si}}^2$. Asbestiform, analyzed by Grüner, (Comp. Rend. xxiv, 794.)
3 $\dot{\text{Fe}}$ =1350· *b.* atoms of acid and bases, 5. *c.* atoms of elements, 14.
2 $\dddot{\text{Si}}$ 1154·62 A. 2504·62÷3·712 (sp. gr.) =674·7

a. At. weight, 2504·62 B. 674·7÷5=135 C. 674·7÷14=48·2

8. Pyroxene—var. $\dot{\text{Mn}}^3\,\dddot{\text{Si}}^2$, Manganese Spar.
3 $\dot{\text{Mn}}$ =1334·1 *b.* atoms of acid and base, 5. *c.* atoms of elements, 14.
2 $\dddot{\text{Si}}$ 1154·62 A. 2488·72÷3·634 (sp. gr.) =684·8

a. At. weight, 2488·72 B. 684·8÷5=136·9 C. 684·8÷14=48·9

VIII. *Anatase, Horn Quicksilver.*

1. Anatase. $\ddot{\text{Ti}}$ 514·7÷3·84 (sp. gr.) =134·0 C. 134·0÷3=44·66
2. Horn Quicksilver, Hg Cl, 1693·3÷6·48 (sp. gr.) =261·3 C. 261·3÷2=130·62

130·62 : 44·66, nearly as 3 : 1 ; and 130·62 : 134·0 = (nearly) 1 : 1.

IX. *Sulphur*, *Selenium* (acknowledged isomorph with Sulphur), *Scorodite.*

1. Sulphur. S, 200÷2·033 (sp. gr.) =98·4
2. Selenium. Se, 495·3÷4·3 (sp. gr.) =115
3. Scorodite.

1 $\overset{\cdot\cdot\cdot\cdot\cdot}{\bar{\text{As}}}$ =1440·08 *b.* atoms of acid and bases, 6. *c.* atoms of elements, 19.
1 $\dddot{\bar{\text{Fe}}}$ 1000·00 A. 2890÷3·23 (sp. gr.) =894·73
4 $\dot{\bar{\text{H}}}$ 449·92 B. 894·73÷6=149·12 C. 894·73÷19=47·1

a. At. weight, 2890·00

47·1, is very nearly ½ the atomic volume of Sulphur; and 149 : 98·4=3 : 2

X. *Celestine, White Iron Pyrites, Graphic Tellurium.*

1. Celestine.

1 $\dddot{\text{S}}$ = 500· *b.* atoms of acid and base, 2. *c.* atoms of elements, 6.
1 $\dot{\text{Sr}}$ 647·3 A. 1147·3÷3·9 (sp. gr.) =294·2

a. At. weight, 1147·3 B. 294·2÷2=147·1 C. 294·2÷6=49·0

2. White Iron Pyrites.

Fe+2S=750. A. 750÷4·76 (sp. gr.)=157·56 C. 157·56÷3=52·52

3. Graphic Tellurium.

7 Te =5612·6 *c.* atoms of elements, 10.
1 Ag 1350· A. 9418·1÷8·28 (sp. gr.) =1137·5
2 Au 2455·5 C. 1137·5÷10=113·75

a. At. weight, 9418·1

The atomic volume C of graphic Tellurium is consequently double of that of White Iron Pyrites; the A relation is 7 : 1.

XI. *Monazite, Chromate of Lead.*

1. Monazite.

1 $\overset{\cdot\cdot\cdot\cdot\cdot}{\bar{\mathrm{P}}}$ = 892·3   *b.* atoms of acid and bases, 4.   *c.* atoms of elements, 12.
2 $\dot{\mathrm{C}}\mathrm{e}$ 1350·0   A. 3086·2÷5 (sp. gr.) =617·25
1 $\dot{\bar{\mathrm{T}}}\mathrm{h}$ 843·9   B. 617·25÷4=154·3   C. 617·25÷12=51·44

a. At. weight, 3086·2   Marignac's at. wt. of Cerium, gives for C, 52

2. Chromate of Lead.

1 $\dddot{\mathrm{C}}\mathrm{r}$ = 628·4   *b.* atoms of acid and base, 2.   *c.* atoms of elements, 6.
1 $\dot{\bar{\mathrm{P}}}\mathrm{b}$ 1394·5   A. 2022·9÷6·06 (sp. gr.) =333·8

a. At. weights, 2022·9   B. 333·8÷2=166·9   C. 333·8÷6=55·6

There is some uncertainty as to Monazite, as the exact proportions of its bases are not accurately known.

XII. *Beryl, Nepheline.*

1. Beryl—using the old atomic weight:—

8 $\dddot{\mathrm{S}}\mathrm{i}$ =4618·48   *b.* atoms of acid and bases, 11.   *c.* atoms of elements, 47.
1 $\dddot{\bar{\mathrm{B}}}\mathrm{e}$ 962·52   A. 6864·6÷2·732 (sp. gr.) =2512·7
2 $\dddot{\bar{\mathrm{A}}}\mathrm{l}$ 1283·60   B. 2512·7÷11=228·4   C. 2512·7÷47=53·46

a. At. weight, 6864·60   Awdejew's atomic weight gives for C, 46·44.

2. Nepheline.

3 $\dddot{\mathrm{S}}\mathrm{i}$ =1731·93   *b.* atoms of acid and bases, 7.   *c.* atoms of elements, 26.
2 $\dddot{\bar{\mathrm{A}}}\mathrm{l}$ 1283·6   A. 3830·32÷2·6 (sp. gr.) =1473·2
$1\frac{5}{6}$ $\dot{\mathrm{N}}\mathrm{a}$ 716·65   B. 1473·2÷7=210·5   C. 1473·2÷26=56·66
$\frac{1}{6}$ $\dot{\mathrm{K}}$ 98·14

a. At. weight, 3830·32

XIII. *Pyroxene,* $\dot{\mathrm{R}}^3\,\dddot{\mathrm{S}}\mathrm{i}^2$—*Acmite,* $\dot{\mathrm{N}}\mathrm{a}\,\dddot{\mathrm{S}}\mathrm{i}+\dddot{\bar{\mathrm{F}}}\mathrm{e}\,\dddot{\mathrm{S}}\mathrm{i}^2$—*Hornblende,* $\dot{\mathrm{R}}^4\,\dddot{\mathrm{S}}\mathrm{i}^3$.

Acmite, as is well known, has the crystalline form of Pyroxene, although different in composition. Hornblende is peculiar in its cleavage and prevalent forms; yet as Rose has shown, its crystals have the same fundamental form as those of Pyroxene.

1. Pyroxene. As above deduced, A=638·77–706; B=127·55–141·2; C=46·1–48·9
2. Acmite.

3 $\dddot{\mathrm{S}}\mathrm{i}$ = 1731·93   *b.* atoms of acid and bases, 5.   *c.* atoms of elements, 19.
1 $\dddot{\bar{\mathrm{F}}}\mathrm{e}$ 1000·00   A. 3122·83÷3·4 (sp. gr.) =918·5
1 $\dot{\mathrm{N}}\mathrm{a}$ 390·9   B. 918·5÷5=183·7   C. 918·5÷19=48·34

a. At. weight, 3122·83

3. Hornblende.

3 $\dddot{\mathrm{S}}\mathrm{i}$ = 1731·93   *b.* atoms of acid and bases, 7.   *c.* atoms of elements, 20.
3 $\dot{\mathrm{M}}\mathrm{g}$ 763·5   A. 2846·92÷2·93 (sp. gr.) =971·6
1 $\dot{\mathrm{C}}\mathrm{a}$ 351·49   B. 971·6÷7=138·8   C. 971·6÷20=48·58

a. At. weight, 2846·92

4. Hornblende, aluminous varieties.

a. Var. From Wolfsberg in Bohemia, analysed by Göschen.—The analysis corresponds to the ratio $2\frac{1}{2}\dddot{\bar{\mathrm{A}}}\mathrm{l}+1\frac{1}{2}\dddot{\bar{\mathrm{F}}}\mathrm{e}+7\,\dddot{\mathrm{S}}\mathrm{i}+4\,\dot{\mathrm{C}}\mathrm{a}+5\,\dot{\mathrm{M}}\mathrm{g}$. We attempt no formula.

7 $\dddot{\mathrm{S}}\mathrm{i}$ =4041·17   *b.* atoms of bases and acids, 20.   *c.* atoms of elements, 66.
$2\frac{1}{2}$ $\dddot{\bar{\mathrm{A}}}\mathrm{l}$ 1604·5   A. 9824·13÷3·15 (sp. gr.) =3119
$1\frac{1}{2}$ $\dddot{\bar{\mathrm{F}}}\mathrm{e}$ 1500·0   B. 3119÷20=155·95   C. 3119÷66=47·25
4 $\dot{\mathrm{C}}\mathrm{a}$ 1405·96
5 $\dot{\mathrm{M}}\mathrm{g}$ 1272·5   If sp. gr. =3·167, then C = 47·0

a. At. weight, 9824·13

b. Var. Carinthine. Analysis by Clausbruch (Pogg., lviii, 168), corresponding to $8\,\dddot{\mathrm{Si}}+1\frac{1}{3}\dddot{\mathrm{Al}}+2\frac{6}{7}\dot{\mathrm{Ca}}+7\frac{1}{7}\dot{\mathrm{Mg}}+4\,\dot{\mathrm{Fe}}$.

$8\ \dddot{\mathrm{Si}}$ =4618·48 *b.* atoms of acid and bases, 23⅓. *c.* atoms of elements, 66⅔.
$1\frac{1}{3}\ \dddot{\mathrm{Al}}$ 855·73 A. 10096·27÷3·127 (sp. gr.) =3229
$4\ \dot{\mathrm{Fe}}$ 1800·00 B. 3229÷23⅓=138·4 C. 3229÷66⅔=48·43
$2\frac{6}{7}\ \dot{\mathrm{Ca}}$ 1004·26
$7\frac{1}{7}\ \dot{\mathrm{Mg}}$ 1817·80

a. At. weight, 10096·27

c. Grammatite of Aker, Bonsdorff. The analysis gives $8{\cdot}17\ \dddot{\mathrm{Si}}+2{\cdot}17\ \dddot{\mathrm{Al}}+3{\cdot}6\ \dot{\mathrm{Ca}}+8{\cdot}6\ \dot{\mathrm{Mg}}+0{\cdot}6\ \dot{\mathrm{Fe}}$. As above, we take the analysis as it is, without attempting to reduce it to the limits of a formula.

$8{\cdot}17\ \dddot{\mathrm{Si}}$ = 4716·6 *b.* atoms of acid and bases, 23·13. *c.* atoms of elements, 69·1.
$2{\cdot}17\ \dddot{\mathrm{Al}}$ 1392·7 A. 9833·4÷2·95 (sp. gr.) =3333·3
$3{\cdot}6\ \dot{\mathrm{Ca}}$ 1265·4 B. 3333·3÷23·14=144 C. 3333·3÷69·1=48·24
$8{\cdot}6\ \dot{\mathrm{Mg}}$ 2188·7
$0{\cdot}6\ \dot{\mathrm{Fe}}$ 270·0

a. At. weight, 9833·4

XIV. *Scapolite*, $(\dot{\mathrm{Ca}}, \dot{\mathrm{Na}})^3\,\dddot{\mathrm{Si}}^2+2\dddot{\mathrm{Al}}\,\dddot{\mathrm{Si}}$—*Meionite*, $\dot{\mathrm{Ca}}^3\,\dddot{\mathrm{Si}}+2\dddot{\mathrm{Al}}\,\dddot{\mathrm{Si}}$—*Wernerite*, $\dot{\mathrm{Ca}}^3\,\dddot{\mathrm{Si}}+3\dddot{\mathrm{Al}}\,\dddot{\mathrm{Si}}$—*Dipyre*, $4(\dot{\mathrm{Ca}}, \dot{\mathrm{Na}})\,\dddot{\mathrm{Si}}+3\dddot{\mathrm{Al}}\,\dddot{\mathrm{Si}}$.

These several compounds crystallize alike.

1. Scapolite.

$4\ \dddot{\mathrm{Si}}$ =2309·24 *b.* atoms of acid and bases, 9. *c.* atoms of elements, 32.
$2\ \dddot{\mathrm{Al}}$ 1283·6 A. 4686·72÷2·71 (sp. gr.) =1729·4
$1\ \dot{\mathrm{Na}}$ 390·9 B. 1729·4÷9=192·1 C. 1729·4÷32=54
$2\ \dot{\mathrm{Ca}}$ 702·98

a. At. weight, 4686·72

2. Meionite.

$3\ \dddot{\mathrm{Si}}$ =1731·93 *b.* atoms of acid and bases, 8. *c.* atoms of elements, 28.
$2\ \dddot{\mathrm{Al}}$ 1283·6 A. 4070÷2·612 (sp. gr.) =1558·2
$3\ \dot{\mathrm{Ca}}$ 1054·47 B. 1558·2÷8=194·8 C. 1558·2÷28=55·65

a. At. weight, 4070·00

3. Wernerite—From Tunaberg and Ersby, as analysed by Walmstedt and Nordenskiöld.

$4\ \dddot{\mathrm{Si}}$ =2309·24 *b.* atoms of acid and bases, 10. *c.* atoms of elements, 37.
$3\ \dddot{\mathrm{Al}}$ 1925·4 A. 5289·11÷2·77 (sp. gr.) =1909
$3\ \dot{\mathrm{Ca}}$ 1054·47 B. 1909÷10=190·9 C. 1909÷37=51·6

a. At. weight, 5289·11

4. Dipyre.

$7\ \dddot{\mathrm{Si}}$ =4041·17 *b.* atoms of acid and bases, 14. *c.* atoms of elements, 51.
$3\ \dddot{\mathrm{Al}}$ 1925·4 A. 7451·35÷2·646 (sp. gr.) =2816
$2\ \dot{\mathrm{Na}}$ 781·8 B. 2816÷14=201·1 C. 2816÷51=55·21
$2\ \dot{\mathrm{Ca}}$ 702·98

a. At. weight, 7451·35

5. Barsowite.—$(\dot{\mathrm{Ca}}, \dot{\mathrm{Mg}})^3\,\dddot{\mathrm{Si}}^2+3\dddot{\mathrm{Al}}\,\dddot{\mathrm{Si}}$. This scapolite-like mineral has A = 2133; B = 194; C = 52.

6. Wernerite—Wolff's analysis of a Pargas variety corresponds very closely with $\dot{\mathrm{Ca}}^2\dddot{\mathrm{Si}}+2\dddot{\mathrm{Al}}\,\dddot{\mathrm{Si}}$ (although referred to the above Wernerite formula by Rammelsberg.)

3 $\dddot{\mathrm{Si}}$ =1731·93 *b.* atoms of acid and bases, 7. *c.* atoms of elements, 26.
2 $\dddot{\mathrm{Al}}$ 1283·6 A. 3718·51÷2·712 (sp. gr.) =1371·1
2 $\dot{\mathrm{Ca}}$ 702·98 B. 1371·1÷7=196 C. 1371·1÷26=52·7
a. At. weight, 3718·51

Idocrase has its vertical axis to that of Scapolite as 5 : 4, and Zircon to that of Idocrase as 6 : 5. For comparison we here insert the atomic volume of Idocrase.

2 $\dddot{\mathrm{Si}}$ =1154·62 *b.* atoms of acid and bases, 6. *c.* atoms of elements, 19.
1 $\dddot{\mathrm{Al}}$ 641·8 A. 2883·72÷3·4 (sp. gr.) =848·16
$2\frac{2}{3}$ $\dot{\mathrm{Ca}}$ 937·3 B. 848·16÷6=141·36 848·16÷19=44·64
$\frac{1}{3}$ $\dot{\mathrm{Fe}}$ 150·
a. At. weight, 2883·72

The atomic volumes of Scapolite, Idocrase and Zircon, are as 54 : 44·64 : 41·05.

XV. *Talc.*—Different varieties, $\dot{\mathrm{Mg}}^3\,\dddot{\mathrm{Si}}^4$, $\dot{\mathrm{Mg}}^4\,\dddot{\mathrm{Si}}^5$, $\dot{\mathrm{Mg}}\,\dddot{\mathrm{Si}}$.

1. 4 $\dddot{\mathrm{Si}}$ =2309·24 *b.* atoms of acid and base, 7. *c.* atoms of elements, 22.
3 $\dot{\mathrm{Mg}}$ 763·5 A. 3072·74÷2·7 (sp. gr.) =1138
B. 1138÷7=162·57 C. 1138÷22=51·73
a. At. weight, 3072·74

2. 5 $\dddot{\mathrm{Si}}$ =2886·55 *b.* atoms of acid and base, 9. *c.* atoms of elements, 28.
4 $\dot{\mathrm{Mg}}$ 1018·0 A. 3904·55÷2·7 (sp. gr.) =1446
B. 1446÷9=160·7 C. 1446÷28=51·64
a. At. weight, 3904·55

3. 1 $\dddot{\mathrm{Si}}$ = 577·31 *b.* atoms of acid and base, 2. *c.* atoms of elements, 6.
1 $\dot{\mathrm{Mg}}$ 254·5 A. 831·81÷2·7 (sp. gr.) =308·1
B. 308·1÷2=154 C. 308·1÷6=51·35
a. At. weight, 831·81

XVI. *Epidote* $\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}+2\dddot{\mathrm{R}}\,\dddot{\mathrm{Si}}$.—*Orthite* $2(\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}+\dddot{\mathrm{R}}\,\dddot{\mathrm{Si}})+\dot{\mathrm{H}}$ of the Ural;
$\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}+\dddot{\mathrm{R}}\,\dddot{\mathrm{Si}}+\dot{\mathrm{H}}$, of Hitteroe.

Orthite has been shown by Kokscharov (Min. Ges. St. Petersb., 1847, p. 147, and this Journal [2], viii, 125), to have the crystallization of Epidote. M : T in Epidote =114° 25′; in Uralorthite 114° 55′ Kokscharov; in Cerine 116° Rose. The above formulas of Orthite are recent results by Rammelsberg, (Poggendorff's Annalen, lxxvi, 98, 1849.) This author also calculates the atomic volume corresponding to the specimens analyzed, and obtains for Epidote having the formula $(\dot{\mathrm{Ca}}^3\,\dddot{\mathrm{Si}})+2(\frac{2}{3}\dddot{\mathrm{Al}}+\frac{1}{3}\dddot{\mathrm{Fe}})\,\dddot{\mathrm{Si}}$, the atomic weight 4309·53, and 4309·53÷3·4 (sp. gr.)=1268.

For Orthite of the Urals (in which $6\dot{\mathrm{R}}=1{\cdot}2\,\dot{\mathrm{Fe}}+2{\cdot}4(\dot{\mathrm{Ce}},\dot{\mathrm{La}})+2{\cdot}4\,\dot{\mathrm{Ca}}$; and $2\dddot{\mathrm{R}}=1{\cdot}5\,\dddot{\mathrm{Al}}+0{\cdot}5\,\dddot{\mathrm{Fe}}$), the atomic weight 6911·82; and 6911·82÷3·598=1921.

For the Orthite of Hitteroe, in which $3\dot{\mathrm{R}}=0{\cdot}6\,\dot{\mathrm{Fe}}+1{\cdot}2\,\dot{\mathrm{Ce}}+1{\cdot}2\,\dot{\mathrm{Ca}}$; and $\dddot{\mathrm{R}}=0{\cdot}7\,\dddot{\mathrm{Al}}+0{\cdot}3\,\dddot{\mathrm{Fe}}$, the atomic weight 3513·72; and 3513·72÷3·459 (sp. gr.) =1017.

Rammelsberg thence observes that the atomic volumes of these minerals are as 1 : 1·5 : 0·8, "or perhaps" as 4 : 6 : 3.

If, however, as heretofore, we divide the aggregate atomic volume obtained by Rammelsberg by the number of atoms of the elements, we obtain

1. For Epidote	1268÷28=45·285
2. For Orthite of the Urals	1921÷40=48·025
3. For the Orthite of Hitteroe	1017÷21=48·43

A close relation, exhibiting satisfactorily the intimate relations of the compounds. Dividing by the number of atoms of bases and acids, gives respectively 1268÷8=158·5, 1921÷13=147·7, 1017÷7=145·3.

4. We add another example—a *Zoisite* from Rothlaue analyzed by Rammelsberg, (Pogg., lxviii, 509.)

3 $\dddot{\mathrm{Si}}$ =1731·93 *b.* atoms of acid and bases, 8. *c.* atoms of elements, 28.
1⅔ $\dddot{\mathrm{\cancel{A}l}}$ 1069·7 A. 4189·43÷3·387 (sp. gr.) =1237
⅓ $\dddot{\mathrm{\cancel{F}e}}$ 333·33 B. 1237÷8=154·6 C. 1237÷28=44·2
3 $\dot{\mathrm{Ca}}$ 1054·47

a. At. weight, 4189·43

Here 44·2 is but little below the determination for Epidote.

XVII. *The Feldspar Family.*—In Orthoclase and Albite, Ryacolite and Labradorite, Loxoclase and Oligoclase, we have three examples of dimorphism.

1. Orthoclase, $\dot{\cancel{\mathrm{R}}}\dddot{\mathrm{Si}}+\dddot{\mathrm{\cancel{A}l}}\dddot{\mathrm{Si}}^3$.—Form monoclinic.

4 $\dddot{\mathrm{Si}}$ =2309·24 *b.* atoms of acid and bases, 6. *c.* atoms of elements, 23.
1 $\dddot{\mathrm{\cancel{A}l}}$ 641·80 A. 3539·90÷2·55 (sp. gr.) =1388
1 $\dot{\mathrm{K}}$ 588·86 B. 1388÷6=231·3 C. 1388÷23=60·4

a. At. weight, 3539·90

2. Albite, $\dot{\cancel{\mathrm{R}}}\dddot{\mathrm{Si}}+\dddot{\mathrm{\cancel{A}l}}\dddot{\mathrm{Si}}^3$.—Form triclinic.

4 $\dddot{\mathrm{Si}}$ =2309·24 *b.* atoms of acid and bases, 6. *c.* atoms of elements, 23.
1 $\dddot{\mathrm{\cancel{A}l}}$ 641·80 A. 3341·94÷2·61 (sp. gr.) =1280·4
1 $\dot{\mathrm{Na}}$ 390·9 B. 1280·4÷6=213·4 C. 1280·4÷23=55·67

a. At. weight, 3341·94

3. Ryacolite, $\dot{\cancel{\mathrm{R}}}\dddot{\mathrm{Si}}+\dddot{\mathrm{\cancel{A}l}}\dddot{\mathrm{Si}}$.—Monoclinic.

2 $\dddot{\mathrm{Si}}$ =1154·62 *b.* atoms of acid and bases, 4. *c.* atoms of elements, 15.
1 $\dddot{\mathrm{\cancel{A}l}}$ 641·80 A. 2236·83÷2·58 (sp. gr.) =867·0
¾ $\dot{\mathrm{Na}}$ 293·2 B. 867÷4=216·7 C. 867÷15=57·8
¼ $\dot{\mathrm{K}}$ 147·21

a. At. weight, 2236·83

4. Labradorite, $\dot{\cancel{\mathrm{R}}}\dddot{\mathrm{Si}}+\dddot{\mathrm{\cancel{A}l}}\dddot{\mathrm{Si}}$.—Triclinic.

2 $\dddot{\mathrm{Si}}$ =1154·62 *b.* atoms of acid and bases, 4. *c.* atoms of elements, 15.
1 $\dddot{\mathrm{\cancel{A}l}}$ 641·80 A. 2147·91÷2·7 (sp. gr.) =795·5
1 $\dot{\mathrm{Ca}}$ 351·49 B. 795·5÷4=198·9 C. 795·5÷15=53·03

a. At. weight, 2147·91

5. Loxoclase, $\dot{\cancel{\mathrm{R}}}\dddot{\mathrm{Si}}+\dddot{\mathrm{\cancel{A}l}}\dddot{\mathrm{Si}}^2$.—Monoclinic.

3 $\dddot{\mathrm{Si}}$ =1731·93 *b.* atoms of acid and bases, 5. *c.* atoms of elements, 19.
1 $\dddot{\mathrm{\cancel{A}l}}$ 641·80 A. 2779·52÷2·615 (sp. gr.) =1063
⅝ $\dot{\mathrm{Na}}$ 244·31 B. 1063÷5=212·6 C. 1063÷19=56·0
⅛ $\dot{\mathrm{K}}$ 73·61
¼ $\dot{\mathrm{Ca}}$ 87·87

a. At. weight, 2779·52

6. Oligoclase, $\dot{\cancel{\mathrm{R}}}\dddot{\mathrm{Si}}+\dddot{\mathrm{\cancel{A}l}}\dddot{\mathrm{Si}}^2$.—Triclinic.

3 $\dddot{\mathrm{Si}}$ =1731·93 *b.* atoms of acid and bases, 5. *c.* atoms of elements, 19.
1 $\dddot{\mathrm{\cancel{A}l}}$ 641·80 A. 2751·49÷2·65 (sp. gr.) =1038·3
⅔ $\dot{\mathrm{Na}}$ 260·66 B. 1038·3÷5=207·66 C. 1038·3÷19=54·647
⅓ $\dot{\mathrm{Ca}}$ 117·16

a. At. weight, 2751·49

We observe that the triclinic form in each of these three cases of dimorphism has the *highest specific gravity*, and the *lowest atomic weight*, and therefore the *lowest atomic volume.*

7. Anorthite, $\dot{\text{R}}^3\,\dddot{\text{Si}}+3\dddot{\text{Al}}\,\dddot{\text{Si}}$.—Triclinic.

4 $\dddot{\text{Si}}$	=2309·24	*b.* atoms of acid and bases, 10.	*c.* atoms of elements, 37.
3 $\dddot{\text{Al}}$	1925·40	A. 5289·11÷2·7=1959	
3 $\dot{\text{Ca}}$	1054·47	B. 1959÷10=195·9	C. 1959÷37=52·95
a. At. weight,	5289·11		

8. Baulite, $\dot{\text{R}}\,\dddot{\text{Si}}^2+\dddot{\text{Al}}\,\dddot{\text{Si}}^6$.—Monoclinic.

8 $\dddot{\text{Si}}$	=4618·48	*b.* atoms of acid and bases, 10.	*c.* atoms of elements, 39.
1 $\dddot{\text{Al}}$	641·80	A. 5750·16÷2·64 (sp. gr.) =2178·1	
$\frac{1}{2}$ $\dot{\text{Na}}$	195·45	B. 2178·1÷10=217·81	C. 2178·1÷39=55·85
$\frac{1}{2}$ $\dot{\text{K}}$	294·43		
a At. weight,	5750·16		

9. Vosgite, $\dot{\text{R}}^3\,\dddot{\text{Si}}^2+3\dddot{\text{Al}}\,\dddot{\text{Si}}$.—Triclinic.

5 $\dddot{\text{Si}}$	=2886·55	*b.* atoms of acid and bases, 11.	*c.* atoms of elements, 41.
3 $\dddot{\text{Al}}$	1925·40	A. 5929·66÷2·737 (sp. gr.) =2166·5	
$2\frac{2}{5}$ $\dot{\text{Ca}}$	843·58	B. 2166·5÷11=197	C. 2166·5÷41=52·84
$\frac{2}{5}$ $\dot{\text{Na}}$	156·36		
$\frac{1}{5}$ $\dot{\text{K}}$	117·77		
a. At. weight,	5929·66		

10. Andesine, $\dot{\text{R}}^3\,\dddot{\text{Si}}^2 + 3\dddot{\text{Al}}\,\dddot{\text{Si}}^2$.—Triclinic.

8 $\dddot{\text{Si}}$	=4618·48	*b.* atoms of acid and bases, 14.	*c.* atoms of elements, 53.
3 $\dddot{\text{Al}}$	1925·40	A. 7776·15÷2·67 (sp. gr.) =2912·4	
$1\frac{1}{2}$ $\dot{\text{Na}}$	586·35	B. 2912·4÷14=208	C. 2912·4÷53=55·0
1 $\dot{\text{Ca}}$	351·49		
$\frac{1}{2}$ $\dot{\text{K}}$	294·43		
a. At. weight,	7776·15		

11. Leucite, $\dot{\text{R}}^3\,\dddot{\text{Si}}^2+3\dddot{\text{Al}}\,\dddot{\text{Si}}^2$.—Monometric.

8 $\dddot{\text{Si}}$	=4618·48	*b.* atoms of acid and bases, 14.	*c.* atoms of elements, 53.
3 $\dddot{\text{Al}}$	1925·40	A. 8310·46÷2·486=3343·15	
3 $\dot{\text{K}}$	1766·58	B. 3343÷14=238·8	C. 3343÷53=63·08
a. At. weight,	8310·46		

As Andesine and Leucite have essentially the same composition and the compound is therefore dimorphous, we here observe again that the triclinic form has the highest specific gravity and lowest atomic weight, and as a consequence, the lowest atomic volume.

XVIII. *Petalite*, $(\dot{\text{Li}}, \dot{\text{Na}})^3\,\dddot{\text{Si}}^4+4\dddot{\text{Al}}\,\dddot{\text{Si}}^4$—*Spodumene*, $(\dot{\text{Li}}, \dot{\text{Na}})^3\,\dddot{\text{Si}}^4+4\dddot{\text{Al}}\,\dddot{\text{Si}}^2$, —*Andalusite*, $\dddot{\text{Al}}^3\,\dddot{\text{Si}}^2$.

1. Petalite.

20 $\dddot{\text{Si}}$	=11546·20	*b.* atoms of acid and bases, 27.	*c.* atoms of elements, 106.
4 $\dddot{\text{Al}}$	2567·20	A. 14815·31÷2·44 (sp. gr.) =6071·8	
$2\frac{1}{4}$ $\dot{\text{Li}}$	408·73	B. 6071·8÷27=224·96	C. 6071·8÷106=57·3
$\frac{3}{4}$ $\dot{\text{Na}}$	293·18		
a. At. weight,	14815·31		

2. Spodumene.

12 $\dddot{\text{Si}}$	=6927·72	*b.* atoms of acid and bases, 19.	*c.* atoms of elements, 74.
4 $\dddot{\text{Al}}$	2567·20	A. 10196·83÷3·17=3216·7	
$2\frac{1}{4}$ $\dot{\text{Li}}$	408·73	B. 3216·7÷19=169·3	C. 3216·7÷74=43·47
$\frac{3}{4}$ $\dot{\text{Na}}$	293·18		
a. At. weight,	10196·83		

Petalite has the structure of a *feldspar*, although not conforming to the general rule for the feldspar family in having the oxygen of the peroxyds to that of the protoxyds as 3 : 1, but instead as 4 : 1. It also approaches Orthoclase in its atomic volume, B equalling 224·9 and C 57·31, while in Orthoclase B = 231·3 and C = 60·4. *Spodumene*, on the contrary, although a lithia species like petalite, and having also the above ratio 4 : 1, differs in its cleavage and in its crystalline form, and is also widely removed from the feldspars in its atomic volume.

3. Andalusite.

2 $\dddot{\text{Si}}$	=1154·62	*b.* atoms of acid and base, 5.	*c.* atoms of elements, 23.
3 $\dddot{\text{Al}}$	1925·40	A. 3080·02÷3·2 (sp. gr.) =962·5	
a. At. volume,	3080·02	B. 962·5÷5=192·5	C. 962·5÷23=41·85

Andalusite has therefore the atomic volume of Spodumene, for C equals 41·85, while in the above it equals 43·47. Moreover the angle of the rhombic prism is nearly the same, it being in Andalusite 91° 33′, in Spodumene 93°. We may hence conclude that the crystallization of Spodumene is not oblique like the Feldspars and Petalite (although often so considered), but *trimetric* like Andalusite, and that *the two species are isomorphous.*

XIX. *Analcime*, $3\dddot{\text{Al}}\,\dddot{\text{Si}}^2+\dot{\text{Na}}^3\,\dddot{\text{Si}}^2+6\dot{\text{H}}$,—*Sodalite*, $\text{Na Cl}+\dot{\text{Na}}^3\,\dddot{\text{Si}}+3\dddot{\text{Al}}\,\dddot{\text{Si}}$,—*Haüyne* $2\dot{\text{Ca}}\,\dddot{\text{S}}+\dot{\text{Na}}^3\,\dddot{\text{Si}}+3\dddot{\text{Al}}\,\dddot{\text{Si}}$,—*Nosean* $\dot{\text{Na}}\,\dddot{\text{S}}+\dot{\text{Na}}^3\,\dddot{\text{Si}}+3\dddot{\text{Al}}\,\dddot{\text{Si}}$.

These species are introduced here for comparison with Leucite. They seem to show that the monometric form in these silicates is connected with a high atomic volume, the amount exceeding that of the monoclinic as well as triclinic feldspars.

1. Analcime.

8 $\dddot{\text{Si}}$	=4618·48	*b.* atoms of bases and acid, 20.	*c.* atoms of elements, 65.
3 $\dddot{\text{Al}}$	1925·4	A. 8391·46÷2·068 (sp. gr.) =4057·7	
3 $\dot{\text{Na}}$	1172·7	B. 4057·7÷20=202·88	C. 4057·7÷65=62·43
6 $\dot{\text{H}}$	674·88		
a. At. weight,	8391·46		

2. Sodalite.

4 $\dddot{\text{Si}}$	=2309·24	*b.* atoms of bases and acid, 11.	*c.* atoms of elements, 39.
3 $\dddot{\text{Al}}$	1925·4	A. 6141·54÷2·29 (sp. gr. of Vesuvian var.) =2682	
3 $\dot{\text{Na}}$	1172·7	B. 2682÷11=244	C. 2682÷39=68·77
1 Na	290·9		
1 Cl	443·3	Sp. gr. of Greenland Sodalite, 2·37. Thence C=66·45.	
a. At. weight,	6141·54		

3. Haüyne.

$2\,\dddot{\mathrm{S}}$ =1000· *b.* atoms of bases and acid, 14. *c.* atoms of elements, 49.
$4\,\dddot{\mathrm{Si}}$ 2309·24 A. 7110·32÷2·45 (sp. gr.)=2902·2
$3\,\dddot{\bar{\mathrm{A}}\mathrm{l}}$ 1925·4 B. 2902·2÷14=207·3 C. 2902·2÷49=59·23
$3\,\dot{\mathrm{Na}}$ 1172·7
$2\,\dot{\mathrm{Ca}}$ 709·98

a. At. weight, 7110·32

4. Nosean.

$4\,\dddot{\mathrm{Si}}$ =2309·24 *b.* atoms of acids and bases, 12. *c.* atoms of elements, 43.
$3\,\dddot{\bar{\mathrm{A}}\mathrm{l}}$ 1925·4 A. 6298·24÷2·3 (sp. gr.) =2738·36
$4\,\dot{\mathrm{Na}}$ 1563·6 B. 2738·36÷12=228·2 C. 2738·36÷43=63·68
$1\,\dddot{\mathrm{S}}$ 500·00

a. At. weight, 6298·24

XX. *Kyanite*, $\dddot{\bar{\mathrm{A}}\mathrm{l}}^3\,\dddot{\mathrm{Si}}^2$—*Bucholzite*, $\dddot{\bar{\mathrm{A}}\mathrm{l}}\,\dddot{\mathrm{Si}}$.

1. Kyanite.

Atomic weight as for Andalusite, 3080·02. A. 3080·02÷3·62 (sp. gr.) =850·83
B. 850·83÷5=170·165 C. 850·83÷23=37·0

2. Bucholzite.

$1\,\dddot{\mathrm{Si}}$ = 577·31 *b.* atoms of acid and base, 2. *c.* atoms of elements, 9.
$1\,\dddot{\bar{\mathrm{A}}\mathrm{l}}$ 641·80 A=1219·11÷3·4 (mean sp. gr.) =358·56

a. At. weight, 1219·11 B. 358·56÷2=179·28 C. 358·56÷9=39·84

$\dddot{\bar{\mathrm{A}}\mathrm{l}}^6\,\dddot{\mathrm{Si}}^5$ (from Bowen's and Hayes's analyses of Sillimanite) gives (G=3·41, Bowen), A=1915·8; B=174·2; C=38·32.

The true nature of the mineral bucholzite has long been in doubt on account of the varying results of analysts. Successive experimenters have placed Sillimanite with kyanite and bucholzite; and finally Prof. Silliman, Jr., has recently united the three. The above results show that the distinct chemical compounds are identical nearly in atomic volume; we may conclude therefore that three or more compounds exist, as Hermann assumed in his paper on "heteromerism;" and analysts instead of proving one another in error have in fact examined the different species.

We observe also that of the two forms of the compound $\dddot{\bar{\mathrm{A}}\mathrm{l}}^3\,\dddot{\mathrm{Si}}^2$, the *triclinic*, as before, has the higher specific gravity and lower atomic weight, and consequently the lower atomic volume.

XXI. *Leucopyrite*, Fe As—*Mispickel*, Fe S^2+Fe As,—*White Iron Pyrites*, Fe S^2.

1. Leucopyrite.

1 As =940 *c.* atoms of elements, 2.
1 Fe 350 A. 1290÷7·228 (sp. gr.) =178·47

a. At. weight, 1290 C. 178·47÷2=89·24

[If As is a double atom, then 178·47÷3=59·49]

2. Mispickel.

1 As =940 *c.* atoms of elements, 5.
2 S 400 A. 2040÷6·127 (sp. gr.)=333
2 Fe 700 C. 333÷5=66·6

a. At weight, 2040 [Considering As a double atom, 333÷6=55·5]

3. White Iron Pyrites.

2 S =400 *c.* atoms of elements, 3.
1 Fe 350 A. 750÷4·76 (sp. gr.) =157·56

a. At. weight, 750 C. 157·56÷3=52·52

The atomic volumes of these minerals are,

If As is a single atom,	89·24	66·6	52·52
If As is a double atom,	59·49	55·5	52·52

These species have each a rhombic form; but as Prof. G. Rose has observed, they appear to differ too widely to be considered isomorphous. The angles M : M are respectively 122°26′, 111°53′ and 106°30′. This chemist also remarks that the elements arsenic and sulphur are very different in crystallization, and therefore we have no good authority for assuming them to be isomorphous. If we admit As to be a single atom the atomic volumes are widely different; but if a double atom, they approximate rather closely.

In this connection, the atomic volume of *olivenite* (with which *Libethenite* is isomorphous) may be stated. The rhombic prism has $M : M\ (\infty P) = 109°10'$, $\breve{P}\infty = 84°45'$; while in white iron pyrites $\infty P = 106°30'$ and $\breve{P}\infty = 81°50'$, in Mispickel $\infty P = 111°53'$ and $\breve{P}\infty = 80°8'$.

1. Olivenite.

$\frac{3}{4}\overset{\cdot\cdot\cdot\cdot\cdot}{As}$ =1080·06 *b.* atoms of acids and bases, 6. *c.* atoms of elements, 16.
$\frac{1}{4}\overset{\cdot\cdot\cdot\cdot\cdot}{P}$ 223·1 A. 3402·04÷4·135 (sp. gr.) =822·74
4 $\dot{Cu}$ 1986·4 B. 822·74÷6=137·12 C. 822·74÷16=51·42
1 $\dot{H}$ 112·48 [If As is a double atom, then *c*=17, and C=48·4.]

a. At. volume, 3402·04

2. Libethenite.

1 $\overset{\cdot\cdot\cdot\cdot\cdot}{P}$ = 892·3 *b.* atoms of acid and bases, 6. *c.* atoms of elements, 16.
4 $\dot{Cu}$ 1986·4 A. 2991·18÷3·7 (sp. gr.) =808·43
1 $\dot{H}$ 112·48 B. 808·43÷6=134·74 C. 808·43÷16=50·53

a. At. volume, 2991·18

XXII. *Nitrate of Soda—Carbonate of Manganese—Carbonate of Zinc—Light Red Silver Ore.* (see p. 220.)

1. Nitrate of Soda, $\dot{Na}\overset{\cdot\cdot\cdot\cdot\cdot}{N}$; R : R=106° 33′.

1 $\dot{Na}$ = 390·9 *b.* atoms of acid and base, 2. *c.* atoms of elements, 8.
1 $\overset{\cdot\cdot\cdot\cdot\cdot}{N}$ 675·06 A. 1065·96÷2·1 (sp. gr.) =507·6

a. At. weight, 1065·96 B. 507·6÷2=253·8 C. 507·6÷8=63·45

2. Carbonate of Manganese, $\dot{Mn}\ddot{C}$; R : R=106°51′.

1 $\dot{Mn}$ = 444·7 *b.* atoms of acid and base, 2. *c.* atoms of elements, 5.
1 $\ddot{C}$ 275· A. 719·7÷3·592=200·4

a. At. weight, 719·7 B. 200·4÷2=100·2 C. 200·4÷5=40·1

3. Carbonate of Zinc, $\dot{Zn}\ddot{C}$, R : R=107°40′.

1 $\dot{Zn}$ = 506·6 *b.* atoms of acid and base, 2. *c.* atoms of elements, 5.
1 $\ddot{C}$ 275· A. 781·6÷4·4 (sp. gr.) =177·6

a. At. weight, 781·6 B. 177·6÷2=88·8 C. 177·6÷5=35·5

4. Light Red Silver Ore, $3Ag\,S+As\,S^3$; R : R=107°36′.
3 Ag =4050·00 *b.* atoms of base and acid, 2. *c.* atoms of elements, 10.
1 As 940·08 A. 6190·08÷5·5=1125
6 S 1200·00 B. 1125÷2=562·5. C. 1125÷10=112·5.
a. At. weight, 6190·08 C′. 1125÷11 (if As is double) =107

5. Dark Red Silver Ore, $3Ag\,S+Sb\,S^3$.
3 Ag =4050·0 A. 6362·80÷5·8 (sp. gr.) =1183
Sb 1612·8 C. 1183÷10=118·3
6 S 1200·
a. At. weight, 6862·8

C in nitrate of soda and carbonate of manganese (which are nearly alike in angle) is as 2 : 3. Carbonate of zinc, isomorphous with carbonate of manganese, has C = 35·5, the angle R : R being a degree larger. The relation between C in carbonate of zinc and light red silver ore (in which the angle is nearly the same) approaches closely 1 : 3,—three times C of zinc being 106·5, while C in the silver ore is 112·5.

XXIII. *Arragonite,* M : M, 116°10′—*White Lead ore,* 117°13′—*Strontianite,* 117°19′—*Witherite,* 118°30′—*Nitrate of Potash,* 119°—*Bournonite,* 115°16′.

1. Arragonite.
1 $\dot{Ca}$ = 351·49 *b.* atoms of acid and base, 2. *c.* atoms of elements, 5.
1 $\ddot{C}$ 275· A. 626·99÷2·93 (sp. gr.) =216
a. At. weight, 626·49 B. 216÷2=108 C. 216÷5=43·2

2. White Lead ore.
1 $\dot{Pb}$ =1394·5 A. 1669·5÷6·6 (sp. gr.) =253
2 $\ddot{C}$ 275·0 B. 253÷2=126·5 C. 253÷6=50·6
a. At. weight, 1669·5

3. Strontianite.
1 $\dot{Sr}$ = 647·3 A. 922·3÷3·66 (sp. gr.) =252·7
1 $\ddot{C}$ 275· B. 252÷2=126 C. 252÷5=50·54
922·3

4. Witherite.
1 $\dot{Ba}$ = 956·5 A. 1231·5÷4·3 (sp. gr.) =286·4
1 $\ddot{C}$ 275· B. 286·4÷2=143·2 C. 286·4÷5=57·3
1231·5

5. Nitrate of Potash.
1 $\dot{K}$ = 588·86 *b.* atoms of acid and base. *c.* atoms of elements, 8 [or 9].
1 $\overset{\cdot\cdot\cdot\cdot\cdot}{N}$ 675·06 A. 1263·92÷1·937 (sp. gr.) =652·5
a. At. weight, 1263·92 B. 652·5÷2=326·2 C. 652·5÷8=81·56

6. Bournonite.
6 Cu =2370· *c.* atoms of elements, 33.
6 Pb 7767· A. 18585·4÷5·766 (sp. gr.) =3223·3
3 Sb 4848·4 C. 3223·3÷33=97·5
18 S 3600· [3223·3÷36 (Sb being double) =89·5]
a. At. weight, 18585·4

We have added several acknowledged isomorphs that the nature of the series may be understood, preparatory for comparison with the other species. This series is,

116°10′	117°13′	117°19′	118°30′
43	50·6	50·54	57·3

In the above series there is a change of 14·3 in atomic volume for a change of 2° 20′ (or 140′) of angle. This is equivalent very nearly to 0·1 for 1′. The differences between the first and second in this series and between the third and fourth correspond nearly with this rate.

To appreciate the relation of atomic volume between nitrate of potash, and the other species of the series, we compare it with witherite which is nearest it in angle, and find the ratio nearly of 3 : 2. With reference to bournonite, we should compare with arragonite, which is nearest it in angle; or perhaps more correctly with a number still smaller than the atomic volume of arragonite, since the angle is nearly a degree less. The true ratio we cannot decide upon without further investigation.

We observe that the atomic volume in the arragonite series increases with the angle while, as shown by Kopp, it diminishes in the calc series. Moreover the species with a prismatic form have a higher atomic volume than the rhombohedral; and in the species calc spar the two series overlap.

$\dot{\mathrm{Zn}}\ddot{\mathrm{C}}$	$\dot{\mathrm{Mg}}\ddot{\mathrm{C}}$	$\dot{\mathrm{Fe}}\ddot{\mathrm{C}}$	$\dot{\mathrm{Mn}}\ddot{\mathrm{C}}$	$\dot{\mathrm{Ca}}\ddot{\mathrm{C}}$	$\dot{\mathrm{Pb}}\ddot{\mathrm{C}}$	$\dot{\mathrm{Sr}}\ddot{\mathrm{C}}$	$\dot{\mathrm{Ba}}\ddot{\mathrm{C}}$
107°46′	107°25′	107°0′	106°51′	105°15′			
35·5	36·25	37·70	40·1	46·24			
				43·	50·6	50·54	57·3
				116°10′	117°13′	117°19′	118°30′

We should hence expect that if either of these species were dimorphous like calc spar, it would be those nearest to calc spar.

The species chrysolite and those of that series differ from arragonite in having M : M = 119° – 120°, and as the angle of the arragonite series enlarges, the crystallization of the two approximates. The atomic volume of the chrysolite series varies from 40 to 46, and this is near arragonite.

We add here the calculations for two species, one of which approaches chrysoberyl and the other arragonite.

Copper glance (Ꞓu S) has M:M=119°35′, and a brachydiagonal prism =125°40′, while chrysoberyl has M : M=119°51′ and a brachydiagonal prism =130°.

Ꞓu =	793·2	A. 993·2÷5·7 (sp. gr.) =174
S	200·	C. 174÷3=58
	993·2	[or if Ꞓu is a single atom, 174÷2=67]

As 2Cu is isomorphous with 1Ag and other metals, the last value of the atomic volume appears to be most correct. This gives the ratio to the chrysolite series of 3 : 2. Serpentine has 44, to which if one-half be added, it becomes the atomic volume very nearly of copper glance.

Brittle Silver Ore (Sprödglaserz$=6\,AgS+SbS^3$) has M : M=115°39′, and one of its brachydiagonal prisms 72°32′; while arragonite has the corresponding angles 116°10′ and 69°22′.

6 Ag =8100·
1 Sb 1612·8
9 S 1800·
11512·8

A. 11512·8÷6·5=1771
C 1771÷16=110·7

This result gives the ratio of 3 : 1.

We do not decide here whether these minerals are proper isomorphs or not of the groups with which they are compared.

Topaz in one position has nearly the axes of chrysoberyl. They are given by von Kobell as follows—

For Chrysoberyl, 0·5800 : 1 : 0·4702
For Topaz, 0·4745 : 1 : 0·5281

and the latter is the same approximately as the former reversed.

Calculating the atomic volume of topaz $(AlF^3+SiF^3)+2\ddot{\overline{Al}}^3\,\dddot{Si}^2$, we find

4 $\dddot{Si}$ =2309·24
6 $\ddot{\overline{Al}}$ 3850·80
2 Al 341·8
6 F 1425·0
1 Si 277·31
8204·15

c. atoms of elements, 55.
A. 8204·15÷3·5(sp. gr,) =2344·0
C. 2344÷55=42·6

The atomic volume thus corresponds with that of the chrysolite series.

The following are some comparisons of dimetric and hexagonal species, alike in the length of the vertical axis. The coincidences of atomic volume cannot be deemed accidental.

	Axis.	Atomic volume.
Vesuvian, *dimetric*,	0·5345	44·64
Dioptase, *rhombohedral*,	0·5295	45·44
Rutile, *dimetric*,	0·6555	40·7
Arsenic, *rhombohedral*,	0·6938	163 (=4×40·75)
Scapolite, *dimetric*,	0·44	54·
Nepheline, *rhombohedral*,	0·4629	56·66
Beryl, "	0·4993	53·46
Tungsten, *dimetric*,	1·0488	50·3
Chabazite, *rhombohedral*,	1·0798	51·5

It is obvious that these observations are but the introduction to a subject of great extent, and of the widest interest to science.

I defer for another occasion what had been prepared upon the monometric species, and conclude with a table of the results here published, and a brief enunciation of some of the conclusions flowing from the facts detailed.

A TABULAR VIEW OF THE RESULTS.

The relations of atomic volume will be at once apparent from the following table; 1, as exhibited in the column of aggregate atomic volumes (column A),—2, in that of the aggregate divided by the number of atoms of acids and bases (column B),—3, that of the aggregate divided by the number of atoms of the elements (column C).

1. *Crystallization clinometric.*

	A.	B.	C.
1. Pyroxene, monoclinic, 1st var., $(\dot{Ca}, \dot{Mg})^3 \dddot{Si}^2$,	637·	127·4	45·5
2d var., $(\dot{Ca}, \dot{Mg}, \dot{Fe})^3 \dddot{Si}^2$,	645·2	129·	46·1
3d var., (Hedenbergite,)	673·4	134·7	48·1
4th var., (Hudsonite,)	706·0	141·2	48·9
5th var., $\dot{Fe}^3 \dddot{Si}^2$,	674·7	135·	48·2
6th var., $\dot{Mn}^3 \dddot{Si}^2$,	684·8	136·9	48·9
2. Acmite, monoclinic,	918·5	183·7	48·34
3. Hornblende, " 1st var.,	971·6	138·8	48·58
2d var., (aluminous,)	. .	155·95	47·25
3d var., "	. .	138·4	48·43
4th var.,	. .	144·0	48·24
4. Borax, monoclinic,	1391·6	107·0	46·38
5. Glauber salt, "	1290·5	107·54	49·6
1. Epidote, monoclinic,	1268·	158·5	45·285
2. Zoisite, "	1237·	154·6	44·2
3. Orthite of the Urals, monoclinic,	1921·	147·8	48·025
4. Orthite of Hitteroe, "	1017·	145·3	48·43
1. Orthoclase, monoclinic,	1388·	231·3	60·4
2. Ryacolite, "	867·	216·7	57·8
3. Loxoclase, "	1063·	212·6	56·0
4. Baulite, "	2178·1	217·81	55·85
5. Albite, triclinic,	1280·4	213·4	55·67
6. Labradorite, "	795·5	198·9	53·03
7. Oligoclase, "	1038·3	207·66	54·647
8. Anorthite, "	1959·	195·9	52·95
9. Vosgite, "	2166·5	197·	52·84
10. Andesine, "	2912·4	208·	55·0
11. Petalite, "	6071·8	224·96	57·3
1. Kyanite, triclinic, $\dddot{\overline{Al}}^3 \dddot{Si}^2$,	850·83	170·165	37·0
2. Bucholzite, " $\dddot{\overline{Al}} \dddot{Si}$,	358·56	179·28	39·84
3. Sillimanite, $\dddot{\overline{Al}}^6 \dddot{Si}^5$ (Bowen's analysis),	1915·8	174·2	38·32
1. Chromate of lead, monoclinic,	333·8	166·9	55·6
2. Monazite, "	617·25	154·3	51·44

2. *Hexagonal or Rhombohedral.*

	A.	B.	C.
1. Specular iron, 85°58′,	192·	. .	38·4
2. Alumina, (Corundum,) 86°04′,	161·7	. .	32·3
3. Phenacite, 83°12′,	354·	88·5	35·4
4. Arsenic, 85°04′,	. . .	. .	163·
5. Antimony, 87°35′	. .	. .	240·65
6. Bismuth, 87°40′,	. .	. .	135·75
7. Tellurium, 86°57′,	. .	. .	129·36
8. Osmium, 84°52′,	. .	. .	124·26
1. Quartz, 94°15′,	218·	. .	54·5
2. Chabazite, 94°46′,	4582·4	143·	51·5
1. Cinnabar, 71°47′,	180·	. .	90·
2. Eudialyte, 73°40′,	2382·	183·2	58·1
1. Beryl, (old at. wt. of Glucina,)	2512·7	228·4	53·46
2. Nepheline,	1473·2	210·5	56·66
1. Talc, $\dot{\mathrm{Mg}}^3\,\dddot{\mathrm{Si}}^4$,	1138·	162·57	51·73
2. “ $\dot{\mathrm{Mg}}^4\,\dddot{\mathrm{Si}}^5$,	1446·	160·7	51·64
3. “ $\dot{\mathrm{Mg}}\,\dddot{\mathrm{Si}}$,	308·1	154·	51·35
1. Carbonate of lime, 105°05′, (from Kopp,)	231·20	165·60	46·24
2. “ lime and magnesia (dolomite,) 106°15′,	202·36	101·18	40·47
3. “ manganese, 106°51′,	200·4	100·2	40·1
4. Nitrate of soda, 106°33′,	507·6	253·8	63·45
5. Carbonate of iron, 107°,	188·50	94·25	37·70
6. “ iron and magnesia, (mesitine,) 107°14′,	186·26	93·13	37·25
7. “ magnesia, 107°25′,	181·25	90·62	36·25
8. “ zinc, 107°40′,	177·6	88·8	35·5
9. Light red silver ore, 107°36′,	1125·	562·5	112·5
10. Dark red silver ore, 108°18′,	1183·	591·5	118·3

3. *Crystallization trimetric.*

1. Chrysoberyl, (new atomic weight,)	216·18	108·9	30·9
“ old atomic weight,	1300·9	185·8	37·16
“ von Kobell's at. wt.,	433·7	144·6	36·14
2. Chrysolite,	416·	104·	41·6
3. Villarsite,	1916·3	100·86	41·65
4. Serpentine,	2068·5	109·	44·9
5. Epsom salt,	881·	98·	44·
6. Picrosmine,	1587·	122·	46·68
1. Topaz,	2344·	. .	42·6
1. Sulphur,	98·4	. .	98·4
2. Scorodite,	894·73	149·12	47·1
3. Selenium, (acknowledged isomorphous with sulphur,)	115·	. .	115·
1. White iron pyrites, (dimorph with common pyrites,) 106°36′,	157·56	. .	52·52
2. Graphic tellurium, 107°44′,	1137·5	. .	113·75
3. Celestine, 104°,	294·2	147·1	49·
4. Heavy spar, 101°40′,	323·64	161·82	53·94
5. Anglesite, 103°49′,	301·67	150·83	50·27

	A.	B.	C.
1. Andalusite,	962·5	192·5	41·85
2. Spodumene,	3216·7	169·3	43·47
1. Leucopyrite—As, a single atom,	178·47	. .	89·24
As, a double atom,	. .	. .	59·49
2. Mispickel —As, a single atom,	333·	. .	66·6
As, a double atom,	. .	. .	55·5
3. White iron pyrites, (as above,)	157·56	. .	52·52
4. Olivenite,	822·74	137·12	51·42
5. Libethenite,	808·43	134·74	50·53
1. Arragonite, 116°10′,	216·	108·	43·2
2. White lead ore, 117°13′,	253·	126·5	50·6
3. Strontianite, 117°19′,	252·	126·	50·54
4. Witherite, 118°30′,	286·4	143·2	57·3
5. Nitrate of potash, 119°,	652·5	326·2	81·56
6. Bournonite, 115°16′,	3223·3	. .	97·5
1. Copper glance, 119°35′,	174·	. .	58 or 67
1. Brittle silver ore,	1771·	. .	110·7

4. *Crystallization dimetric.*

1. Scheelite, (tungstate of lime,)	301·6	150·8	50·3
2. Tungstate of lead,	355·9	177·9	59·3
3. Fergusonite,	967·5	138·2	57·0
1. Zircon,	370·3	185·15	41·15
2. Rutile,	122·3	. .	40·7
3. Tin ore,	134·4	. .	44·8
1. Scapolite,	1729·4	192·1	54·
2. Meionite,	1558·2	194·8	55·65
3. Wernerite,	1909·	190·9	51·6
4. Dipyre,	2816·	201·1	55·21
5. Barsowite,	2133·	194·	52·
6. Wernerite, Pargas,	1371·1	196·	52·7
7. Gehlenite (Rammelsberg's analysis),	2505·3	156·6	51·13
1. Idocrase,	848·16	141·36	44·64
1. Anatase,	134·0	. .	44·66
2. Horn quicksilver,	261·3	. .	130·65

5. *Crystallization monometric.*

1. Leucite,	3343·	238·8	63·08
2. Analcime,	4057·7	202·88	62·43
3. Haüyne,	2902·2	207·3	59·23
4. Nosean,	2738·36	228·2	63·68
5. Sodalite—Sp. gr.=2·29,	2682·	244·	68·77
Sp. gr.=2·37,	. .	. .	66·45

Conclusions from the preceding facts.

I. The law of Isomorphism, in view of the facts detailed, has greatly widened limits. It includes the received law—Like or homologous compounds of isomorphous elements are isomorphous; and also the more general law,—Unlike compounds, of the same or different elements, may be isomorphous, and when so, they are alike or proportional in atomic volume.

II. Cleavage may differ among substances, and yet the species be isomorphous. Thus augite and hornblende have different cleavage; anatase and horn quicksilver; sulphur and scorodite. This is a point, however, which requires much more investigation.

III. The relations of atomic volume shown in the three columns are all of interest, but especially those in the *third* or C column. The C relation is seen to be in general a relation of approximate *equality*, while the A relation when simple is usually one of multiple ratio; and sometimes it is far from simple. The C relation exhibits the comparative character of the monoclinic, triclinic and monometric feldspars, in a simple and obvious manner, while from the A relation, no deduction could be made: and so in other cases where general principles are concerned. The C relations often show a consistent difference between a substance with its allies and others unlike, when no such difference is apparent in the A relations. The C relation moreover exhibits the differences which are compatible with a ratio of equality, and hence enables us to compare more correctly the A relations. It is unnecessary to review here the ratios in the C column. We mention only a few cases of the ratios (approximate) apparent in the A column which in many cases are simple and deserve full consideration. We take the number for the species first mentioned in each paragraph as the unit for comparison with the others.

1. Pyroxene, dif. var., 1; acmite 1½; hornblende 1½; borax 2; glauber salt 2.

2. Epidote 1; zoisite 1; Ural orthite 1½; Hitteroe orthite ⅘.

3. Orthoclase 1; ryacolite ⅔; loxoclase ¾; baulite 1½; albite 1; labradorite ⅔; anorthite 1½; vosgite 1½; andesine 1½; petalite 4½.

4. Kyanite 1; bucholzite $\frac{42}{100}$; sillimanite (one var.) 2¼.

5. Quartz 1; chabazite 20. In deducing the ratio here as in other cases, we have some reference necessarily to the difference observed in the C ratios.

6. Talc, 1st var., 1; 2d var., 1¼; 3d var., $\frac{27}{100}$. In the C column the numbers are nearly equal.

7. Chrysolite 1; chrysoberyl ½ (or 1); villarsite 4·6; serpentine 5; Epsom salt 2; picrosmine 3½.

8. Rutile 1; zircon 3.—9. Scheelite 1; fergusonite 3.

We do not pursue this further, as the ratios are readily deducible from the table.

IV. The view of Scheerer, that three of water may replace one of magnesia, if true, is only true for a special case or set of cases, and is subordinate to the more general law of atomic volume. If true, we should expect, in dividing the aggregate atomic volume by the number of atoms of the elements, that it would be right to reckon three atoms of water as eqivalent to one of magnesia, instead of counting each element as equal to one; but the facts observed are opposed to this course.

The Gerhardtian principle that protoxyd bases replace peroxyds, is also, when true, only a special case. The relations of the feldspars do not appear to be explicable on Gerhardt's principle; nor the relations of the varieties of scapolite or hornblende.

V. Species of the same atomic volume may be wholly unlike in crystallization, and hence volume alone does not seem to determine the form. Quartz has the atomic volume (C) of the feldspars—an interesting fact in view of their frequent association—and the A relation between it and albite is 1 : 6; yet there is no isomorphism between them. The fact that the two forms of a dimorphous substance differ but little in the calculated atomic volume, (often much less than one of the forms differs from another isomorphous with it,) appears to be a case in point. Yet if instances of dimorphism are also instances of isomerism, it is possible that the volume may actually be double that which is deduced. We have much therefore, to ascertain on this point, before we can determine the true relation of form to volume.

VI. There are difficulties in the way of applying these principles to some compounds, arising from doubts with regard to the atomic weights. But, as in the case of hydrogen, (which is doubled by the Berzelian school,) these investigations seem to afford data for arriving at the truth.

VII. Since the relations of atomic volume are exhibited through the volume of the elemental molecules of compounds, it may be inferred that *the elemental molecules are not combined together or united with one another in a compound; but that, under their mutual influence, each is changed alike and becomes a mean result of the molecular forces in action.* If the elemental molecules were actually combined, as is usually supposed, the atomic volume of the aggregate should be the atomic volume of the compound; so that in all comparisons between different substances, these aggregate results should present the true relation. But, it appears that the true atomic volume relation is found in the elemental molecules of compounds, and much less clearly or uniformly in the aggregate results. This inference is at variance with received ideas on chemical combination; yet if our premises are correct—we admit they need farther investigation—we see not how to avoid it.

We add an additional word upon the name applied to isomorphism among unlike compounds. *Heteromerism*, as stated, is unmeaning, this term being the correlative of *isomerism*, which has no relation to isomorphism. *Heteromerous isomorphism* is in itself applicable; but the word *isomerous* is in use, and heteromerous, if employed at all, should correspond in signification. As the above terms are therefore objectionable, we suggest as appropriate and significant, the expressions *isonomic* and *heteronomic isomorphism;* the isomorphism being in one case between homologous substances, or those of like law or proportion in constitution,—and in the other between substances unlike in constitution.

Art. XXVI.—*Observations on the Size of the Brain in various Races and Families of Man;* by Samuel George Morton, M.D.*

I have great pleasure in submitting to the Academy the results of the internal measurements of six hundred and twenty-three human crania, made with a view to ascertain the relative size of the brain in various races and families of man.

These measurements have been made by the process invented by my friend, Mr. J. S. Phillips, and described in my Crania Americana, p. 253, merely substituting leaden shot, one-eighth of an inch in diameter, in place of the white mustard-seed originally used. I thus obtain the *absolute capacity of the cranium, or bulk of the brain, in cubic inches;* and the results are annexed in all those instances in which I have had leisure to put this revised mode of measurement in practice. I have restricted it, at least for the purpose of my inferential conclusions, to the crania of persons of sixteen years of age and upwards, at which period the brain is believed to possess the adult size. Under this age, the capacity-measurement has been resorted to only for the purpose of collateral comparison; nor can I avoid expressing my satisfaction at the singular accuracy of this method, since a skull of a hundred cubic inches, if measured any number of times with reasonable care will not vary a single cubic inch.

All these measurements have been made with my own hands. I at one time employed a person to assist me; but having detected some errors in his measurements, I have been at the pains to revise all that part of the series that had not been previously measured by myself. I can now, therefore, vouch for the accuracy of these multitudinous data, which I cannot but regard as a novel and important contribution to Ethnological science.

I am now engaged in a memoir which will embrace in detail the conclusions that result from these data; and meanwhile I submit the following tabular view of the prominent facts. (See opposite page.)

The measurements of children, idiots and mixed races are omitted from this table, excepting only in the instance of the Fellahs of Egypt, who, however, are a blended stock of two *Caucasian* nations,—the true Egyptian and the intrusive Arab, in which the characteristics of the former greatly predominate.

No mean has been taken of the Caucasian race† collectively, because of the very great preponderance of Hindu, Egyptian and

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* From the Proceedings of the Academy of Natural Sciences, Philadelphia, October, 1849.

† It is necessary to explain what is here meant by the word *race*. Further researches into Ethnographic affinities will probably demonstrate that what are now termed the *five races* of men, would be more appropriately called *groups;* that each

Table showing the Sizes of the Brain in cubic inches, as obtained from the internal measurement of 623 Crania of various Races and Families of Man.

Races and Families.	No. of Skulls.	Largest I. C.	Smallest I. C.	Mean.	Mean.
MODERN CAUCASIAN GROUP.					
TEUTONIC FAMILY.					
Germans,	18	114	70	90	92
English,	5	105	91	96	
Anglo-Americans,	7	97	82	90	
PELASGIC FAMILY. Persians, Armenians, Circassians,	10	94	75	84	
CELTIC FAMILY. Native Irish,	6	97	78	87	
INDOSTANIC FAMILY, Bengalees, &c.	32	91	67	80	
SEMITIC FAMILY. Arabs,	3	98	84	89	
NILOTIC FAMILY. Pellahs,	17	96	66	80	
ANCIENT CAUCASIAN GROUP.					
From the Catacombs. PELASGIC FAMILY. Græco-Egyptians,	18	97	74	88	
NILOTIC FAMILY. Egyptians,	55	96	68	80	
MONGOLIAN GROUP.					
CHINESE FAMILY.	6	91	70	86	
MALAY GROUP.					
MALAYAN FAMILY.	20	97	68	86	85
POLYNESIAN FAMILY.	3	84	82	83	
AMERICAN GROUP.					
TOLTECAN FAMILY. Peruvians,	155	101	58	75	79
Mexicans,	22	92	67	79	
BARBAROUS TRIBES Iroquois, Lenapé, Cherokee, Shoshoné, &c.	161	104	70	84	
NEGRO GROUP.					
NATIVE AFRICAN FAMILY.	62	99	65	83	83
AMERICAN-BORN NEGROES.	12	89	73	82	
HOTTENTOT FAMILY.	3	83	68	75	
ALFORIAN FAMILY. Australians,	8	83	63	75	

Fellah skulls over those of the Germanic, Pelasgic and Celtic families. Nor could any just *collective* comparison be instituted between the Caucasian and Negro groups in such a table, unless the small-brained people of the latter division (Hottentots, Bushmen and Australians) were proportionate in number to the Hindoos, Egyptians and Fellahs of the other group. Such a computation, were it practicable, would probably reduce the Caucasian average to about 87 cubic inches, and the Negro to 78 at most, perhaps even to 75, and thus confirmatively establish the difference of at least nine cubic inches between the mean of the two races.

Large as this collection already is, a glance at the Table will show that it is very deficient in some divisions of the human family. For example, it contains no crania of the Eskimaux, Fuegians, Californians or Brazilians. The skulls of the great divisions of the Caucasian and Mongolian races are also too few for satisfactory comparison, and the Sclavonic and Tchudic (Finnish) nations, together with the Mongol tribes of Northern Asia and China, are among the especial *desiderata* of this collection.

Among the facts elicited by this investigation are the following:

1. The Teutonic or German race, embracing, as it does, the Anglo-Saxons, Anglo-Americans, Anglo-Irish, &c., possesses the largest brain of any other people.

2. The nations having the smallest heads, are the ancient Peruvians and Australians.

3. The Barbarous tribes of America possess a much larger brain than the demi-civilized Peruvians or Mexicans.

4. The ancient Egyptians, whose civilization ante-dates that of all other people, and whose country has been justly called "the cradle of the arts and sciences," have the least-sized brain of any Caucasian nation, excepting the Hindoos; for the very few Semi-

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of these groups is again divisible into a greater or smaller number of primary races, each of which has expanded from an aboriginal nucleus or centre. Thus I conceive that there were several centres for the American group of races, of which the highest in the scale are the Toltecan nations, the lowest the Fuegians. Nor does this view conflict with the general principle, that all these nations and tribes have had, as I have elsewhere expressed it, a common origin; inasmuch as by this term is meant only an indigenous relation to the country they inhabit, and that collective identity of physical traits, mental and moral endowments, language, &c., which characterizes all the American races. The same remarks are applicable to all the other human races; but in the present infant state of Ethnographic science, the designation of these primitive centres is a task of equal delicacy and difficulty. I may here observe, that whenever I have ventured an opinion on this question, it has been in favor of the doctrine of *primæval diversities* among men,—an original adaptation of the several races to those varied circumstances of climate and locality, which, while congenial to one are destructive to the other; and subsequent investigations have confirmed me in these views. See *Crania Americana*, p. 3; *Crania Ægyptiaca*, p. 37; *Distinctive Characteristics of the Aboriginal Race of America*, p. 36; *American Journal of Science and Arts*, 1847; and my *Letter to J. R. Bartlett, Esq.*, in vol. ii. of the Transactions of the Ethnological Society of New York.

tic heads will hardly permit them to be admitted into the comparison.

5. The Negro brain is nine cubic inches less than the Teutonic, and three cubic inches larger than the ancient Egyptian.

6. The largest brain in the series is that of a Dutch gentleman, and gives 114 cubic inches; the smallest head is an old Peruvian, of 58 cubic inches; the difference between these two extremes is no less than 56 cubic inches.

7. The brain of the Australian and Hottentot falls far below the Negro, and measures precisely the same as the ancient Peruvian.

8. This extended series of measurements fully confirms the fact stated by me in the Crania Americana, that the various artificial modes of distorting the cranium, occasion no diminution of its internal capacity, and consequently do not affect the size of the brain.

ART. XXVII.—*Remarks on the Aneroid Barometer;* by Professor J. LOVERING of Harvard University.

MOST of the scientific journals of Europe and America have published descriptions of the new French barometer, as it is called. For the construction of the instrument and the history of its invention I may refer to them, particularly to that contained in this Journal, September, 1849.

The two ordinary statical ways of measuring forces are, 1st, by means of gravity, and 2d, by elasticity. Our common balances to measure weight employ either the gravity of a known counterpoise or the elasticity of a spring. In like manner the weight of a column of the atmosphere is determined when we know the height of a similar column of some known fluid which it is able to support or the elasticity of some familiar substance with which it is in equilibrium. The barometer with which all have long been familiar employs the first method. The aneroid barometer, which, as its name implies, excludes all liquids from its construction, is based on the last principle, viz., that of measuring weight by elasticity.

This new instrument is already manufactured in large numbers in France and Great Britain. Its adoption is recommended on the ground of accuracy as well as its great strength and compactness. Barometers are now extensively used, not only for tracing out the grand laws of meteorology, but also as a practical guide to the mariner to forewarn him of approaching storms, and an indispensable instrument of research to the physical geographer and geologist. It is highly important that the mineralogist, the navigator and the student of general science should know what degree of accuracy may be claimed for the new barometer and how far they are allowed to trust themselves to its indications. With the hope of assisting those who desire to form an opinion on this subject, I present the following experiments and observations, undertaken originally at the suggestion of Prof. A. D. Bache, Superintendent of the U. S. Coast Survey. The instrument employed in this research was furnished by Prof. Bache, and bears the mark 1265, Lerebours and Secretan, Paris.

A series of experiments was first made with this aneroid barometer to determine the whole range of the instrument. For this purpose, it was placed first under the receiver of an exhausting pump, and afterwards under the receiver of a condensing engine. In this way, it was found capable of indicating a change of atmospheric pressure which would move the column of mercury in a common barometer from about twenty inches up to thirty-one inches. From the nature of its construction, the index cannot go beyond the point which corresponds to twenty inches of the mercurial barometer on one side, or that which corresponds to thirty-one inches of the same on the other. How accurately its march between these limits agrees with that of the mercurial barometer will appear from an examination of Table I. The pressure of the air in the receiver of the pump was obtained from the mercurial pump-gauge, which was supplied with common mercury and corrected for level and capillarity. This table shews that, while the index of the aneroid barometer is able to move, it moves farther than the column of mercury under the same change of atmospheric pressure. As it approaches its lower limit, however, it will begin of course to be restrained in the amplitude of its motion, until, at length, the difference between the two instruments changes its sign. It is obvious that, in the particular instrument examined at least, and for long ranges, similar changes of pressure are not marked by equal quantities of motion in the index in all parts of the scale. This might be expected in an instrument where no consideration is given to the distinction between potential and apparent leverage. Besides this which may be called the instrumental error, there is an irregularity in the motion of the index, arising from friction, bending, or some other cause, which would interfere seriously with the accuracy of its indications even if the arc over which the index moves were so graduated as to eliminate the instrumental error.

At the meeting, in 1848, of the British Association for the Advancement of Science, it was stated by Mr. Lloyd that one of his friends had made a similar experiment to that I have described, and that the indications of the aneroid barometer corresponded to those of the pump-gauge to within ·01 of an inch. Such is the statement in the London Atheneum, although I find no mention made of the subject in the Report of the Association for that year. As the reader is not informed to what amount of diminished pressure the aneroid barometer was subjected in this case, and whether the difference above mentioned was the result of a single observation or the mean residuum of many, he is not able to decide how far the experiments to which Mr. Lloyd refers are at variance with those here published. I cannot say how much of the error manifested in my comparison of the two barometers is fairly to be charged to the general character of the new barometer, and how much is peculiar to the single instrument with which I experimented. As soon as an opportunity offers, I desire to submit other specimens of the aneroid barometer of English and French construction to the same trial.

My next series of experiments consisted in a comparison of the aneroid barometer, day by day, with the common barometer, under the ordinary changes of atmospheric pressure. The mercurial barometer used for the purpose was made by W. & S. Jones, London, and is the same as that employed by Prof. Farrar in his barometric observations published in Volume III. of the Memoirs of the American Academy, Boston. This instrument is furnished with an adjustment for level, an attached thermometer and a scale of corrections for temperature. This correction as well as that for capillarity has been applied to my observations. In this series of experiments it was necessary to know how much the aneroid barometer was affected by a change of temperature. Only a partial compensation is attempted in the construction of the instrument. An increase of temperature tends to make the air in the reservoir expand in the same way as diminished pressure. But the same increase of temperature, by enlarging the metallic surfaces of the reservoir and increasing its capacity, may sometimes even over-compensate for the increased elasticity of the contained gas. In the instrument which I used the compensation fell short; and the amount of the deficiency was determined by exposing the barometer side by side with a thermometer to a temperature of 32° Fah. and reading the index, and then exposing it to a high temperature (in some instances as high as 140° Fah.) and reading the index once more. The difference of the two readings divided by the difference of the two temperatures was adopted as the correction for a single degree and was applied to each of the observations. The value of this correction as obtained from the mean of five experiments is ·0021 of an inch, with the same sign as in the mercurial barometer. The aneroid barometer in my possession was not provided (as is sometimes the case) with an attached thermometer. A thermometer by the side of it and not under the same case as the air-chest will not indicate the exact temperature of the working parts of the instrument. The slowness with which the index returned to its old mark, after the barometer had been subjected to excessive heat or cold and was then restored to a medium temperature, manifests the importance of having the thermometer inclosed as the rest of the instrument. The standard of temperature adopted was 55° Fah. to accommodate the scale of the mercurial barometer.

The result of this series of comparisons is contained in Table II. Although the agreement is much closer than with the low ranges, it falls far below the requirements of nice scientific investigations. Mr. David Purdie Thompson in his very recent "Introduction to Meteorology," has the following paragraph. "Upon comparison of indications made with the aneroid barometer—not corrected for the particular temperature—and a very perfect mercurial barometer, given by Mr. Dent, we find that from forty-nine observations made between the 6th of January and 23d of February, 1848, the mean difference was 0·037 of an inch, the *aneroid* being in excess; and from sixty similar observations made with a standard barometer, during December, 1848, and between the 3d and 31st of January, 1849, the mean difference amounted to 0·026 of an inch, the *mercurial* being, in this case, in excess over the aneroid barometer. Combining these observations (109 in number) a mean difference amounting to 0·0025 of an inch is found to exist, the indications of the aneroid being in excess. For general use the instrument is thus shown to be well suited; for the measurement of heights it is peculiarly adapted, from its portability and comparative strength; and for nautical purposes we know of no better instrument."—p. 448.

Now it will be observed that the mean difference in the twenty-eight comparisons of the two barometers which I have given amounts to only ·040 of an inch. So far as can be inferred from the value of the mean differences, the comparisons were as satisfactory as in the first set given by Mr. Thompson. Still the single differences are large; whether larger or smaller than in Mr. Dent's observations I am not able to say, as Mr. Thompson has not given the individual differences. Provision has been made in the construction of the instrument for diminishing the mean difference as we alter the general rate of a chronometer. If the mean difference is eliminated from the comparisons and the remaining differences are placed in a column as in Table II, they manifest by the signs of plus and minus the irregularities of the instrument in small ranges and the errors to be expected from these irregularities in single observations. I have arranged the same observations in Table III, according to the sign and the value of these remaining differences. From the sign of the differences it appears that when the barometers fall the aneroid falls most, and when the barometers rise the aneroid rises most. In other words, the aneroid index moving on either side of the point where it agrees with the mercurial barometer moves too fast.

The experiments with the air-pump indicate the same tendency more unequivocally and to about the same proportional amount. For in these experiments, where the barometer and the pump-gauge were indicating the effect of diminished pressure, the aneroid stood at the lowest point; so that when the elevation of the mercury in the pump-gauge is subtracted from the backward motion of the index in the aneroid the sign is always plus: at least, until the lower limit of range is approached. Although this is the general character of the differences, a nice examination of the observations shows that here as well as in the experiments with the air-pump there are errors and fluctuations which cannot be traced to any law of the instrument, and against which no provision can be made.

Table IV. contains a series of observations made with the view of ascertaining the stability in the levers of the aneroid barometer and the firmness of other parts of the instrument. The instrument was read off before being exposed to diminished pressure: it was then noticed with what fidelity and dispatch the index returned to its original position when the original pressure was restored.

In estimating the merits of the aneroid barometer, it must not be forgotten that it is single observations, indicating momentary changes of the atmospheric pressure, on which the navigator most relies. In some of the hurricanes to which he is exposed, the barometer occasionally sinks so low as to come within the range of the experiments made with the air-pump. And yet here if any where the aneroid barometer finds its appropriate sphere. In meteorology, the barometer is the most important instrument of research. The barometer alone of all the instruments in the hands of the meteorologist is independent of merely local changes and gauges the atmosphere to its upper limit. But the range of atmospheric pressure is so limited, that laborious series of observations, with the nicest barometers that can be constructed, are necessary in order to develop the harmonies of this strangely agitated envelope of our planet. No observer would be willing to risk the value of this long labor by trusting to the new barometer until its peculiarities are better understood than at present. It may possibly happen that a long series of observations which eliminate irregularities of weather will eliminate instrumental irregularities at the same time. The same objections apply with greater force to the application of the aneroid barometer to the measurement of heights above the level of the sea. An elevation of eighty-seven feet depresses the mercury by about ·1 of an inch only; hence a small error in the barometer will entail a large error on the estimated elevation. Moreover, a very long series of observations will, in this case, be generally impracticable. I would suggest one farther consideration. The mercurial barometer is in danger of being broken when exposed to the perils of mountain-travel. In this case, the damage, however great, is known, and no error is introduced into science. Unless the tube is broken, the instrument is so simple in its construction that it is not liable to be injured at all. It is otherwise with the aneroid barometer. To appearance it is stronger than the old barometer and can bear a greater strain without being broken. On the other hand, we can easily foresee that it may be materially injured without attracting the notice of the observer at the time, and in this way may conceal its own infirmities under its apparent strength.

TABLE I.

1849.	Fall of the Aneroid Barometer under the receiver.	Rise of the mercury in the pump gauge corrected for capillarity and level.	Difference.		Fall of the Aneroid Barometer under the receiver.	Rise of the mercury in the pump gauge corrected, &c.	Difference.
Sept. 24.	4.27	4.258	.012+	Sept. 27.	10.42	20.721	10.301−
Thermometer not observed. Barometer 29·760.	7.78	7.673	.107+	Thermometer 66. Barometer 29·940.	10.40	19.338	8.938−
	10.10	15.830	5.730−		10.38	18.236	7.856−
	10.07	16.030	5.960−		10.38	17.294	6.914−
	9.78	10.150	.370−		10.36	16.282	5.922−
	9.44	9 268	.172+		10.30	15.030	4.730−
	8.46	8.216	.244+		10 02	10.140	.120−
	7.52	7.264	.256+		9 60	9.268	.332+
	6.48	6.232	.248+		8.68	8.246	.434+
	5.48	5.240	.240+		7.72	7.224	.496+
	4.45	4.388	.062+		6.79	6.332	.458+
	3 38	3.256	.124+		5.61	5.270	.340+
	2.32	2.214	.106+		4.49	4.208	.282+
					3.50	3 256	.244+
					2.36	2.254	.106+
Sept. 26.	10.13	18.537	8.407−	Sept. 29.	10.63	23.035	12.405−
Thermometer 72·5 Fah. Barometer 29·690.	10.11	17.294	7.184−	Thermometer 66·5. Barometer 30·170.	10.59	16.262	5.672+
	10.11	16.382	6.272−		10.23	10.220	.010+
	10.07	15.280	5.210−		9.75	9.328	.422+
	9.75	10.220	.470−		9.02	8.426	.594+
	9.36	9.268	.092+		7.95	7.294	.656+
	8.71	8.316	.394+		6.93	6.332	.598+
	7.67	7.274	.396+		5.80	5.270	.530+
	6 67	6.262	.408+		4.63	4.238	.392+
	5.53	5.120	.410+				
	4.67	4.238	.432+		2.45	2.224	.226+
	3.34	3.206	.134+				
	2.30	2.154	.146+				

Dec. 4. The Aneroid barometer was placed under the receiver of a condensing pump and it was observed that the index only moved forward to 31, which corresponds to 31 of the mercurial barometer.

TABLE II.

1849.	Aneroid corrected for Temperature.	Mercurial corrected for level, capillarity and temperature.	Difference.	Difference after eliminating mean difference of instruments.
Dec. 10	29.932	29.977	.045−	·005−
11	30.089	30.107	.018−	.022+
12	30.439	30.507	.068−	.028−
13	30.267	30.237	.030+	.070+
14	30.122	30.117	.005+	.045+
15	30.378	30.397	.019−	.021+
16	30.148	30.147	.001+	.041+
17	29.870	29.907	.037−	.003+
18	30.327	30.327	.000	.040+
19	30.519	30.537	.018−	.022+
20	29.703	29.787	.084−	.044−
21	30.119	30.127	.008−	.032+
22	30.012	30.067	.055−	.015−
23	29.353	29.447	.094−	.054−
24	29.595	29.667	.072−	.032−
25	29.488	29.597	.109−	.060−
26	30.212	30.310	.098−	.069−
27	30.087	30.160	.073−	.033−
28	30.407	30.447	.040−	.000
29	30.025	30.090	.065−	.025−
30	30.200	30.197	.003+	.043+
31	30.115	30.147	.032−	.008+
1850.				
Jan. 2	30.360	30.407	.047−	.07 −
3	30.156	30.207	.051−	.011−
4	29.890	29.937	.047−	.07 −
5	30.125	30.137	.012−	.028+
6	30.464	30.517	.053−	.013−
7	30.340	30.367	.027−	.013+
Mean,	30.098	30.138		
"		30.098		
Diff'nce.		.040−		

TABLE III.

Observations in Table II, arranged according to the amount and the sign of their differences.		
	29.597	.069−
	30.310	.058−
	29.447	.054−
	29.787	.044−
	30.160	.033−
	29.667	.032−
	30.507	.028−
	30.090	.025−
	30.067	.015−
	30.517	.013−
	30.207	.011−
	30.407	.007−
	29.937	.007−
	29.977	.005−
Mean,	30.048	.029−
	30.237	.070+
	30.117	.045+
	30.197	.043+
	30.147	.041+
	30.327	.040+
	30.127	.032+
	30.137	.028+
	30.537	.022+
	30.107	.022+
	30.397	.021+
	30.367	.013+
	30.147	.008+
	29.907	.003+
Mean,	30.212	.029+
"	30.048	
Difference,	.164	

1849. Sept. 10. The Aneroid stood at 30·39. It was placed under the receiver of an air pump and the atmospheric pressure diminished by 5 inches. When the air was admitted, the index moved forward to 30·35. It rose to 30·375 in two or three minutes. The following table embraces similar experiments with their results.

TABLE IV.

	Original reading of the Aneroid Barometer.	Reading after the air was admitted.	Difference.	Degree of rarefaction as measured by the pump-gauge.		Original reading.	Reading after the air was admitted.	Difference.	Degree of rarefaction.
Sept. 10.	30.390	30.375	.015−	5 inch	Sept. 24	29.760	29.720	.040−	16 inch.
	30·480	30.530	.050+	5 "	26	29.690	29.680	.010−	18 "
	30.375	30.360	·015−	5 "	27	29.940	29.930	.010−	20 "
	30.360	30·460	·100+	9 "	29	30.170	30.050	.120−	22 "
	30.480	30.500	·020+	5 "					
	30.530	30.530	.000	9 "					

Art. XXVIII.—*An account of some Fossil Bones found in Vermont, in making excavations for the Rutland and Burlington Railroad;* by Zadock Thompson.

In addition to the benefits derived directly from railroads in the business of travel and transportation, the cause of science and particularly the science of geology is deriving indirectly no small advantage from their construction. The deep cuttings which these works often require, expose the various strata of rocks where they have not been affected by the weather for the examination of the geologist, and the vast excavations in stratified sand and clay, and in the confused beds of drift materials, exhibit not only the relations of these to each other, but frequently disclose organic remains which shed new light upon the early history of our earth.

Only about four years have elapsed since the construction of railroads was commenced in Vermont, and at this time, nearly three hundred miles of railroad are so far completed as to be in use within the state; and, while the excavations for these roads have conduced to a more accurate knowledge of the position, age and lithological character of the rock formations, they have at the same time very unexpectedly disclosed organic remains, which are of much scientific interest and importance. In grading the line of the Rutland and Burlington Railroad, portions of the skeletons of two large animals, both belonging to the class *mammalia*, and to families which no longer exist here in a living state, were found deeply buried in the earth, and the bones were for the most part in a very good state of preservation.

Fossil Elephant.—The Rutland and Burlington Railroad passes over the range of Green Mountains in the township of Mount Holly, at an elevation of 1360 feet above the level of the sea. In the notch through which the railroad passes, and very near the dividing point between the waters which flow westward into Lake Champlain and those which run eastward into Connecticut River, there is a deep deposit of vegetable muck. The cut for the railroad is through this muck-bed. In making it the workmen, to their great astonishment, found an enormous tooth. It was resting upon gravel at the bottom of the muck, which was there about nine feet deep. It was in a very good state of preservation, weighed eight pounds, and measured about eight inches transversely across the crown. It was pronounced by Professor Agassiz to be a *grinder* of an extinct species of elephant. Subsequently, as the excavation was continued, the two tusks and several of the bones of this elephant were found, and it is not improbable that the remaining parts of the skeleton are still buried beneath the same muck-bed.

Fossil Cetacean.—The fossil bones, which it is more particularly the object of this paper to describe, were found on the line of the Rutland and Burlington Railroad in the month of August, 1849, in the township of Charlotte, about twelve miles south of Burlington, and a little more than one mile eastward from the shore of Lake Champlain. In widening a deep and extensive cut through stratified sand and clay, the workmen there struck upon a mass of bones. They were between eight and nine feet below the natural surface of the ground, and were very compactly bedded in fine adhesive blue clay. Little notice was taken of them at first, until some of the overseers, thinking that they observed peculiarities in the form of several of the bones, were induced to commence an examination. They soon found that the bones discovered belonged to the anterior portion of the skeleton of some unknown animal, the head of which had already been broken into fragments by the workmen, and many of the fragments carried away with the earth which had been removed. On carefully removing more of the clay, the vertebræ were found extending in a line obliquely into the bank, and apparently arranged in the order in which they existed in the living animal. These vertebræ were, as was supposed, all taken out, and together with the sternum, fragments of head, ribs, &c., forwarded to Burlington, and by the kindness of Messrs. Jackson and Boardman, engineers on the railroad, were placed in my hands.

Upon a careful examination of these bones, I ascertained that the greater part of the head, all of the teeth, and several vertebræ, ribs, and bones of the limbs, were wanting in order to complete the skeleton. To recover these if possible, I immediately visited the locality; and at this and a subsequent visit, I succeeded in obtaining most of the anterior portion of the head, nine of the teeth, and thirteen additional vertebræ, together with the bones of one forearm, several chevron bones and portions of ribs. My first object being to insure the preservation of the bones, I carefully cleansed them from the adhesive clay, and then saturated them with animal glue.

When I first looked at the bones, I was in doubt whether they belonged to an animal of the cetaceous or saurian family, but my doubt was soon removed by a careful examination of the caudal vertebræ. These I found to have their articulating surfaces convex and rounded in such a manner as to allow of very extensive vertical motion of the tail, and but very little lateral motion. This circumstance plainly indicated that the movements of the animal in the water were effected by means of a horizontal caudal fin, and that it, therefore, belonged to the family of *Cetacea.*

Fig. 1 represents the thirteenth, fourteenth and fifteenth vertebræ of the tail, showing the manner in which they move upon each other—*a*, as viewed from above—*b*, as seen laterally.—[The fraction after the No. of the figure, denotes the linear proportion of the figure to the object which it represents.]

But, if there had still remained any doubt with regard to the general character of the animal, it would have been entirely removed, when I succeeded afterwards in reconstructing out of the fragments of bones which I had procured, so much of the upper anterior portion of the head, as to exhibit distinctly its *spiracles*, or blow-holes, showing unequivocally that it belonged to the Whale family. My next object was to ascertain, if possible, whether it belonged to an extinct, or to a living species or genus of this family. By a careful examination of Cuvier's great work on Fossil Bones, I became satisfied that, in the osteology of the head, it bore a strong resemblance to a small arctic cetacean, called the *Beluga*, or white whale, (*Delphinus leucas*, *Cuv. Oss. Foss.*, v, p. 297, pl. xxii, fig. 5 and 6, Paris ed., 1825,) and that it therefore belonged rather to the living than to the extinct types; and this opinion was confirmed by Prof. Agassiz, to whose unrivaled skill and kind assistance in the investigation of these fossils I am deeply indebted.

The head of the skeleton, as already remarked, was broken into a great number of pieces, but enough of these have been recovered and matched to determine very nearly the form and entire length of the head and of one side of the lower jaw, and of its symphysis with the other side. The fragments of the anterior portion of the upper jaw were found and matched, with the exception of so much of the maxillary bone as formed the alveolar margin of the left side. The alveolar margin on the right side measures 6·85 inches in length and contains eight alveoli. In the corresponding side of the lower jaw there are seven alveoli in a length of 5·5 inches, the alveolar margin extending three inches farther backward, but not perforated for teeth. Fig. 2 represents the head, viewed from above, so far as reconstructed, and fig. 3, a side view with the lower jaw dropped a little below its true place.

It appears, from what has been said above, that the animal had seven teeth in the lower jaw and eight in the upper, on each side, making thirty teeth in the whole. The teeth are all of one kind, being conical with flat or rounded crowns, and their substance is very dense and firm. They vary in length from one to nearly two inches, with a diameter of about half an inch. Fig. 4 represents their different forms. Only nine of the teeth have been recovered, and none of these were in their places in the jaws when I obtained them; but that they were in their places up to the time the bones were first discovered by the workmen, appears evident from the fact, that, while every other cavity in the bones was filled with clay, the alveoli were all empty.


4. 1/1
1. 1/2
b
a
a
6. 1/3
b
5. 1/3
3. 1/6
2. 1/8

Of the vertebræ I have secured forty-one, of which four are cervical, eleven dorsal, ten lumbar and sixteen caudal. Three of the cervical vertebræ, the first, fifth and sixth, are evidently missing, which, with those obtained, would make *seven*, the usual number. These vertebræ are all free, not being soldered together as in the common dolphin and some other cetaceans. Fig. 5 represents the third cervical vertebra.

Of the dorsal vertebræ, the second and twelfth are missing, making their whole number thirteen. Fig. 6 represents the seventh dorsal vertebra—*a*, as seen from behind—*b*, as seen laterally.

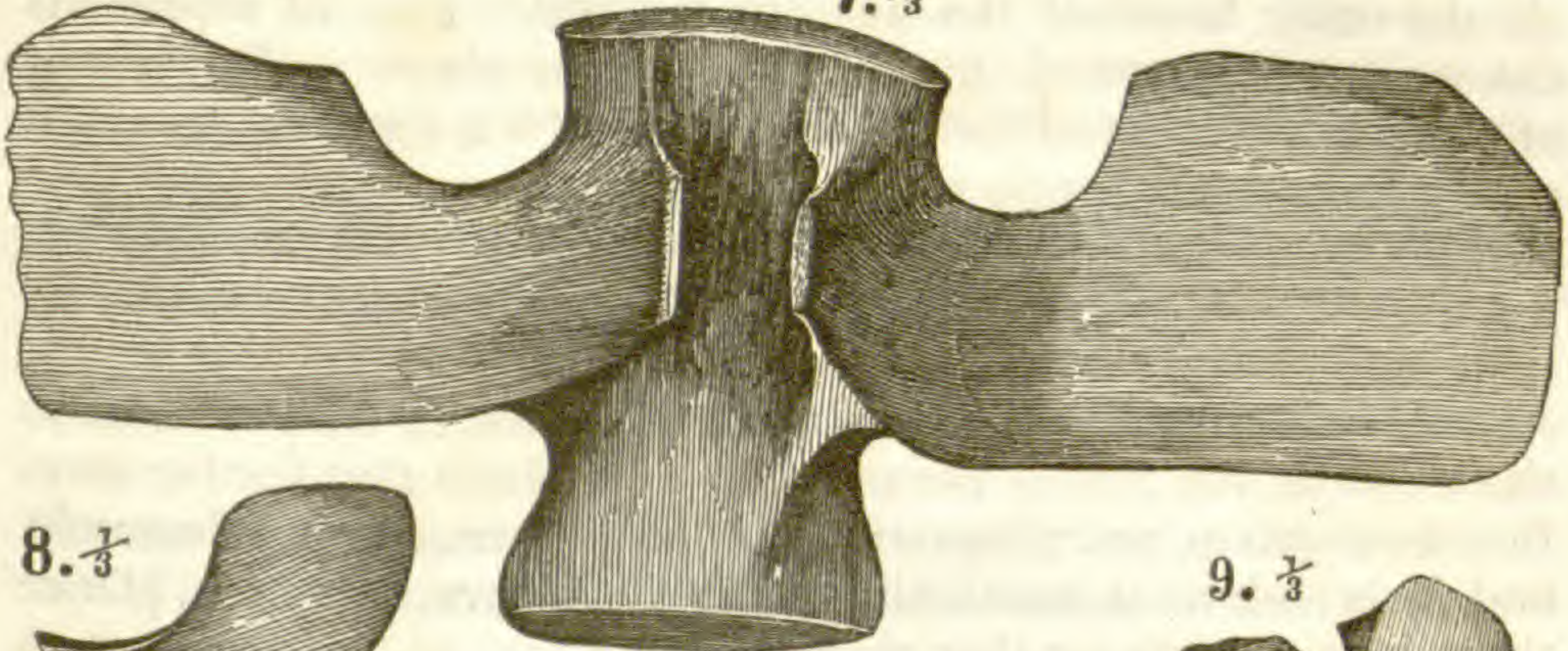
Two of the lumbar vertebræ, the sixth and twelfth, are missing, making twelve in the whole. Fig. 7 represents the seventh lumbar vertebra. They all have the same general form, but the lateral winged processes are more decayed and broken in some of them than in the one represented. The eleventh and seventeenth caudal vertebræ are missing, and perhaps a nineteenth and twentieth, making their probable whole number twenty. Fig. 8 represents the fourth caudal vertebra. The form of those towards the extremity of the tail may be seen in fig. 1.

From these statements it appears, that the whole number of vertebræ in the skeleton was fifty-two. Eleven of these are missing, two of which are known to have been taken away after they were dug up, and may perhaps be recovered. Articulating surfaces on the under sides of the caudal vertebræ, indicate five chevron bones, of which I have all but one, only the fourth being gone. Fig. 9 represents the second chevron bone.

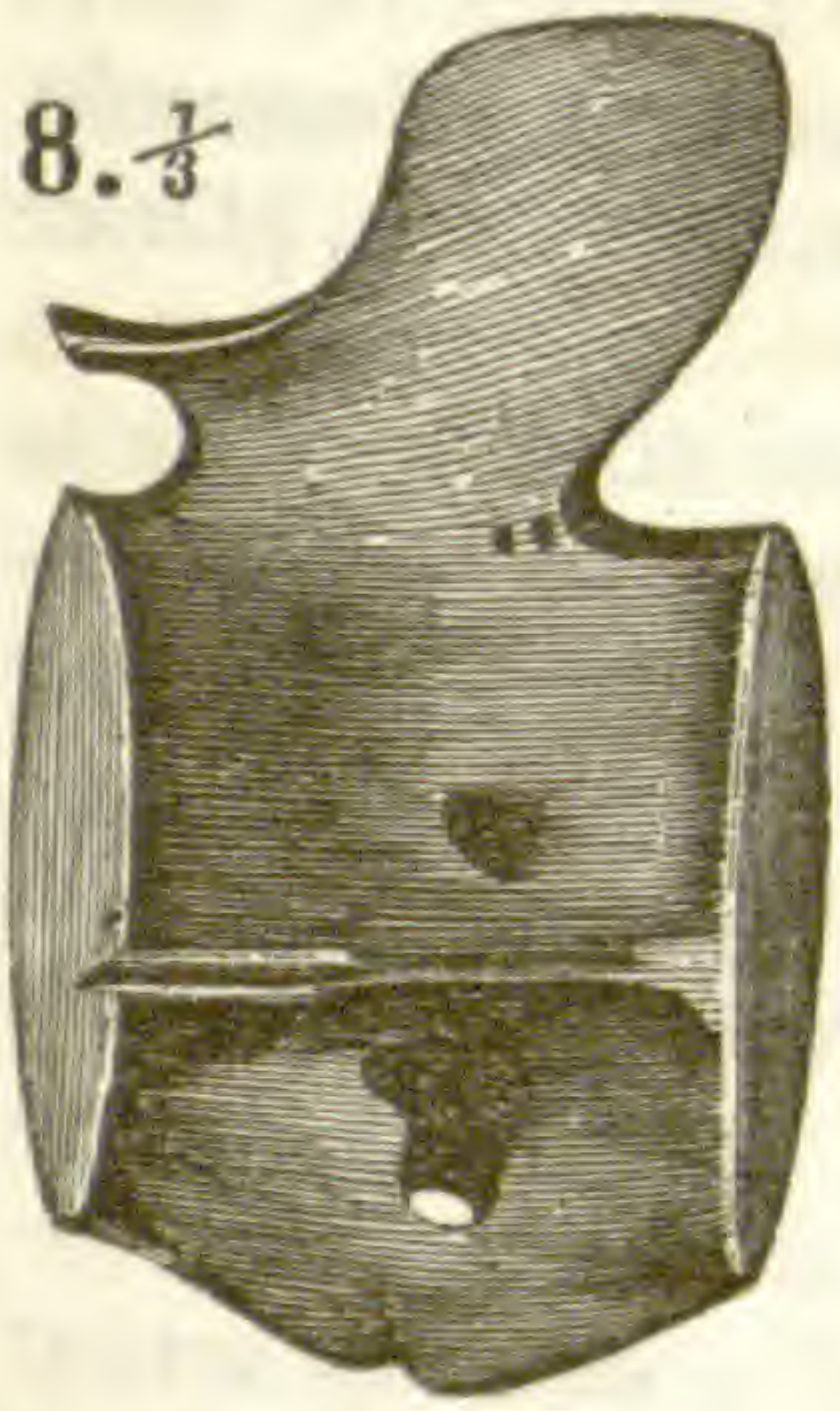
The total length of the vertebral column, (due allowance being made for the eleven missing vertebræ, but none for intervertebral cartilages,) is just ten feet, or one hundred and twenty inches. Of this length the cervical vertebræ occupy eight inches, the dorsal thirty-six, the lumbar forty-two, and the caudal thirty-four. The lumbar vertebræ are largest, having an average length of about four inches and a diameter of three inches. The total length of the animal, including the head and caudal fin, must have been at least thirteen feet. The *hyoid* bone, fig. 10, and the *sternum*, fig. 11, are both very large and strong in proportion to the size of the skeleton. The former measures eight and a half inches in a straight line from point to point, and the latter is fifteen inches long, from three to seven inches wide, and on an average nearly one inch thick. There are four articulating cavities for ribs on each side.

The ribs are considerably decayed and much broken. The longest rib, in one piece, measures just twenty-four inches along the curve. The ribs which form the anterior pair are very strong, and unbroken, and consist, on each side, of two parts of solid bone as represented in fig. 12.

7. $\frac{1}{3}$

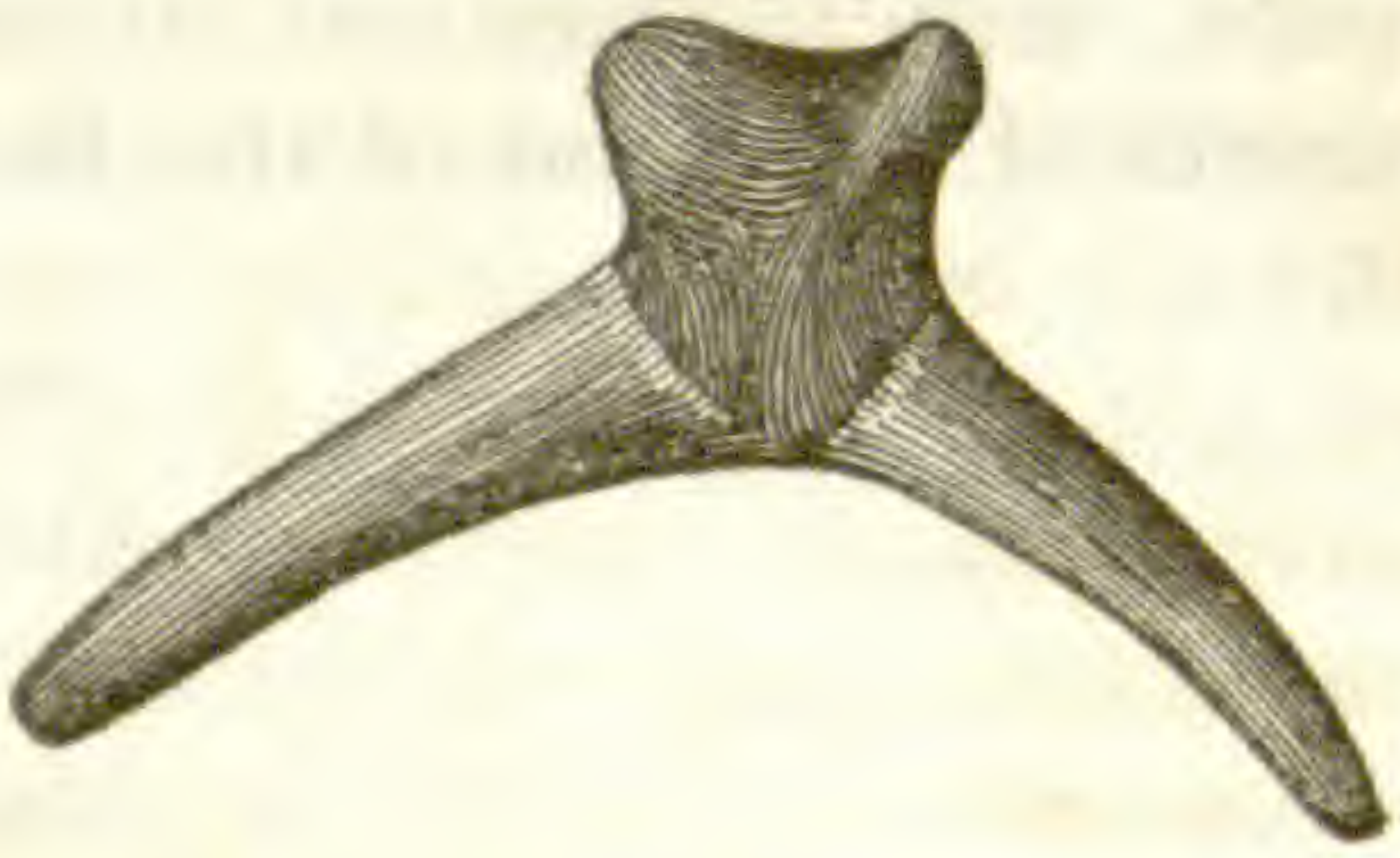


8. $\frac{1}{3}$



9. $\frac{1}{3}$

10. $\frac{1}{6}$



11. $\frac{1}{6}$

12. $\frac{1}{6}$

13. $\frac{1}{6}$

Of the limbs, the two scapulæ, one humerus, and the two fore-arm bones on one side, and the ulna of the other side, are secured; all the other bones of the fins are missing. Fig. 13 represents the recovered bones of the left fin, in their places. The height of the scapula is seven inches, the length of the humerus five, and of the forearm four inches.

There are several of the recovered bones, whose places are not yet ascertained. Some of these may be appendages to the hyoid bone and others may belong to a rudimentary pelvis. Professor Agassiz who has manifested, as already stated, a deep interest in these fossils, has kindly consented to give them that further careful investigation, and illustration, which their importance demands, and for which he is most ably qualified; I have, therefore, placed them in his hands for that purpose.

The following measurements of the head, are all that I have been able to make, which admit of direct comparison with Cuvier's measurements of the head of the Beluga, *D. leucas.* (Oss. Foss., v, p. 302.)

	Fossil.	*D. leucas.*
Length of the head from the occipital condyles to the end of the snout,	21·2 inches,	·532 m. = 20·9 inc.
" of one side of the lower jaw,	16 5 "	·408 " = 16·5 "
" of the alveolar margin, "	8·2 "	·198 " = 7·8 "
" of the symphysis "	3·1 "	·080 " = 3·1 "

From these measurements it might be inferred that the *fossil* and the *D. leucas* were identical in species, as well as in genus; but, at the same time, so many points of disagreement have been observed, as to render it highly probable that they are specifically different. In the number of teeth, they differ, as expressed below.

Dental Formulæ — *Fossil.* $\frac{8}{7}\,\frac{8}{7}=30$: *D. leucas.* $\frac{9}{9}\,\frac{9}{9}=36$.

They also differ much in the relative width of the maxillary and intermaxillary bones, as developed on the upper side of the snout, the intermaxillary being wider than the maxillary in Cuvier's figure, while in the fossil, the latter is twice the width of the former. The lines of the face appear also to be straighter, and the coronal process less elevated, making the upper portion of the head flatter in the *fossil* than in the *D. leucas.*

That this fossil cetacean belongs to the genus *Delphinus* of Linnæus, and to Lacepede's subgenus, *Delphinapterus*, I have little doubt; but, as already stated, it is highly probable that it belongs to a different species from Gmelin's *leucas.* I would, therefore, propose *Delphinus Vermontanus* for its provisional specific name, until its identity with the *D. leucas*, or some other known species, shall be established.

The locality, where these fossil bones were found, is situated a little more than one mile to the eastward of lake Champlain, and 60 feet above the mean level of the lake, as ascertained by the railroad survey. The mean height of the lake is 90 feet above the level of the sea, making the height of the point, where the fossils were imbedded, 150 feet above the sea. The geological formation, in which they were found, is very clearly characterized. It belongs to that portion of the Post-tertiary, which has sometimes been denominated the *Pleistocene* formation. This formation extends along the whole length of lake Champlain, and throughout the valley of the St. Lawrence. On the east side of the lake, in Vermont, it frequently attains a width of several miles, and, in places, exceeds 100 feet in depth. It consists, for the most part, of regularly stratified clay and sand, resting upon the Champlain rocks, or upon unstratified drift, and portions of it abound in marine bivalve fossil shells. These shells are of several species, nearly, or quite all of which are now found in a living state, on the Atlantic shores of New England: and it is common to find them with their valves united, with their epidermis undisturbed, and buried in such a position as to show, unequivocally, that they lived, propagated and died, in the places where they are found. The most abundant species is the *Sanguinolaria fusca.* The *Mya arenaria*, *Saxicava rugosa* and *Mytilus edulis* are quite common. Some other species are occasionally found.

The cut for the railroad, in which these fossil bones were obtained, is nearly half a mile in length, extending from north to south, and its greatest depth is about eighteen feet. The depth of the cut, at the place where the skeleton was found, is ten feet. About four feet of this depth, reckoning from the natural surface of the ground, consists of sand, showing no signs of stratification. Next below this is a mixture of sand and clay, which is regularly and distinctly stratified, for a depth of two and a half feet, below which is a vast bed of fine blue clay, in which I observed no signs of stratification, and which appears to have been, previous to the deposit of the sand and clay above it, a kind of quagmire. In the lower part of the stratified sand and clay, and nearly in contact with the upper surface of the blue clay, the shells of *Sanguinolaria fusca* and *Mytilus edulis* were exceedingly numerous. Below these, imbedded in the blue clay, were the *fossil bones.* The head of the skeleton was towards the northwest and lay lowest, while the body and tail extended towards the southeast. The highest part of the skeleton was about eighteen inches below the upper surface of the blue clay, or eight feet below the natural surface of the ground. In the clay, mingled with the bones, I found a number of specimens of *Saxicava rugosa* and two or three of *Nucula;* and I also found in it such indications of vegetable remains as to leave little doubt that this clay bed, once and for a long time, constituted a salt marsh, with rushes and grasses on the shore of the Pleistocene sea that then occupied the valley of lake Champlain.

Burlington, Vt., Jan. 1, 1850.

Art. XXIX.—*Abstract of a Meteorological Journal, kept at Marietta, Ohio, for the year* 1849, Lat. 39° 25′, Long. 4° 28′ west of Washington city; by S. P. Hildreth, M.D.

MONTHS.	THERMOMETER.			Fair days.	Cloudy days.	Rain and melted snow.	Prevailing winds.	BAROMETER.		
	Mean temperature.	Maximum.	Minimum.			In. and 100ths.		Maximum.	Minimum.	Range.
January, - -	30·46	59	6	9	22	4·09	W. & N. W.	30·10	29·25	·85
February, -	30·21	68	−2	12	16	2·58	W. S. W. & S. E.	29·85	29·20	·65
March, - -	45·04	72	21	14	17	4·37	S. S. W. & S. E.	29·60	28·88	·72
April, - -	50·57	84	21	20	10	2·50	S. W. & S. E.	29·60	28·95	·65
May, - -	61·40	86	38	20	11	5·92	S. & S. E.	29·70	29·10	·60
June, - -	71·33	89	50	21	9	4·42	S. & S. W.	29·65	29·20	·45
July, - -	72·20	89	48	25	6	1·21	S. & S. E.	29·70	29·30	·40
August, - -	69·61	86	52	22	9	3·50	S., N. & E.	29·50	29·15	·35
September, -	62·57	84	40	27	3	2·63	S., N. & S. E.	29·75	28·90	·85
October, - -	53·15	74	30	19	12	3·92	S. W. & W.	29·70	28·88	·82
November, -	47·25	78	20	25	5	2·58	S. S. E. & W.	29·58	29·10	·48
December, -	31·33	55	9	12	19	5·17	W., N. & S. E.	30·00	28·95	1·05
Mean for year,	52·09					43·18				

The mean temperature for the year 1849, is fifty-two degrees and nine hundredths, (52·09), being somewhat below the average temperature for this place, and was occasioned by the low grade of the summer months. It goes, however, to prove that the mean heat for this locality lies between fifty-two and fifty-three degrees of Fahrenheit.

The amount of rain and melted snow for the year is forty-two inches and eighty-nine hundredths, being over an inch less than in 1848, and ten inches less than in 1847. The rain has been very equally distributed through the year, affording an abundant supply for the crops generally, although some locations suffered from drought in July, injuring the corn crop considerably.

The past year has been marked by no great excesses in temperature. The cold in January and February, for a portion of the time, was quite severe; sinking the mercury on the 19th of the latter month, to two degrees below zero. It caused a great deal of floating ice in the Ohio river, so as to stop the progress of steamboats for a short time, but did not at any period freeze over the river so as to afford travellers a passage on the ice. The Muskingum from the slack-water improvements was closed for some weeks. The mean for the winter months is 34° 25′, being about two degrees less than that of 1848. Of snow, there fell about fourteen inches on six different periods; the largest amount at one time being six inches.

The mean of the spring months is 52° 33′; being rather below that of the previous year. Spring frosts continued to harass us as late as May, while on the 15th, 16th, and 17th of April, the frost was severe, sinking the temperature to 23°. It happened after a week of quite warm weather, and at a time when the pear, peach and plum were in bloom—killing nearly all these fruits. The apple did not bloom until the 27th of the month, but the germs were so much injured that the crop was almost entirely destroyed. One of the serious evils attached to our climate, is the frequent occurrence of late spring frosts at a time when fruit trees are most liable to injury. The beginning of May was marked by excessive rains, there falling nearly six inches during that month.

The mean temperature of the summer months is seventy-one degrees and five hundredths, which is about two degrees above that of 1848, and exactly that of 1846.

At two o'clock, on the morning of the 15th of June, a tremendous storm of electric fluid passed over this region, continuing for nearly two hours to discharge a continual stream of lightning, accompanied by terrific peals of thunder; several dwelling houses were struck, and trees demolished in the town. It ran along the telegraph wires into the office at Marietta, and ruined the magnetic machine. There fell two inches of rain, attended with little or no wind. The latter part of June was quite wet, rain falling almost daily, with a hot moist atmosphere, accompanied near the rivers with fogs. This state of the weather has been noticed by agriculturalists, as very injurious to the wheat crops, falling as it does at a time when the grain is forming, about the middle or last of June, producing a mildew or rust on the head and straw, and thus blighting the berry. The rust or blight this year prevailed throughout all the southern portions of Ohio, extending into Indiana and Illinois; while the northern districts of these states, being later in ripening, suffered but little. The color of this parasite was that of a bright iron rust, and so abundant that a cloud of dust arose from the straw as it fell before the progress of the reapers, covering the garments of the workmen with a red powder, as if colored by a dye. The same red fungus attacked the leaves of the common blackberry bushes, near the wheat, and was seen on the earth in divers places in the fields and in some gardens. Its effects were ruinous to the wheat crops, shrinking the grain in the most favored fields fifteen or twenty pounds in the bushel, destroying its farina so that merchantable flour could not be made from it, and causing a loss to the farming interest of several millions of dollars. Thousands of acres were entirely ruined and not harvested at all. Rye suffered more than wheat, being somewhat earlier in its growth. Grapes were attacked in the same manner, the mould on them being white, attaching itself to the stems, causing the fruit to blight and fall to the ground. Potatoes were generally good and free from "the rot." Indian corn was a fair yield, while the hay crop was never better. Our soil and climate are so constituted that if one of the staples fails, some other will supply its place; and it is not probable we shall suffer from famine, as they do in many parts of the earth.

The mean of the autumnal months is fifty-four degrees and thirty-two hundredths, being nearly five degrees warmer than that of 1848. Frost did not materially injure vegetation and garden plants until the first of November, when the cold destroyed the bloom of the Dahlia.

Floral Calendar.—March 7, White maple in bloom; 8th, Robin appears; 17, Hepatica triloba in bloom. Red elm, garden crocus.

April 4th, Apricot, Sanguinaria canadensis; 7th, Peach; 8th, Sugar tree quite green on side-hills; 11th, Green gage and cherry in bloom; 12, Pear; 15th, thermometer at 24° this morning, froze hard; 16th, thermometer 23°, some snow fell; the fruit blossoms to a large extent killed, and early garden vegetables; 25th, Tulip in bloom; 27th, Apple; Late cherry; 29th, Judas tree and Service berry.

May 1st, Ranunculus; 2d, Quince tree; 5th, Black haw; 7th, Cornus florida; 11th, Frost on fences back of town; 19th, frost on boards; 24th, Locust tree; 29th, Hudson strawberry ripe.

June 3d, Early peas fit for table; 15th, Russian cucumber, raised in open air; 19th, thermometer 121° in the sun's rays at 2 P. M.; 22d, the Rust noticed on the wheat, but began as early as the 15th in some places.

July 2d, Wheat harvest begins; 3d, Catalpa in bloom.

Marietta, January 23, 1850.

ART. XXX.—*Chemical Examinations of the Waters of some of the Mineral Springs of Canada;* by T. S. HUNT, Chemist and Mineralogist to the Geological Commission of Canada.

IN the course of my official duties it has devolved upon me to examine the various mineral waters of the province and to submit the more important of them to accurate analyses. The first part of the results of these inquiries have already appeared in the Report of Progress for 1847, 1848, which was submitted to his excellency the Governor General on the 1st of May, 1849, from which I extract the analyses that follow. Some remarks as to the mode of collecting the waters may not be out of place here, as showing the precautions taken to prevent errors and to transport the waters unchanged to the place of analysis. Unless otherwise stated, they were always collected by myself from the spring, and put into large glass jars, holding about one hundred pounds; these were nearly filled, and being carefully stopped, the mouths were secured by a lute, which entirely excluded air and prevented the escape of gases. For the determination of the gases, the processes directed by Fresenius, in his admirable treatise, were employed; they consist in directly fixing upon the spot the carbonic acid gas by ammonio-chlorid of calcium, and the sulphuretted hydrogen by a solution of chlorid of arsenic. Carefully measured portions of the water being placed in bottles with these substances, the bottles were tightly sealed, and could thus be preserved until they were brought to the place of analysis.

In stating the composition of the waters, I shall first give the quantity of bases, acids and radicals in a thousand parts, and then in accordance with the general custom, shew how these may be united to form saline combinations; in following this course I have conformed to the general practice of chemists, rather because the results are more intelligible to the unscientific, and at the same time more readily compared with those of other analysts, than because the compounds thus calculated can be supposed to represent the real constitution of the water; for in the present state of our knowledge, we must, I think, be led to adopt the idea of a partition of bases among the different radicals, so that the bromine in a saline water instead of being, as it is here represented, in conformity with general custom, combined as a bromid of magnesium, is divided between the four metals usually present, in proportions which we have not yet the means of determining.

The analyses were performed upon weighed portions of water in preference to using measures; and the weights, including the specific gravities, were determined by a delicate balance made to order by Deleuil of Paris, and sensible to the demi-milligramme, when loaded with two hundred grammes.

The Caledonia Springs.—These springs which are well known as a place of resort during the warm season, are situated a few miles south of the Ottawa River, about forty miles from Montreal; the fountains which are four in number rise through strata of post-pliocene clay which overlie a rock equivalent to the Trenton limestone. Three of them, known as the Gas Spring, the Saline Spring, and the White Sulphur Spring, are situated within a distance of four or five rods, and the mouths of the latter two are not more than four feet apart. The fourth, known as the Intermitting Spring, is situated about two miles distant, and is much more saline than the others. The first three are alkaline, the sulphur spring strongly so, while the fourth contains in solution a great quantity of earthy chlorids.

None of these waters are what are called "acidulous saline," a character which is due to the presence of large quantities of carbonic acid, the quantity of this acid found, being in no case more than is required to form bicarbonates with the bases present.

I. *The Gas Spring.*—The waters of this spring were collected on the 27th of September, 1847. The temperature of the air being 61·7° Fahrenheit, that of the spring was 44·4. The discharge was ascertained by careful measurement to be four gallons per minute, a quantity which is little subject to variation. The water in the well is kept in constant agitation by the escape of carburetted hydrogen gas, which is evolved in considerable quantity. It was roughly estimated at the time, to be three hundred cubic inches a minute, but the discharge as I was informed, is often much more abundant.

The specific gravity of the water was found to be 1006·2. It is pleasantly saline to the taste, but not at all bitter; by exposure to the air it gradually deposits a white sediment of earthy carbonates. Its reaction is distinctly alkaline to test papers.

The examination of the unconcentrated water shewed the presence of chlorine, calcium and magnesium, but when the liquid is concentrated by boiling, these bases are wholly precipitated as carbonates, and the clear liquid is alkaline, yielding with a solution of chlorid of barium, a copious precipitate of carbonate which is dissolved by hydrochloric acid, leaving only a small quantity of sulphate of baryta. The alkaline liquid being evaporated to dryness, and the residue digested with alcohol, the solution gave evidence of the presence of both bromine and iodine; the saline residue was found to consist of salts of sodium with a small portion of chlorid of potassium. The precipitate of earthy carbonates contained traces of alumina, iron and manganese. On evaporating to dryness a quantity of the water with an acid, and treating the residue with water, a portion of silica was obtained.

The modes by which the quantities of chlorine, sulphuric acid, calcium, magnesium, sodium and potassium were obtained, need no particular description. The sketch of the plan of analyses here given, will be sufficient to show the processes adopted throughout the research, except that where the waters contained chlorids of calcium and magnesium, the amount of these bases was determined first upon one thousand grammes of the water evaporated with an acid, and then the same quantity having been boiled with the addition of distilled water until all the earthy salts were precipitated, the respective amounts of the calcium and magnesium, both in the precipitate and filtrate, were determined, and those in the latter, regarded as corresponding to the chlorids and sulphates of those bases, in the recent water. The alkalies were separated by successive treatment with baryta and carbonate of ammonia, and the amount of potassium in the mixed chlorids was then determined by converting them into the platino-chlorids, and separating the sodium salt by alcohol.

The bromine and iodine were determined by evaporating fifty pounds of the water to a small bulk, separating the earthy precipitate, and finally evaporating the residue to dryness. This was treated with alcohol of sp. gr. ·835 until all traces of iodids and bromids were removed. The alcoholic solution was then evaporated to dryness, and the treatment renewed with alcohol of ·820; this process was repeated a third time, having previously ignited the residue to destroy any organic matters, and the solution being again evaporated to dryness, was dissolved in water, and the amount of iodine determined after the admirable method of Lassaigne, which consists in precipitating it as an iodid of palladium.

The bromids and chlorids remaining in the solution, were decomposed by a solution of nitrate of silver, and the mixed precipitate of chlorid and bromid of silver, after being fused and carefully weighed, was submitted in a state of fusion to the action of a current of dry chlorine gas, until the whole was converted into chlorid; from the loss, the amount of bromine was deduced by calculation.

The total amount of carbonic acid was determined by mixing measured portions of the water at the source, with caustic ammonia and a solution of chlorid of calcium; the proportion of carbonic acid in the precipitate thus obtained, was determined in the usual manner. The amount of carbonic acid required by those bases which were known to exist as carbonates in the water, was then deducted. The quantity of carbonate of soda was calculated from the excess of sodium over that required for the saturation of the chlorine, bromine, iodine and sulphuric acid, controlled by the amount of carbonate of baryta obtained by treating a solution of the solid residue of 1000 grammes of the water with chlorid of barium; the two results closely agreeing.

1000 parts of the water of the Gas Spring gave—

Chlorine,	4·242810
Bromine,	·011730
Iodine,	·000461
Sulphuric acid (SO^3),	·002400
Soda,	3·726400
Potash,	·022100
Lime,	·082880
Magnesia,	·254600
Alumina,	·004400
Silica,	·031000
Iron and manganese,	traces,
Carbonic acid,	·705000

These may be combined to form the following compounds—

Chlorid of sodium,	6·967500
" of potassium,	·030940

Bromid of sodium,	·015077
Iodid of sodium,	·000530
Sulphate of potash,	·005280
Carbonate of soda,	·048570
" of lime,	·148000
" of magnesia,	·526200
" of iron and manganese,	traces,
Alumina,	·004400
Silica,	·031000
Carbonic acid,	·349000
Water,	991·873503
	1000·000000

Saline ingredients in 1000 parts, 7·7775.

Carbonic acid in 100 cubic inches, 17·5.

II. *The Saline Spring.*—The spring thus named, is very similar to the last, but in reality less strongly saline. Its temperature was 45° F., that of the air being at the same time 60° F. The specific gravity 1005·824. Its reaction is more strongly alkaline, but otherwise the results of its qualitative examination are similar to those given under the head of the "Gas Spring." It contains no sulphuretted hydrogen whatever; some few bubbles of carburetted hydrogen are evolved, but the quantity is very small. The discharge from this spring is about ten gallons per minute.

1000 parts of the water gave—

Chlorine,	3·93830
Bromine,	·01317
Iodine,	·00123
Sulphuric acid (SO^3)	·00220
Soda,	3·52246
Potash,	·04100
Lime,	·06580
Magnesia,	·25020
Silica,	·04250
Alumina, iron and manganese,	traces,
Carbonic acid,	·64800

These may be combined in the following manner:—

Chlorid of sodium,	6·44090
" of potassium,	·02960
Bromid of sodium,	·01696
Iodid of sodium,	·00146
Sulphate of potash,	·00480
Cabonate of soda,	·17620
" of lime,	·11750
" of magnesia,	·51724

Carbonate of iron and manganese, Alumina, ...	traces,
Silica, ...	·04250
Carbonic acid, ...	·29200
Water, ...	992·36084
	1000·00000

The amount of solid matter in 1000 parts of the water is by calculation 7·347; experiment gave 7·280, which is a close approximation. The carbonate of magnesia loses a part of its carbonic acid during the evaporation, and exists in the residue as a basic carbonate; hence the slight deficiency in the result of experiment.

The quantity of carbonic acid, above what is represented as combined with the bases, equals 14·7 cubic inches in 100 cubic inches of the water.

III. *The Sulphur Spring.*—This spring is situated very near to the last; the openings of the two wells being not more than four feet apart. Although it bears the name of a sulphur water, its claim to that title is very small. It has a feebly sulphurous taste and odor, and darkens slightly salts of lead and silver, but the quantity of sulphur existing either as sulphuretted hydrogen or as alkaline sulphuret is very inconsiderable, and cannot be quantitatively estimated by the ordinary processes.

Several bottles of the water were mixed with a solution of arsenic at the spring, but the precipitate of sulphuret of arsenic was scarcely perceptible; the quantity of the sulphuretted hydrogen was not equal to a cubic inch to a gallon. It is still, however sufficient to impart medicinal powers to the water, for the efficacy of this spring over all the others in rheumatic and cutaneous affections is well attested. According to Dr. Stirling, who has been for many years a resident at the springs, and is a careful observer, the water was formerly much more sulphurous than at present; a thing not at all improbable, as it is well known that springs often change their character materially in the course of a few years.

The supply from this spring is apparently about the same as that of the "Gas Spring;" its waters flow into the same reservoir as those of the saline springs, and the two are used for hot baths. The mixture, after being heated for use, is without any odor of sulphur.

The temperature of the spring was found to be 46° F., that of the air being 60° F. The specific gravity of the water at 60° F. is 1003·7; its reaction is strongly alkaline, and the results of its qualitative examination show that it closely resembled the two preceding waters, except that only traces of iodine were detected in it.

1000 parts of the water of the sulphur spring gave :—

Chlorine,	2·12500
Bromine,	·00781
Iodine,	traces,
Sulphuric acid,	·01030
Potash,	·01450
Soda,	2·12370
Lime,	·11760
Magnesia,	·14230
Iron,	traces,
Alumina,	·00265
Silica,	·08400
Carbonic acid,	·59000

These combined in the usual manner, give as the composition of 1000 parts of the water :—

Chlorid of sodium,	3·84300
" of potassium,	·02300
Bromid of sodium,	·01004
Iodid of sodium,	traces,
Sulphate of soda,	·01833
Carbonate of soda,	·45580
" of lime,	·21000
" of magnesia,	·29400
" of iron,	traces,
Alumina,	·00265
Silica,	·08400
Carbonic acid,	·14100
Water,	994·91818
	1000·00000

The amount of solid matters in 1000 parts of the water is 4·9406.

The quantity of carbonic acid over that required to form neutral carbonates, would in a gaseous state equal 7·2 cubic inches in 100 of the water. The amount required to form the above carbonates is ·449, and an equal quantity of carbonic acid would be necessary to enable them to exist as bicarbonates, a condition in which these earthy bases are generally regarded as being dissolved in mineral waters. The whole of these alkaline waters have shown, it will be observed, a deficiency in the quantity of carbonic acid, and this is particularly marked in this last and most strongly alkaline of them all. This apparent difficulty is at once explained by the fact that the whole, or a part of the carbonate of magnesia, exists in the form of a double carbonate of soda and magnesia, a compound which is readily soluble in water and much more permanent than the bicarbonate

The large amount of silica which it contains, is an interesting peculiarity, and naturally connects itself with the strongly alkaline character of the water. As silica is capable of decomposing a solution of carbonate of soda, it is probable that a portion of the soda must really exist in the condition of a silicate. From the uncertainty which still remains as to the composition of these soluble silicates, it is impossible to calculate the portion of the soda which should be deducted from that represented as existing as carbonate, but an indirect experiment throws some light upon the question. 1000 grammes of the water were evaporated to perfect dryness, to render all the magnesia insoluble. The residue being then dissolved in distilled water, was mixed with a solution of chlorid of barium, and yielded a precipitate of carbonate, with a little sulphate, which contained an amount of carbonic acid corresponding to ·2540 of carbonate of soda, while the excess of soda above that required for saturating the chlorine, bromine and sulphuric acid, equalled ·4558 parts of carbonate. The difference ·2018 corresponds to ·1179 of pure soda, which may be regarded as forming a silicate with the ·0840 of silica. With our imperfect knowledge of silicates, especially the soluble ones, it is obviously useless to speculate farther upon the mode of combination in which these substances exist.*

IV. *The Intermitting Spring.*—This spring has been already described as situated about two miles distant from the others. It rises out of a bank of clay near the edge of a brook; a well has been sunk nearly thirty feet through the clay, and the water rises near to the surface. It is kept in almost constant agitation by the evolution of large quantities of carburetted hydrogen gas; the water from this cause, is kept constantly turbid by the quantity of clay diffused through it, and it is only after being allowed to stand for several hours in a quiet place, that it becomes transparent. The discharge of gas is not regular, some minutes often elapsing, during which only a few bubbles escape from time to time, after which a copious evolution occurs for a few moments, followed by another period of quiescence; from this peculiarity it is named the intermitting spring.

The temperature was found to be 50° F. at the bottom of the well; that of the air being 61°. The amount of water furnished by the spring could not be easily determined, as part of it escapes through the bank, but it is not large. At the time of my visit, the recent rains had diluted the spring with a good deal of surface

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* Since my report was published, I find that Mr. O. Henry in his fine researches upon the sulphurous alkaline waters of the Pyrenees, has already shown that the soda generally regarded as existing in them as carbonate, is really in a great part in the form of a silicate, a similar conclusion to that which I have deduced from my examination of the sources of Caledonia. (See Journal de Pharm. et de Chim., t. vii., p. 15.

water, and I accordingly availed myself of the politeness of the proprietor, Mr. Wilkinson, who allowed me to take as much as I required, from a supply which had been brought from the spring a month previous, and preserved in well covered puncheons.

This was sensibly stronger to the taste than the water at the spring, and unlike the previously described waters, was disagreeably bitter, as well as saline. Its specific gravity was 1010·939.

A qualitative examination shewed the presence of chlorine, bromine and iodine, with potassium, sodium, calcium, and magnesium; a large portion of the latter two exist in the condition of chlorids. No sulphuric acid was detected; but traces of iron and alumina. Baryta, strontia, fluorine and phosphates were sought for; but with the exception of slight traces of the latter, the results were altogether negative.

1000 parts of the water of the Intermitting Spring afforded,

Chlorine	8·36979
Bromine	·02059
Iodine	·00187
Potash	·01930
Soda	6·49360
Lime	1·44930
Magnesia	·55467
Alumina and iron	traces.
Silica	·02250

These may be so combined as to give the following composition for 1000 parts of the water:—

Chlorid of sodium	12·250000
" of potassium	·030500
" of calcium	·287050
" of magnesium	1·033840
Bromid of magnesium	·023840
Iodid of magnesium	·002057
Carbonate of lime	·126460
" of magnesia	·863230
" of iron,	traces.
Alumina	
Silica	·022500
Carbonic acid	·501350
Water	984·859173
	1000·000000

The solid matter in 1000 parts, as determined by calculation, is 14·639 parts; the result obtained by directly evaporating a weighed quantity, and drying the residue at 300° F., was 14·500, the difference being probably due to a partial decomposition of the magnesian chlorid during the evaporation.

The carbonic acid of this water was not determined, as the fresh water, which was required for this purpose, was so much diluted as to be unlike the specimen analysed.

In a subsequent paper I purpose to describe some of the saline springs of the valley of the lower St. Lawrence, which are generally saline, and contain a greater or less proportion of earthy chlorids. The history of the mineral springs of the province when complete, will present some interesting relations to the geological structure of the country and the nature of the strata from which they rise.

Montreal, May 15, 1849.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Researches upon some derivatives of the Benzoic Series;* by G. CHANCEL, (Comptes Rend. des Travaux de Chimie, Juin, 1849, p. 177.)—The author has prepared the nitrobenzoic ethers of alcohol and wood-spirit, and confirmed their composition by analyses. He has found that they crystallize in right rhombic prisms of about 120°, and are consequently isomorphous. By the action of ammonia upon the vinic ether he obtained the nitrobenzamid which Mr. Field had before found by decomposing the nitrobenzoate of ammonia by heat. This body is sparingly soluble in water, above all in the cold, but dissolves readily in alcohol and ether, and crystallizes from them by slow evaporation in tables like gypsum. By a solution of potash it is decomposed with the evolution of ammonia, and yields nitrobenzoate of potash. When nitrobenzamid is dissolved in boiling water and hydrosulphuret of ammonia added in sufficient quantity, not the least trace of the amid separates on cooling. The liquid deposits a large amount of sulphur after standing a few hours, and by evaporation in a water bath to separate the last traces, the residue dissolved in water and filtered, gives by slow evaporation beautiful crystals which give on analysis the formula $C_7 H_{10} N_2 O_2$ (notation of Gerhardt). It loses an equivalent of water at 100° to 120° C., without undergoing any apparent alteration, so that its real formula, as is established by its compounds, is $C_7 H_8 N_2 O$.

This new substance no longer belongs to the benzoic series (C_7), but has disceded into the formic (C) and phenic (C_6) series, as will be seen by the results of its decomposition. It is a double carbonate of ammonia and aniline, *minus* the elements of two equivalents of water.

$$C H_2 O_3, C_6 H_7 N, H_3 N = C_7 H_8 N_2 O_2 + 2H_2 O.$$

The author has therefore called it *carbonilamid.* When gently heated with a mixture of lime and potash, it evolves in the form of ammonia exactly one half its nitrogren: if now the heat be considerably raised, pure aniline distils over and carbonate of potash remains. In the first stage of the process there is evidently the formation of a salt which if not an *anthranilate*, is isomeric with it and the true *carbonilate*, which is then by an elevation of temperature decomposed into a carbonate and aniline. The action of sulphuric acid is equally characteristic; sulphanilic acid and sulphate of ammonia are formed with the evolution of carbonic acid gas.

$$C_7 H_8 N_2 O+2SH_2O_4=CO_2+C_6 H_7 N SO_3+S(H, H_4 N) O_4$$

This body sustains a close relation to *urea* which is truly *carbamid;* carbonilamid is urea in which the residue of an equivalent of aniline replaces that of one of ammonia. To represent this by the abbreviated formulas of M. Laurent,

$Am=(H_3 N+H)$ $Am^{-2}=(H_3 N+H)-H_2$
$An=(C_6 H_7 N+H)$ $An^{-2}=(C_6 H_7 N+H)-H_2$
Urea, (carbamid) ...... $C\, Am^{-2}\, A^{-2}\, O=C_2 H_4 N_2 O$
Carbonilamid, ... $C\, An^{-2}\, Am^{-2}\, O=C_7 H_8 N_2 O$

Like urea the new substance is readily soluble in water, alcohol and ether; the alcoholic solution decomposes spontaneously, but the watery solution gives fine colorless prisms of a fresh taste like nitre. The resemblance to urea is still farther shown by its action with acids, it is a veritable alkaloid and forms well defined crystalline salts. The nitrate, hydrochlorate and oxalate have been examined; the former is very sparingly soluble. It combines also with the nitrate of silver and the bichlorid of mercury; the chloroplatinate crystallizes in beautiful orange colored prisms. T. S. HUNT.

2. *On the Products of the dry distillation of Benzoate of Lime;* by G. CHANCEL, (Compt. Rend. des Trav. de Chim., March, 1849, p. 87.)—According to the researches of M. Peligot, the result of this distillation is a liquid, which he named benzone, and which corresponds to acetene, while carbonate of lime remains as a residue; he also recognized a portion of benzene and a hydrocarbon which he regarded as napthalene and which seemed to be secondary products of the decomposition.

But according to M. Chancel, the process is less simple and is always accompanied with the evolution of gaseous hydro-carburets during the whole process. When the dried salt is heated, the decomposition is complete at a temperature near low redness; along with the inflammable gases is obtained a brown liquid heavier than water. By distillation, a small quantity of benzene is separated; but the purification of the residue by this process was found impracticable. When submitted to the action of strong nitric acid, it evolves red vapors and ignites; if the action is now carried too far, a brown viscid mass results, insoluble in water; dissolved in a mixture of alcohol and ether and mixed with hydro-sulphuret of ammonia, the vessel after two or three days is found filled with magnificent golden yellow crystals. The same compound is obtained by dissolving the crude product of distillation in strong sulphuric acid, and after some days adding a little water until it becomes milky; the mixture on standing yields an abundant crust of this crystalline matter, which is even deposited in small quantities after a lapse of time from the crude liquid. It is consequently an original product of the decomposition of the benzoate; and its analysis, in whichever way obtained, gives numbers corresponding exactly to the formula $C_{13} H_{10} O$

(notation of Gerhardt), which is exactly the composition that theory assigns to benzone :—

$$2C_7 H_5 Ca O_2 = C O_2 Ca_3 + C_{13} H_{10} O.$$

Its claim to be considered as the acetonid of benzoic acid is shown by the fact that under the influence of potash-lime, it discedes at about 260° C. into benzoate of potash and pure benzene without evolving a trace of hydrogen gas or any other foreign substance.

$$C_{13} H_{10} O + KHO = C_7 H_5 KO_2 + C_6 H_6.$$

M. Chancel has given it the name of *benzophenone*, to show at once its relation to the benzoic and phenic series, while the termination recalls its place among the acetonids. It is insoluble in water but soluble in alcohol and ether; from a mixture of the two it is obtained by spontaneous evaporation in large transparent monoclinic prisms, of a slight amber tint. It fuses at 46° and boils at 315° C., distilling without alteration; its odor is fragrant, somewhat resembling benzoic ether.

Neither nitric nor sulphuric acids affect it in the cold; but fuming nitric acid by heat converts it into an oily liquid, which is dissolved by ether and deposited again almost immediately as a yellowish crystalline powder. This is *binitric benzophenone*, $C_{13} H_8 (N_2 O_4) O$ or $C_{13} H_8 X 2O$.

The product of the action of hydrosulphuret of ammonia upon this, is an alkaloid which had been some time before described by MM. Laurent and Chancel, under the name of *flavine*. The crude product of the distillation of the benzoate of lime, freed from benzene, was boiled several hours with fuming nitric acid and then diluted with water. The oily residue is mixed with ether, and after a time deposits a crystalline matter which was washed with a mixture of alcohol and ether. It is a mixture of binitric benzophenone, with some foreign matters which are very difficultly separable. By digestion in the cold with a mixture of hydrosulphuret of ammonia, alcohol and ether, the principal part is dissolved, and after twenty-four hours the vessel is filled with needles of the new alkaloid, which is purified by solution in hydrochloric acid, precipitation by ammonia and crystallization from alcohol. It forms fine needles, colorless or pale yellow, which are almost insoluble in water but dissolve in alcohol and ether. Fused with potash it disengages an oil possessing the properties of an alkaloid. Its formula is $C_{13} H_{12} N_2 O$. Its salts are soluble and crystallizable; the chloroplatinate is $C_{13} H_{12} N_2 O, 2(Cl\ HP \text{ and } Cl_2)$, a compound with two equivalents of the platinic chlorid.

These details respecting flavine are given in the Comptes Rendus des Trav. de Chimie for April, and the editors in a note announce that M. Chancel has found it to be in reality *carbanilid* or *anilic urea*. The details are promised in a following number. By referring to the account given above of carbanilamid by the same author, we shall see that while this is $C\ An^{-2}\ Am^{-2}\ O$, flavine is $C\ An^{-2}\ An^{-2}\ O = C_{13} H_{12} N_2 O$; the former being the substance intermediate between flavine and urea. The alkaline product obtained by the action of potash upon this new alkaloid will then be no other than aniline.

Among the products found in the crude liquid which yields the benzophenone, are two solid carbonates of hydrogen isomeric with napthalene, one fusing at 92° and the other at 65° C.; the latter is obtained with benzonitryl when the vapor of benzoate of ammonia is passed over ignited caustic baryta.

M. Chancel refers to the analogy pointed out by Gerhardt between the ethers and the products of the action of the mineral acids upon hydrocarbons;* as between nitrobenzene and nitromethol, sulphobenzenic and sulphomethylic acids. He has extended this view still farther, and shows that as nitrobenzene contains the elements of nitric acid and benzene, minus H_2O, so benzophenone is derived from the benzoic acid and benzene, minus the same elements. $C_7H_6O_2+C_6H_6=C_{13}H_{10}O+H_2O$. As the name of *phene* has already been given to benzene, which in reality does not belong to the benzoic series, M. Chancel observes that it will be well to apply to its derivatives the names of *nitrophenone* and *sulphophenone*, which will have the advantage of recalling their relations to benzophenone. T. S. H.

3. *On the Action of Nitric Acid upon Butyrone*, LAURENT and CHANCEL, (Compt. Rend. des Trav. de Chimie, 1848, p. 174.)—The acid obtained some years since by M. Chancel, by the action of nitric acid upon butyrone, and by him named butyronitric acid, has been submitted to a new examination, from which it results that its formula is $C_3H_5NO_4=C_3H_5XO_2$; it is consequently *nitrometacetonic acid.* The normal acid being $C_3H_6O_2$. It is insoluble in, and more heavy than water; has a very sweet taste and an aromatic odor. Its salts are crystallizable and explode by heat; that of potash forms yellow scales like iodoform. T. S. H.

4. *On Sulphuretted Benzamid;* by A. CAHOURS, (Compt. Rend. des Trav. de Chim., Avril, 1849, de Comp. Rend. de l'Acad., t. xxvii, p. 239.)—As the nitryls by fixing H_2O or $2H_2O$ yield amids or ammoniacal salts, M. Cahours was desirous to determine whether from the analogy between water and sulphuretted hydrogen, it might be possible to produce the corresponding sulphuretted compounds. On dissolving benzonitryl in slightly ammoniacal alcohol and saturating with H_2S, the solution became discolored, and after some time on concentrating by evaporation, a substance separated in yellow flakes, which dissolved in boiling water and crystallized by slow cooling in long sulphur-yellow needles of a satiny lustre. Analysis gave the formula C_7H_7NS, which represents sulphuretted benzamid. It is decomposed by red oxyd of mercury giving rise to water and sulphuret of mercury, and regenerating benzonitryl. Potassium decomposes it with the formation of a sulphuret and cyanid. M. Cahours proposes to pursue this interesting inquiry. T. S. H.

5. *On the Composition of Chloropicrine;* by A. CAHOURS, (Compt. Rend. des Trav. de Chimie, May, 1849, p. 171.)—In this Journal for May, 1849, p. 430, a new substance was described as discovered by Dr. Stenhouse by acting upon nitropicric acid by a solution of hypochlorite of lime. To this the discoverer assigned the formula $C_4Cl_7N_2O_{10}$. As this seemed quite anomalous, I proposed in its place, assuming the quantities of carbon and chlorine found to be correct, $C_4HCl_7N_2O_{10}$, and the more readily as his analysis actually gave a quantity of hydrogen amounting to one equivalent. M. Gerhardt remarking upon this

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* Precis de Chimie Organique, tom. 1er, p. 154. See also this Journal for July, 1849, p. 90.

substance (Compt. Rend. des Trav. de Chimie, Fevrier, p. 34), suggested that its real formula is $C\,Cl_3\,NO_2$, (corresponding to $C_2\,Cl_3\,NO_4$ in the ordinary notation,) and that it is *nitric chloroform* $C\,Cl_3\,X$. This formula which requires carbon 7·2, chlorine 65, and azote 8·4, has been verified by analyses made by M. Cahours upon a pure specimen of chloropicrine, which has given him carbon 7·09–7·19; chlorine 64·59. M. Gerhardt calls attention to the close resemblance between the properties of this compound and that obtained by Marignac in action with nitric acid upon the chlorid of napthalene, which he has described in his Precis, as *formène, bichloro-binitrique*, and which is represented by $C\,Cl_2\,N_2\,O_4 = C\,Cl_2\,X_2$. T. S. H.

6. *Process for the use of Tin Plate Scrap in the Manufacture of Malleable Iron;* patented by Ed. Schunck, (Chem. Gaz., Aug., 1849.)—Large quantities of tin plate scrap accumulate in the manufacture of tinman's ware; these and worn out articles of the same material are useless except for small articles which are sometimes made from them. Their employment in the manufacture of wrought iron has been prevented hitherto by the presence of the tin; the present process is proposed for its removal.

A hot solution of alkaline persulphuret, for instance, persulphuret of sodium, obtained by fusing sulphur with carbonate of soda, converts the tin into sulphuret which is retained in solution, leaving the iron perfectly free from tin.

The same end is attained, although in a less perfect manner, by a solution of oxyd of lead in caustic alkali, or by alkaline chromate in the caustic alkali. The former, however, produced a deposit of metallic lead, the latter of chromic oxyd, and the removal of either of these is attended with inconvenience; the first process is therefore preferred.

The tin is removed from the solution by evaporation and crystallization; the mass when drained and pressed is dried and roasted in a reverberatory furnace; carbonaceous matter with dry carbonate of soda or quicklime is then added and the tin reduced. The slag resulting from this process contains an alkaline sulphuret, to which more sulphur may be added to form again the solution for stripping the tin plate.

The iron scraps from which the tin has been removed are washed and packed into sheet iron cylinders, which are raised to a welding heat and brought under the hammer, as in the manufacture of other scrap iron. G. C. Schaeffer.

7. *Anisole, Salicylic Ether, and substances derived from them;* by A. Cahours, (Comptes Rendus, Mar. and May, 1849.)—This investigation is another result of the fine discovery of Zinin, that hydro-sulphate of ammonia is capable of transforming the nitric compounds into true organic bases. This process was at first applied almost exclusively to the nitric compounds of the hydrocarbons; but other facts show its extension to compounds originally containing oxygen. This remark applies to the researches before us. The value of this extension of the process of Zinin is not trifling when we consider that many of the more important organic bases contain oxygen; we are therefore nearer than ever to the fulfilment of the promise long since made, of the artificial formation of quinine, morphine, &c.

From the distillation of balsam of Tolu, Deville obtained a hydrocarbon $C_{14}\,H_8$, which has been named a toluole; it is a homologue of benzole. This substance furnished Drs. Muspratt and Hofmann by the process of Zinin, a new organic base, toluidine, a homologue of aniline. Their paper in the Lond. and Edin. Phil. Mag., Sept., 1845, well deserves reading, and is particularly valuable for a tabular view of the parallel anisic and phenic series. Most of the compounds in the anisic series had been discovered or investigated by M. Cahours; the present investigation fills many of the gaps by supplying homologues of the phenic series, and in some cases, furnishes compounds without a parallel in the latter series. Still more, in the paper above mentioned, Drs. Muspratt and Hofmann announce a new base, nitraniline, being aniline in which one equiv. of H_7 is replaced by NO_4—a most remarkable discovery, for the entrance of the elements of peroxyd of nitrogen without effect upon the basic properties of the original substance. We shall presently see that three new bases of this singular kind have been discovered, anisole, which bears the same relation to toluole that phenole does to benzole, has already furnished bi- and trinitric species, in which 2H and 3H are replaced by $2NO_4$ and $3NO_4$. By acting upon anisole with fuming nitric acid and keeping the mixture cold, M. Cahours has succeeded in forming the *mono-nitric anisole*—an amber colored, aromatic, heavy fluid, boiling at about 505° F. This substance is readily decomposed by an alcoholic solution of hydrosulphate of ammonia; sulphur is deposited and a new base, *anisidine*, is formed, $C_{14}\,H_9\,NO_2$.

By a similar process, bi-nitric anisole furnishes a new base, differing from the last in having H replaced by NO_4, and is, notwithstanding the presence of the elements of a powerful acid, a true base capable of forming well defined crystalline salts with acids. *Nitric anisidine*, it may be called, $C_{14}\,H_8\,N_2\,O_6$, crystallizes in long reddish brown lustrous needles, insoluble in water, but readily soluble in boiling alcohol. Some of its salts are colorless when quite pure.

Fuming nitric acid forms with toluole a liquid mono-nitric, and a crystalline bi-nitric species. The former furnished with hydrosulphate of ammonia, toluidine, to Drs. Muspratt and Hofmann. The latter by the same reagent has given M. Cahours a new alkaloid, the *nitric toluidine*, $C_{14}\,H_8\,N_2\,O_4$, being toluidine with H replaced by NO_4.

Anisic acid with fuming nitric acid is found to form among other products, a new acid isomeric with tri-nitric anisole, and a homologue of picric acid. This substance, *chrysanisic acid*, $C_{14}\,H_5\,N_3\,O_{14}$, crystallizes from alcohol in beautiful golden yellow rhombohedral plates. It is distinguished from similar acids by giving a very soluble salt with potash.

The salycilic ether of wood-spirit (oil of wintergreen) forms a crystalline compound with bases, which furnishes on distillation, anisole. In like manner, Cahours has found that the salycilic ether of alcohol, forms crystalline compounds, and that of baryta on distillation gives a new substance, phenetole, $C_{16}\,H_{10}\,O_2$, a homologue of anisole. This, when acted upon by strong nitric acid, forms a binitric species, resembling binitric anisole, and probably also a trinitric species.

The alcoholic solution of the former with sulphuretted hydrogen and ammonia, forms *nitric phenetidine*, the homologue of nitric anisidine.

As the mono-nitric phenetole has not yet been obtained, we are without the original alkaloid phenetidine, of which the above is a derivative.

To render the relation of these remarkable substances more clear, we subjoin a table, containing also the previously known homologues.

I.	Phenole	$C_{12}H_6O_2$
	Nitrophenesic acid Bi-nitric phenole	$C_{12}\left\{\begin{matrix}H_4\\2NO_4\end{matrix}\right\}O_2$
	Picric acid. Trinitric phenole	$C_{12}\left\{\begin{matrix}H_3\\3NO_4\end{matrix}\right\}O_2$
II.	Anisole	$C_{14}H_8O_2$
	Nitric anisole	$C_{14}\left\{\begin{matrix}H_7\\NO_4\end{matrix}\right\}O_2$
	Bi-nitric	$C_{14}\left\{\begin{matrix}H_6\\2NO_4\end{matrix}\right\}O_2$
	(Chrysanisic ac.) Tri-nitric anisole	$C_{14}\left\{\begin{matrix}H_5\\3NO_4\end{matrix}\right\}O_2$
	Anisidine,	$C_{14}H_9NO_2$
	Nitric anisidine	$C_{14}\left\{\begin{matrix}H_8\\NO_4\end{matrix}\right\}NO_2$
III.	Phenetole	$C_{16}H_{10}O_2$
	Bi-nitric phenetole	$C_{16}\left\{\begin{matrix}H_8\\2NO_4\end{matrix}\right\}O_2$
	Tri-nitric phenetole	$C_{16}\left\{\begin{matrix}H_7\\3NO_4\end{matrix}\right\}O_2$
	Phenetidine,	(wanting.)
	Nitric phenetidine	$C_{14}\left\{\begin{matrix}H_{10}\\NO_4\end{matrix}\right\}NO_2$

IV. Benzole	$C_{12}H_6$	V. Toluole	$C_{14}H_8$
Aniline	$C_{12}H_7N$	Toluidine	$C_{14}H_9N$
Nitric aniline	$C_{12}\left\{\begin{matrix}H_6\\NO_4\end{matrix}\right\}N$	Nitric toluidine	$C_{14}\left\{\begin{matrix}H_8\\NO_4\end{matrix}\right\}N$

G. C. S.

8. *On the Compound Ammonias;* by ADOLPHE WURTZ, (Comptes Rendus, Aug., 1849.)—In the last number of this Journal (Jan., 1850, p. 65) Mr. Hunt has most clearly explained the mode of formation of this new alkaloid, and also their relation to a very interesting group of compounds. Since that paper was written, M. Wurtz has more fully described the properties of Methylamine and Ethylamine, and has also added a new ammonia to the series Valeramine.

Methylamine, as well as the other new alkaloid, may be obtained from its hydrochlorate by the action of zinc, just as ammonia is obtained from sal-ammoniac. Thus prepared, methylamine is a gas of ammoniacal odor, condensing into a liquid at about 32° F. Its density is a little greater than that of ammonia. It is the most soluble of all gases; at 53° F., one vol. of water dissolves 1040 vols.; at 77°, 959 vols.

In all its reactions, this substance can scarcely be distinguished from ammonia—it precipitates the same bases, e. g., magnesia, alumina, iron, lead, &c., and redissolves the same—zinc, copper and silver. The compound analogous to fulminating silver, however, does not detonate. Methylamine may be distinguished from ammonia by its burning with a yellowish flame. Its salts are generally soluble in absolute alcohol.

Ethylamine, by a freezing mixture is obtained as a caustic fluid, of ammoniacal odor, and boiling at 62° F. Its reactions are very similar to those of methylamine, but it does not form a precipitate with chlorid of platinum. It burns with a bluish flame.

Valeramine, the new alkaloid is obtained by the action of potash on cyanate of amylene (cyanic ether of fousel oil), the latter being prepared by distilling sulphamylate of potash in the cyanate of potash. Valeramine is a liquid with a burning bitter taste and ammoniacal odor; its solution in water produces the same reactions as above described, it redissolves the precipitate of salts of copper with more difficulty than the other ammonias; the same may be said of the solution of the chlorid of silver. The formula is $C_{10}H_{13}N$.

The strong resemblance of these new alkaloids to ammonia has undoubtedly caused their presence to be overlooked in many decompositions of nitrogenous substances. In a recent paper on the decomposition of caffeine by chlorine, Rochleder describes under the name of formyline, a new base to which is assigned the impossible formula C_2H_4N. This is undoubtedly methylamine, the analysis corresponding better with the composition of the latter substance, than with the above formula. Mr. Anderson has recently examined an alkaloid, petinine, $C_8H_{10}N$, which in all probability is butyramine. We have then the following homologous series.

Ammonia,	H_3N
Methylamine,	C_2H_5N
Ethylamine,	C_4H_7N
Butyramine,	$C_8H_{11}N$ (Petinine, *Anderson*.)
Valeramine,	$C_{10}H_{13}N$

9. *On a Copper Amalgam;* by Dr. PETTENKOFER, (Ann. der Chem. u. Pharm., June, 1849, in Chem. Gaz.)—This remarkable compound, used by dentists for filling teeth, contains 30 parts copper and 70 parts mercury. As found in the shops, it is so hard as to require a powerful blow with a hammer to break it; the texture is crystalline. When heated to near 600° F., it swells slightly, and after trituration in a mortar, it becomes so soft on cooling that it may be moulded in the fingers like clay. In a few hours it again becomes hard enough to cut bone. Its density in the two conditions is so nearly the same, that if pressed into a glass tube while in the soft state, it becomes an air-tight stopper when hard. Many useful and less hazardous applications than filling teeth may be made of this curious substance.

Of several modes of preparation, the following appears to be the easiest and best. Finely divided copper obtained by precipitation by iron, is triturated in a porcelain mortar with protoxyd of mercury, metallic mercury and boiling hot water. The mass from brittle becomes soft and plastic when enough mercury is taken up. The excess of mercury should be pressed out, and the cake allowed to harden, which takes more time, than after the second softening. G. C. S.

10. *Benzole;* by C. B. MANSFIELD, (Chem. Gaz., June, 1849.)—A useful application of coal naphtha, which is mainly benzole, was noticed in this Journal for June, 1849, p. 106. The author proposes a process for obtaining pure benzole in large quantities from coal tar. The light coal naphtha from coal tar, is to be distilled in a metallic retort or still, the head of which is surrounded by water—this rising to 212° and no higher, suffers the volatile substances of higher boiling point to fall back into the vessel, while the more volatile benzole passes over and is condensed as usual. By a second rectification, keeping the still head at a temperature of 176°, the benzole is obtained still purer. It is next agitated with one-tenth its bulk of strong nitric acid, poured off and again agitated with sulphuric acid. When redistilled, it may be further purified by cooling to 4° F.; the crystals pressed and afterwards treated with chlorid of calcium, furnish a pure article.

As benzole dissolves India rubber, gutta percha and most resins, it may be valuable for these purposes, for which, however, the crude coal naphtha is generally used. Its solvent power renders it, according to the author, a cheap and less volatile substitute for ether in the laboratory.

A large number of most interesting compounds, aniline, nitraniline, &c., may be obtained from this substance in great quantity, at but moderate cost. G. C. S.

11. *On the Separation of Phosphoric Acid from Alumina;* by H. ROSE, (Bericht der K. P. Akad. Wissensch. zu Berlin, 1849, 220; Chem. Gaz., No. 173.)—The author recently published a method* upon separating phosphoric acid from bases by means of mercury, which admits of the phosphoric acid being separated from most of the bases in such a manner, that not only its quantity can be determined with great accuracy, but that after its separation the bases can be readily examined and accurately estimated, without being contaminated by the substance used for separating the phosphoric acid. The proposed method gave unsatisfactory results with the presence of peroxyd of iron and alumina. When iron alone is present, it requires but a slight modification; but with the presence of alumina the difficulties increase to such an extent that the method becomes inapplicable.

It is however often of importance to be able to determine the phosphoric acid with accuracy in complex compounds which also contain alumina. In several rocks, especially in the basalts, salts of phosphoric acid occur, principally apatite; and undoubtedly the great fertility of a soil consisting of decomposed basalt is owing to the admixture of apatite.

When basalt is treated in the pulverized state with a dilute acid, this dissolves the apatite, together with the constituents of the decomposed zeolitic mineral soluble in acids, among which alumina is almost always present. Now by means of the molybdate of ammonia, the acid solu-

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* See this Journal, viii, 181, Sept. 1849.

tion can easily be tested for a small quantity of phosphoric acid, in order that when present, even in minute quantity, it may not be overlooked in the analysis.

After numerous experiments, the author has found the following method to be the most advantageous for analyzing quantitatively complex phosphatic compounds containing alumina. The phosphate is dissolved in an acid, nitric or hydrochloric acid; and after dilution with water, a sufficient quantity of carbonate of baryta added. After it has stood for a couple of days in the cold, having been frequently agitated, it is filtered and the insoluble residue washed with cold water. The filtered solution contains the bases which were combined with the phosphoric acid, excepting alumina, peroxyd of iron and other weak bases. These, as well as the whole amount of phosphoric acid, are thus completely precipitated. The dissolved baryta is removed from the solution by sulphuric acid. This is somewhat difficult when much lime is present. In the filtered solution the bases are determined according to the usual methods.

The insoluble residue contains the whole amount of phosphoric acid which was present in the compound, as well as the alumina and the peroxyd of iron. It is dissolved in dilute hydrochloric acid, and the baryta removed by sulphuric acid. The filtered solution is saturated with carbonate of soda, and evaporated to dryness; the dry mass is mixed with silica and carbonate of soda, and heated to redness. The calcined mass is digested in water, and carbonate of ammonia added to it, when a considerable amount of silica is precipitated; it is filtered. The filtered liquid contains the whole of the phosphoric acid; it is supersaturated with hydrochloric acid, then with ammonia, and the phosphoric acid precipitated as ammonio-phosphate of magnesia.

The insoluble residue is digested with muriatic acid and the whole evaporated to dryness. The dry mass is humected with hydrochloric acid, and the silica separated in the usual manner, after which the alumina and peroxyd of iron are determined.

12. *On the Atomic Weight of Silica;* by H. Kopp, (Liebig's Ann., lxvii, p. 356; Chem. Gaz., July 16, 1849, p. 271.)—The doubts entertained respecting the atomic weight of silicon and the composition of silica according to one of the three formulæ SiO, SiO_2 or SiO_3, have not been solved by the views which have hitherto prevailed on this subject, where in general the decision has been made to depend on the circumstance, that a particular series of compounds might be most simply represented, sometimes according to one, sometimes according to the other formula. A peculiar mode of conceiving this subject shows that, admitting the correctness of the analytical results of Pelouze, the atomic weight of silicon with $H=1$ is 21·3, and the formula of silicic acid SiO_3.

Kopp has deduced this result from the difference between the boiling-points of the chlorid and bromid of silicon. The possibility is sufficiently evident of deciding the question by this means from a number of determinations of the differences between the boiling-points of several chlorids and bromids, in which the chlorine, on the one hand, may be regarded as a substitute for the bromine in the corresponding bromid, thereby establishing how many degrees the boiling-point rises or falls when, in any compound, chlorine is replaced by bromine, or *vice versâ*, bromine by chlorine. After determining the number of degrees which express this difference for the substitution of each atom of chlorine or bromine, it is possible, on the other hand, to conclude, from the difference between the boiling-points of a chlorid and the corresponding bromid, as to the number of atoms replaced. Now it results, from the comparison of the boiling-points of several bromids and chlorids, that the substitution of 1Cl by 1Br raises the boiling-point 32° Cent.; of 2Cl by 2Br, $2\times32=64°$; of 3Cl by 3B, $3\times32=96°$; while the boiling-point falls in the same proportion when, on the contrary, bromine is replaced by chlorine. Compare, for example, the boiling point of the following substances:—

		Boiling-point.
C_4H_5Cl	Chlorethyle, ...	+11°, Pierre.
C_4H_3Cl	Chloracetyle, ...	−18° to 15°, Regnault.
PCl_3	Chlorid of phosphorus . .	78°, Dumas, Pierre.

		Boiling-point found.	Calculated.
C_4H_5Br	Bromethyle	41° Pierre.	43°.
C_4H_3Br	Bromacetyle	Ord. temp.	14° to 17°.
PBr_3	Bromid of phosphorus . . .	175°, Pierre.	174°.

Several other comparisons enumerated by Kopp lead to the law above announced respecting the change in the boiling-point in substitutions of bromine and chlorine. It consequently follows, as above stated, that according as the boiling-point of a bromid, on comparison with that of its corresponding chlorid, is situated at 32, 64 or 96 degrees higher than in the chlorine compound, this latter must be regarded as containing 1, 2, 3 atoms of chlorine replaced by bromine. The boiling-points of the chlorid of silicon and of the bromid of silicon have been determined by Pierre, a most accurate observer, the first to be 59°, the latter to be 153°; the difference is 94°; whence it follows that in the bromid of silicon 3 atoms of bromine are substituted for 3 atoms of chlorine in the chlorid of silicon; that the first is $SiBr_3$, the latter $SiCl_3$, and that silica is therefore SiO_3; and consequently we must admit the atomic weight of silicon to be 21·3, H being assumed $=1$.

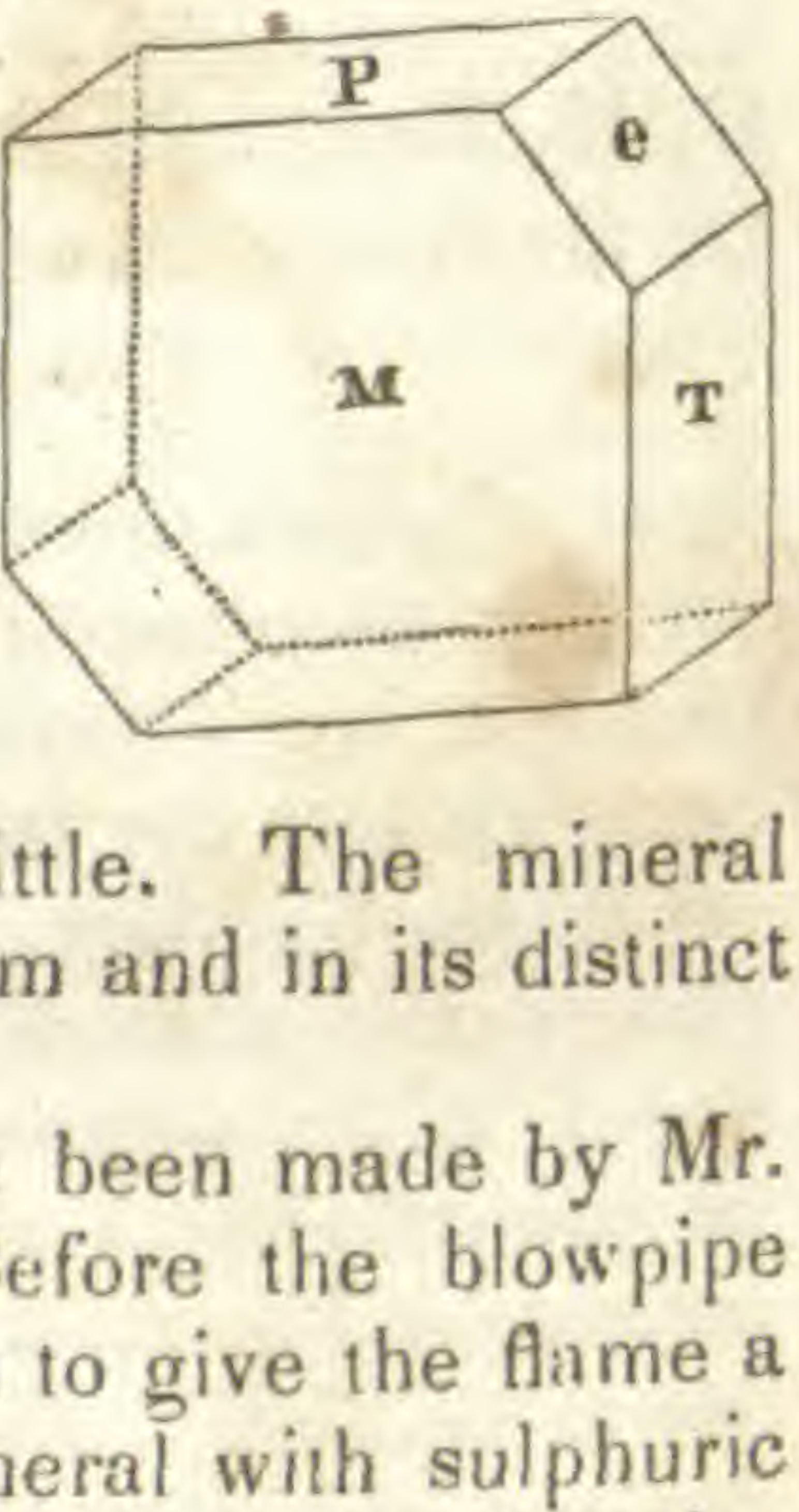
13. *On the Extraction of Mannite from the Dandelion;* by Messrs. SMITH; with an Analysis of the Mannite, by Dr. STENHOUSE. Communicated by Dr. GEORGE WILSON, (Proc. R. Soc. Edinb., ii, 223.)—Messrs. Smith stated that they had extracted from the dandelion, a large amount of a crystalline sweet substance, having all the physical characters of mannite. It was analysed by Dr. Stenhouse, and found to contain carbon, hydrogen, and oxygen, in the proportions which characterize the accepted formula for mannite; viz., $C_6H_7O_6$, so that it certainly was the substance it was supposed to be.

Messrs. Widumann and Frickhinger, it is stated, had anticipated Messrs. Smith in the separation of mannite from the dandelion juice, and were led to believe that the mannite did not preëxist ready formed in the dandelion; but was formed in the juice as the result of a peculiar fermentation which it underwent. This result was confirmed by the Messrs. Smith, who experimented with large parcels of the plant, and found that even from quantities of the fresh root, so large as 40 lbs., no mannite could be extracted, if the expressed juice were prevented from fermenting; whilst, if fermentation were permitted, the same weight of roots yielded a large quantity of mannite, which appears to be derived from the sugar, inulin, &c., of the dandelion, which was converted into mannite, gum, and lactic acid.

The Messrs. Smith stated, in conclusion, that they had not been able to confirm the statement of Polex, that the dandelion contains a bitter crystallizable substance, such as he had described under the name of taraxacine.

II. MINERALOGY AND GEOLOGY.

1. *On Danburite;* by J. D. DANA.—The species Danburite, from Danbury, Conn., has recently been found, through the explorations of Mr. G. J. Brush, in crystallized specimens, which have afforded the following crystallographic and chemical characters.



Triclinic; P : M=110° and 70°; M : T=54° and 126°; P : T=93° nearly; P : e=135°. Cleavage distinct parallel to M and P, less so parallel to T. Crystals imbedded in feldspar, associated with dolomite, and often an inch across. Occurs also disseminated massive without regular form. H.=7–7·5. G.=2·95, Silliman, Jr.; 2·97, Brush. Color pale yellow or whitish. Lustre vitreous. Translucent to subtranslucent. Exceedingly brittle. The mineral resembles chondrodite somewhat, but differs in form and in its distinct cleavage, as well as chemical characters.

The chemical examinations of the species have been made by Mr. H. Erni, in the Yale Laboratory, New Haven. Before the blowpipe it fuses rather easily, and in the dark it is seen to give the flame a green color, especially after having heated the mineral with sulphuric acid. With bisulphate of soda and fluor spar the green color (a color due to boracic acid) is as distinct and strong as with borax. With borax or soda, a transparent glassy globule is easily obtained. The amount of the mineral under examination was so small that the boracic acid could be estimated only from the loss. Mr. Erni obtained—

	I.	II.	Oxygen ratio for I.		
Silica,	49·74	49·71	25·84		12
Lime,	22·80	22·38	6·48	10·50	5
Magnesia,	1·98	1·30	0·78		
Soda,	9·82	. . . .	2·51		
Potash,	4·31	. . . .	0·73		
Perox. iron and Alumina,	2·11	1·65			
Boracic acid (loss),	9·24	. . . .	6·35		3
	100 00				

The ratio gives the formula $\dot{R}\dddot{B}+4\dot{R}\dddot{S}i$. The alumina is probably due to some feldspar, which is often detected penetrating the crystals.

Prof. Shepard, who described the mineral in this Journal, vol. xxxv, p. 137, obtained for its composition,

$\dddot{\text{Si}}$ 56·00, $\dot{\text{Ca}}$ 28·33, $\dddot{\text{Al}}$ 1·70, $\dot{\text{Y}}$? 0·85, $\dot{\text{K}}$ (with $\dot{\text{Na}}$?) and loss 5·12, $\dot{\text{H}}$ 8·0=100,

making it essentially a hydrous silicate of lime, a composition incompatible with the high degree of hardness. The presence of boracic acid accounts for this peculiarity.

2. *On the discovery of Sulphuret of Nickel in Northern New York;* by Dr. Franklin B. Hough, A.M., with additional observations by S. W. Johnson, (communicated for this Journal.)—In January of the present year, while visiting my friend Dr. Hough at his residence in Somerville, St. Lawrence Co., N. Y., he showed me specimens of a mineral which from its physical characters he had decided to be sulphuret of nickel.

As its existence in the United States has not been heretofore reported, I communicate the substance of a notice he furnished me, in his own words—"This mineral has been found in limited quantities at the Sterling iron mine, in Antwerp, Jefferson Co., N. Y. It was first noticed by the writer about two years since, and attracted his attention from its delicate capillary appearance, brilliant lustre, and the difference of its crystalline form from that of sulphuret of iron, which in color and association it so nearly resembles.

"It occurs mostly in radiating tufts of exceedingly minute and slender crystals of a brass-yellow color, and very brilliant lustre, which when highly magnified present the appearance of flattened hexagonal prisms with striated faces, the striæ being parallel with the principal faces of the prism.

"No cleavage was observed, nor could the terminal planes of the prisms (if they possess any) be determined. When moderately magnified, the minute acicular crystals appear to gradually narrow to a point, but lenses of a higher power disclose the fact that these needles are composed of several crystals of unequal length united by one or more of their lateral faces.

"They occur in geode-like cavities of the iron ore, which are lined with crystallizations of spathic iron, specular iron, quartz, calcite, cacoxene, and sulphuret of iron; from among these crystals the tufts proceed, attached generally to the spathic iron, more rarely to the crystals of iron. It is not an abundant mineral; only perhaps one or two dozen specimens have been procured since its discovery."

In one elegant specimen in Dr. Hough's cabinet, a cavity of more than half an inch in diameter is traversed by six or eight somewhat parallel crystals of larger size than any other yet procured. Their diameter is about $\frac{1}{60}$ of an inch. These are attached, as are all the few larger crystals, by both extremities.

In a specimen which the writer procured of a miner, several crystals $\frac{1}{2}$ inch in length and $\frac{1}{80}$ of an inch in diameter, extended from side to side of the cavity, being irregularly disposed, and firmly attached to the spathic iron at each end. Inspection of the sectional surface formed by the breaking of the geode, led to the observation of minute crystals apparently springing from the iron, and traversing the spathic iron. In two instances a crystal was found completely transfixing a rhomb of spathic iron, and supporting it in air, at a distance of $\frac{1}{8}$ inch above the inner surface of the cavity. In one of these cases, from the rhomb thus sustained, another needle of sulphuret of nickel projected upwards. These penetrating crystals are not in the least distorted. The larger ones of this specimen would admit of goniometrical measurement.

Chemical Examination.—A small fragment of one of the larger crystals heated in an open tube, evolved a strong odor of *sulphurous acid*. The roasted mineral which was black, but unaltered in form, was treated with hydrochloric acid, no action was manifest upon addition of nitric acid, and on application of heat, it quickly dissolved. The solution was evaporated to dryness, the residue dissolved and a drop of ferrocyanid of potassium added. The transparency of the solution was disturbed by a fine apparently white precipitate ; an exactly similar result followed a parallel experiment, made upon a like quantity of a pure salt of nickel. This reaction is chiefly valuable as proving the absence of iron and copper.

A hot borax bead was brought in contact with a tuft of crystals. Some adhered. They melted in the oxydating flame, and dissolved in the borax, tinging it while hot, of a yellowish color, and upon cooling it appeared by reflected light, of a peculiar blackish shade, but colorless by transmitted light. In the reduction flame the glass after a time became gray and opaque. The blowpipe behavior of oxyd of nickel is differently stated in the books, but I have always observed the above phenomena with a certain rather slight degree of saturation.

The small quantity of mineral has precluded a more extended examination. Hereafter the associated specular iron, and spathic iron will be examined for nickel.

3. *New Mineral Localities in New York;* by Dr. F. B. Hough, (communicated for this Journal.)—*Pearl Spar*, has been discovered of a fine quality, in the town of Rossie, St. Lawrence county. It occurs in seams and crevices of white limestone, in a precipitous bank on the right side of the Oswegatchie river, and can be procured in considerable quantities.

Associated with this is calcareous spar, crystallized in the forms most common in the vicinity, viz., the scalene dodecahedron with the summits of the pyramids replaced by three rhombic faces. Another modification is common at this locality, in which the acute summit of the pyramids is replaced by a single hexagonal plane, perpendicular to the axis. The pearl spar is very white, and occurs crusting over the crystals of calcareous spar.

Idocrase, of a dark reddish brown color, and crystallized in the usual forms, occurs about a mile south of the village of Gouverneur, St. Lawrence county, in white limestone and associated with scapolite. The crystals attain a diameter of one or two inches, but the specimens which are best characterized are much smaller.

Sulphuret of copper, in limited quantities, has lately been discovered near Vrooman's Lake, in Antwerp, Jefferson county. Associated with this was fluor spar, and beautifully crystallized calcareous spar.

Sulphate of barytes, on the farm of Judge E. Dodge, in Gouverneur, St. Lawrence county, of a highly crystalline structure, and associated with fluor and calcareous spars. This locality is in the northwest part of the town, about four miles from the village, and has been known about two years, although no account of it has (to the writer's knowledge) ever been published. It appears to exist in great abundance, in veins in sandstone rock, and may hereafter become of economical importance. It breaks readily in the direction of the cleavage, and specimens which have been exposed to decay, present an appearance not unlike that of a mass of nails, which have been partially fused, and melted together. Color when recently broken, pure white.

The same mineral has been discovered on the farm of Mr. R. Dean, in Antwerp, Jefferson county, about one mile east of the village of Ox-Bow. It occupies cavities in a coarse half decayed white limestone, is of low specific gravity, in consequence of numerous vermicular cavities with which it abounds, and occasionally presents botryoidal surfaces, studded with crystalline faces. From the presence of iron pyrites in small quantities, it becomes quickly stained with oxyd of iron, when exposed to the weather.

Stalactitic quartz, has been found in limited quantities at a newly opened pit at the Parish iron mine, in the town of Rossie, St. Lawrence county. The same has been found at the Sterling iron mine, in Antwerp, Jefferson county, with the surfaces beautifully encrusted with cacoxenite.

4. *A list of the Minerals associated with the Emery of Asia Minor;* by J. LAWRENCE SMITH, (in a letter to one of the editors.)—Dr. Smith observes: I find associated with the emery,—calc spar; iron pyrites; octahedral and massive protoxyd of iron; magnetic iron ore; peroxyd of iron; hydrous peroxyd of iron; emerylite and other micas; sismondite or chloritoid (they evidently being the same mineral); diaspore; a mineral of waxy aspect having a similar composition to mica, being probably a kind of amorphous mica; a beautiful emerald green mineral, unalterable by heat and of considerable hardness, quantity in my possession too small to determine its character or composition; and black tourmaline. I do not allude here to the prismatic crystals of corundum, the massive blue corundum, as they properly constitute the emery.

5. *On the Degradation of the Rocks of New South Wales and Formation of Valleys*, (from the Geol. Rep. Exp. Exped., by J. D. DANA.)—The great depth, extent, and number of the valleys of New South Wales are calculated to excite wonder, and perplex us much in the study of their origin. In some of these sandstone regions, the gorges intersect the country in endless succession, with usually inaccessible precipices of one, two, or three thousand feet. They are deep gulfs, with walled sides composed of horizontal layers of sandstone. These layers seem once to have been continuous: and what is the force which has thus channelled the mountain structure? Are they "stupendous rents in the bosom of the earth?"[*] Are they regions of subsidence? Can it be that they were never filled, but were depressions left between the heaps of accumulating sediment that constitute the sandstone, which depressions were afterwards enlarged by the sea during the elevations of the land?[†] Or may we adopt the "preposter-

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[*] Strzelecki's New South Wales and Van Diemens Land, p. 57.

[†] Darwin's Volcanic Islands, p. 137.

ous" idea, that simple running water has been the agent; and if so, was it fresh water, or the ocean?

The forms of these valleys are as remarkable as their extent. Major Mitchell states that Cox's River rises in the Vale of Clywd, 2150 feet above the sea, and leaves this expanded basin through a gorge 2200 yards wide, flanked on each side by rocks of horizontally stratified sandstone eight hundred feet high: here it joins the Warragamba. Some of its tributaries rise at a height of 3500 feet above the sea, and the ravines they occupy cover an area of 1212 square miles. From this he calculates that *one hundred and thirty-four cubic miles* of stone have been removed from the valley of the Cox.[*] The facts observed by us are sufficient to substantiate the general result, although we cannot add definite estimates of our own. The Kangaroo Valley is another example of a valley, two to three miles in width, and a thousand feet to eighteen hundred deep, opening outward through a comparatively narrow gap: and by a rough calculation from our own examinations, and the map of Major Mitchell, the amount of rock necessary to fill the valley is equivalent to a rectangular ridge, twelve miles long, two miles wide, and two thousand feet high. On the map of the Illawarra District, the form of this valley, (from the colonial surveys,) may be seen; and it is interesting as an illustration of the general character of these sandstone gorges, though wider than many of them in proportion to its length. This is but a small example, however, compared with those of the interior. Mr. Darwin remarks upon this peculiarity of form,—their extent and width and many branches, yet narrow openings at their lower extremity; and he observes that the same is the character of the bays along the coast.

In studying the origin of these valleys, we have then to consider the following particulars:—

1. Their high, precipitous, or vertical walls of stratified sandstone, and their flat areas at bottom—excepting where the descent of the stream is rapid.

2. Their frequent great breadth towards their head, while below, they are often very narrow, like a large bay with a small entrance.

3. The absence of all traces of the fragmentary material which could have filled these valleys.

The idea that running water was the agent in these operations appears not so "preposterous" to us, as it is deemed by Mr. Darwin; and we think it may be shown that Major Mitchell was right in attributing the effects to this cause. The extent of the results is certainly no difficulty with one who admits time to be an element which a geologist has indefinitely at command. But the subject admits of full explanation, as we believe, without making any improbable supposition on this point. We need but refer to a former page, in which we have discussed the subject of valley-making by denudation among the Pacific islands,[†] to show that New Holland, after all, is not the most remarkable land in the world for valleys of denudation.

We should consider that the rock material is far more yielding than that of basaltic Tahiti. Indeed the whole rock, from the uppermost layer to the deposits below the coal, is remarkably fragile, considering

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[*] Expedition into Australia, ii. 352.

[†] See this volume, p. 48.

the age of the deposits,—crumbling readily, and often breaking without difficulty in the fingers; and besides, it is much fissured. Even the harder fossiliferous Wollongong rock has been described as sometimes falling to pieces of itself when exposed to the air. Moreover there are occasional clayey or argillaceous layers which are still softer; and many of those of the coal formation are not firmer than the material of a common clay bank. The denudation of such material requires no preparatory decomposition, as with many igneous rocks, but takes place from wear alone, and with but slight force in the agent.

It is obvious for the same reason that the material carried off by denudation ought not to appear in fragments through the lower country. A short journey along a rapid stream would reduce even large masses to powder. The plains of the Kangaroo Valley are covered in places with basaltic pebbles or boulders; but the sandstone, which is the prevailing rock along the bed of the stream and in the enclosing hills, has scarcely a representative fragment among the debris. The sandstone blocks are worn to sand or earth by the torrent, while the harder basalt is slowly rounded. On the plains of Puenbuen, similar facts were apparent. The hills contain sandstone and basalt, but only the latter appears as boulders or pebbles over the plains, or along the streams below.

This Sydney sandstone does not even require running water to promote degradation. In many caverns along cliffs, the rock gradually falls to powder by a species of efflorescence. There are numerous instances of this along the coves of Port Jackson, where the crystallization of the saline spray reduces the rock to its original sand; and in the interior of the country there are large caves, formed apparently by this same process, though probably from the crystallization of nitrates. Near Puenbuen, these caves are from six to twenty feet deep, and from four to forty long. The roof is arched, and appears to be constantly crumbling, while the bottom is covered with a fine dry ash-like sand, into which the feet sink several inches. The same operation is going on along the summits of the Illawarra range; and one huge block was found so hollowed out in this way as to be a mere shell, which sounded under the hammer like a metallic vessel.

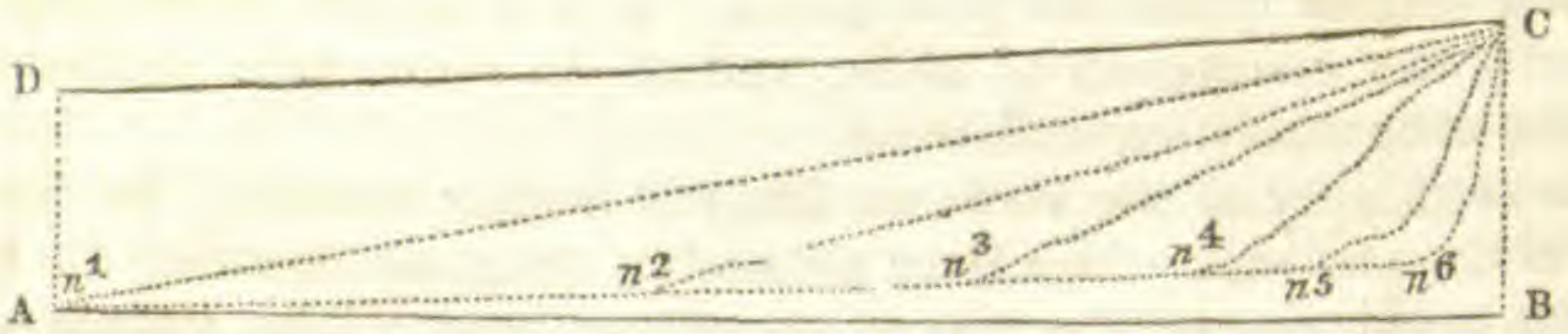
These various facts bring before us some idea of the yielding nature of the rock which the waters have to contend with in the denudation of this country, and they also illustrate the various processes at work. We allude to a single other mode of degradation before passing: it is the action of growing trees and their roots, both in opening fissures and tumbling blocks down the precipices. It is a cause influencing very decidedly the characters of cliffs, and at the same time preparing the rock for decomposition and wear.

The credibility of the view we favor is farther sustained by the character of the streams. We have alluded to the great extent of the floods, and the rapid rise of the rivers attending them. The stream of the Kangaroo Grounds, when visited by the writer, was a mere brook, fordable in any part, and it flowed along with quiet murmurings. How different when the brook becomes a river thirty feet deep, driving on in a broad torrent, and flooding the valley; and this had been its condition but a few weeks before. If, as has been shown, the transporting power of running water *increases as the sixth power of the velocity*, and a stream of fifteen miles an hour has more than ten times the transporting power of one moving ten miles an hour, and more than a million that of a stream two miles an hour,* we can comprehend how very inadequate must be the conceptions of this force which we derive from viewing a stream at low water.

This rise in the Kangaroo Grounds is an index of what takes place every few years over the whole country. Our surprise at the amount of degradation subsides before such facts; and we rather wonder that sandstones so soft and fragile, which have been exposed probably from the Oolitic period, still cover the surface to so great an extent as they do at the present time.

Mr. Darwin derives his principal argument against the hypothesis of denudation from the forms of the valleys,—their width, extent and ramifications, and yet *narrow* embouchures. But we find on consideration that this form is a necessary result of the mode of denudation under the circumstances supposed.

In our account of the valleys of the Pacific islands,† it has been shown that the gorges change their character where the slopes become quite gradual, from a narrow defile with convergent sides, to a broad channel with vertical walls and flat bottom: the cause of this change has also been explained. The same cause should produce a like effect in Australia. Though it be a repetition, we add in this place a brief explanation of the process. A stream, in making a descent of two or three thousand feet from the higher summits to the level of the sea, gradually deepens its bed by wear. Since the waters are increasing in quantity from various sources as they flow onward, this deepening of the gorge should be most rapid at its lower extremity; and it would continue in progress until the bed in that part became so low or gradual in slope, that the waters had lost to a large degree their rending force, and any excavation at bottom was made up by the material deposited along its course. This fact determines a permanent height for the bottom of the lower valley. As the stream continues its wearing action, in the same manner, the lower valley is gradually prolonged upward, retaining nearly the same slope at bottom (one or two feet to the mile); consequently the steeper portion of the gorge is at the same rate becoming shorter and still steeper. Thus the head of the stream may finally become a series of cascades, or, as it happens at times in the Pacific, it may be reduced mostly to a single cascade of a thousand feet or more.



The progress of this change may be better understood from the cut here given.

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* Wm. Hopkins, *On the Transport of Erratic Blocks*, Trans. Camb. Phil. Soc., viii, 1844, p. 221.

† p. 379 of this Report; also this volume, p. 57.

A B C D is the rock to be cut through by the stream. Suppose denudation to produce first the course $C\,n^1$. The stream is filled, as is commonly the case, by lateral channels and rills down the sides of the gorge, as well as by the main source; and the amount or depth of water is thus in constant increase, as it flows onward. Denudation is consequently most rapid the farthest from the head, or towards n^1; the valley, therefore, increases in depth in this part till the slope has become so gentle here as to counterbalance the greater amount of water, at which point the bottom of the valley ceases to deepen; in this condition $n^1\,n^2$ becomes the bottom of the lower valley, and $C n^2$ the steeper portion above it. In the same manner the valley bottom continues to prolong at nearly the same slope, and $C\,n^3$, $C\,n^4$, $C\,n^5$ become successively the course of the stream descending into it. And even $C\,n^6$, is no exaggeration of possibilities; for many examples of it are met with.

But the results explained are but a part of the actual course of things in these regions of horizontally stratified rock. As on Oahu and elsewhere, when the denudation at bottom has reached its limit, the waters exert but little degrading power except during floods, and this takes place by the sides of the overflowing stream; at the same time, depositions of detritus take place along its banks. The result is that the rocks bounding the valley are worn away below, and are often undermined, as before explained; the valley widens at bottom to a flat plain, while the enclosing wall by the process becomes nearly vertical. A narrow riband of land between high precipices of rock is therefore a necessary result of the action.

Degradation still continues along the upper or steep part of the main stream, and also along the many streamlets and rills pouring down the valley's sides; and in each of these streamlets there is a tendency to produce below a flat-bottomed valley. The consequence is, that they increase the width and extent of the main valley-plain; for whenever they become thus flat-bottomed, they contribute to its lateral enlargement. At the same time, the bluffs at the lower extremity or embouchure of the main valley remain without much change, as the denudation is mostly confined to the vicinity of the streamlets alluded to, and these streamlets are most abundant above, since they are produced and fed chiefly by the rains in the higher part of the mountains. It is natural enough, therefore, that the valleys should not only become flat below and precipitous in their sides, but also that they should widen least at their lower extremity. We see, therefore, no necessity of appealing to any other cause than simply running water to account for the most stupendous results in Australia.

It has been supposed that the sea has been largely concerned in the denudation which has produced the Australian valleys. On this point enough, perhaps, has already been said on a former page. We find no reason for attributing any of the valleys to this source, although it is possible that some modifications may thus have resulted. The facts at Port Jackson are a sufficient reply on this point. The cliffs of the estuary actually undergo very little change from the action of its waters, and are far more altered by the mode of efflorescence described, and by rills of running water; and such action as is exerted, tends to remove the headlands instead of deepening the coves. There is, therefore, good reason for believing that such estuaries as Port Jackson and Macquarie were dug out by fresh waters, and have since been submerged. The fact that there is a correspondence in trend with the fissures of the sandstones, shows that their direction was determined by these fissures, or by faults which have the same origin. We have remarked that the rock has not the same dip in the two Heads of Port Jackson, a fact indicating the existence of one or more intermediate faults.

III. Zoology.

1. *Report on Zoophytes;* by James D. Dana, Geologist of the Exploring Expedition under Captain Wilkes, U.S.N. 740 pp. 4to, 1846; with an Atlas of 61 plates in folio, mostly colored, 1849.—The publication of this work has been briefly announced in this Journal. The number of species of corals collected in the course of the voyage of the expedition was quite large, and it consequently became necessary to revise this department of science throughout; the volume therefore includes all known species of existing coral zoophytes, up to the date of its publication. The species added by Mr. Dana, or described anew from specimens examined, are in all cases indicated in connection with the mention of the locality; and moreover, in the catalogue of species accompanying the remarks upon each genus, the new and redescribed species are designated by an asterisk, in order that the observations for which the author is not personally responsible, may in all instances be readily obvious. The references and synonymes have been collected from a consultation and study of the original authors in this department, and not simply from the systematic treatises. There has thus been a complete revision of the synonymy of the science, besides a corrected identification of the species described or figured by former writers.

Out of the 444 known species of coral zoophytes, (excluding the Alcyonaria,) 233 are new species first described by the author; and of the remaining 211, 122 are redescribed from specimens. To the genus Madrepora, previously numbering 20 species, 52 new species are added, and 12 of the old species redescribed from specimens. The 30 known species of Astrææ were increased to 62; the four of Euphylliæ, D. (referred to Caryophyllia by Lamarck) to 15; the 17 of Fungidæ, to 60; the 57 of Madreporidæ to 141, and 34 out of the 57 old species were redescribed from specimens. This addition of species rendered it necessary to describe the old genera in some instances with more precision, and the examinations of the animals made it in general possible to give these descriptions a *zoological* character, a course in which Ehrenberg had led the way. Thus the science, like that of mollusca, is at last rescued from being a mere systematical arrangement of animal secretions. Species hardly distinguishable in the corals were sometimes found very different in the animals. The Antipathes, supposed hitherto to belong with the Gorgoniæ, from a resemblance in mode of growth, (as the species of each group have a horny axis,) were shown to be zoologically related to the Madreporæ,—the *naked* character of the tentacles and their number, *six*, being widely different from the same in the Gorgoniæ and other Alcyonaria, in which the tentacles are *fringed* with papillæ, and the number is *eight.* The Actiniæ usually separated widely from coral zoophytes, have received their true place, in close affiliation with the Astræidæ.

2. *A new genus of Orchestidæ;* by J. D. DANA.—In a synopsis of the genera of Gammaracea, in this Journal, volume viii, p. 135, three genera of Orchestidæ are mentioned, Talitrus, Orchestia and Allorchestes. We here add a fourth; and for the purpose of giving a fuller comparative view of the four, and correcting a misprinted word, we insert the generic characters for the group.

1. Pedes primi non cheliformes nec subcheliformes, articulo styliformi confecti; secundi sæpe subcheliformes, manu sive parvulâ et debili sive nullâ. Antennæ superiores basi inferiorum breviores.	*Talitrus* (Latreille).
2. *Talitro* pedes primos antennasque similis. Pedes *maris* secundi valde subcheliformes, manu grandi.	*Talitronus* (Dana).
3. Pedes primi secundique plus minusve subcheliformes. Antennæ superiores basi inferiorum breviores. Maxillipedes apicem obtusi.	*Orchestia* (Leach).
4. Pedes primi secundique plus minusve subcheliformes. Antennæ superiores breviores, basi inferiorum longiores. Maxillipedes apicem unguiculati.	*Allorchestes* (Dana).

3. *On the Genus Astræa;* by JAMES D. DANA.—In the Report on Zoophytes by the writer, the Genus Astræa has the same extent nearly that was given it by Lamarck, but based on zoological evidence. It includes all those species of Actinacea in which the budding is from the summit and is a consequence of the gradual widening of the summit by growth: in some the budding resulting in a subdivision of the disk of a polyp; and in others, in the development of a new polyp from the widening parts just exterior to the disk, the widening not extending to the disk. The latter division had previously been separated by Ehrenberg and united with some other species, including one or two Gemmiporæ, to form his genus Explanaria, a Lamarckian generic name but with a wholly new application.

The author has shown that the budding and growth of the Gemmiporæ is essentially different from that of the Astræoid species here alluded to—in the former, the buds being *lateral* from towards the base of the polyps, while in the latter (as in Astræas) the *summit* of the polyps gradually widens or extends and produces buds. The corals of this species show this difference in a striking manner.* Rejecting, therefore, the genus Explanaria, (a name objectionable on account of its double use, as well as its etymological incorrectness,) the author retained the Astræoid species in the genus Astræa and introduced the subdivisions, corresponding, of Orbicella† and Fissicella, the latter including the species which increase by a subdivision or fission of disks, and the former those whose buds were marginal or interstitial.

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* See this Journal [2], iii, 16, 18.

† Corresponds to Blainville's subdivision *Tubastræa,* a name of hybrid origin.

Professor Agassiz has made some recent observations on the ova and development of a species of Actinia, and has shown that the number of tentacles in the young animal is at first *five;* and he has consequently inferred that this is a typical or normal number for the true Actiniæ. The Actiniæ, it should be observed, are identical with the ordinary coral polyps in all points of structure, and this number should therefore be expected to occur among them.

But the author has elsewhere shown* that in the Orbicellæ the number of tentacles is a multiple of 6 or 4. In the *Orb. argus*, *glaucopis*, *curta*, the number is forty-eight; in the *coronata* and *rotulosa*, thirty-six; in the *pleiades*, *hyades*, *excelsa*, *annularis*, *stellulata*, *microphthalma*, *ocellina*, twenty-four; in the *stelligera*, eighteen. The number *six* is likewise characteristic (perhaps sometimes *four* and not *six*) of the species of the genus Caryophyllia and other Caryophyllidæ; also of the Madreporidæ in which the number is *twelve;* and of the Antipathidæ, in which it is *six*.

From these different observations we therefore seem to have two typical numbers in the same group of animals. Prof. Agassiz's observation is sustained by the fact that many Actiniæ have a five-lobed summit, or a five-lobed mouth.

It is therefore a very probable inference that those Astræidæ which bud by subdivision of the disk pertain to the five series, and owe to this in part the indefinite growth of the disk and multiplication of tentacles, and the consequent fission that takes place. While those of the six series, as far as direct observation has gone, have a fixed limit to the number of tentacles,—the even number *six* being a limit-number, while *five* may or may not be so. The multiplication of tentacles as growth proceeds, has been shown by the writer to be quite analogous to the spiral development of the leaves or petals of a plant; and it is therefore an interesting fact that *five* should be the number for the unlimited spiral, while *six* is a limited spiral. This is a point, however, which direct observation on the young of the fissiparous zoophytes alone can fully establish.

From this and other considerations, the author concludes that the two subgenera of Astrææ are much more widely separate than is admitted in his system, as published in his Report. The Actinaria appears to contain two grand groups, one characterized probably by the number *five*, and multiplication by fission, while the other is characterized by the number *six*, and an absence of fission. The former includes the *Actinidæ* (excluding the Orbicellæ, Echinoporæ, and Phyllastrææ), with the *Fungidæ;* while the latter embraces—1. the *Orbicellidæ* (the species of the three genera just mentioned); 2. the *Cyathophyllidæ;* 3. the *Caryophyllidæ;* 4. the *Gemmiporidæ;* 5. the *Zoanthidæ;* 6. the *Madreporidæ;* 7. the *Antipathidæ*.

The subgenus *Orbicella* should therefore take the rank of a genus. We shall probably find that there are Actiniæ of both kinds, although hitherto not distinguished.

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* See Report on Zoophytes, p. 49, and this Journal [2], iii, 9.

As far as the writer has observed, none of the Palæozoic corals, or Cyathophyllidæ, bud by subdivision of disks. Some species have summit or disk buds; but these buds *grow out from* the disk, like those which grow from the sides; and are not a consequence of a gradual and successive multiplication of the tentacles and widening of the original disk, ending in a progressive subdivision. The nearest representatives of the ancient Cyathophyllidæ are to be found in the Orbicellæ and Caryophylliæ. But the transverse horizontal septa of many of the ancient species have nothing corresponding in these groups though represented among the Pocilloporæ and some other genera of recent Madreporidæ.

IV. MISCELLANEOUS INTELLIGENCE.

1. *On the Extraction of Gold from the Copper Ores of Chessy and Sain-Bel;* by Messrs. ALLAIN and BARTENBACH, (Comptes Rendus, Nov. 19, 1849; Chem. Gaz., Jan. 1, 1850, p. 17.)—It results from our experiments, that at least two ten-thousandths of gold may be extracted from the above copper ores, the working of which, as the mines in question are of considerable extent, may become highly important. The density of the ore being 4, 1 cubic metre represents 800 grms. of gold. The operations are easy and rapid, and consist in first roasting the ore, and then dissolving out the gold.

After the mineral has been roasted in small fragments in the air, with a view to render it more friable, it is pulverized, passed through a fine brass sieve, and again roasted as much as possible, that is to say, until the powder has acquired a homogeneous brownish-red color. It is then formed into a paste with sulphuric acid of 66°, and roasted a last time until there is no further disengagement of sulphurous or sulphuric acid. The employment of sulphuric acid is most efficacious, as on the one hand, the sulphur in the form of sulphuric acid serves to remove sulphur, and on the other, as this metalloid, on becoming oxydized either by the air or at the expense of the oxygen of its compound, furnishes a greater amount of sulphuric acid than is wanted if the sulphurous vapors of the different roastings are passed into leaden chambers. Again, sulphuric acid is preferable for removing the oxyds of zinc and copper formed, as it readily converts the last traces of sulphurets which may have escaped the roasting into sulphates.

The substance is then reduced to as fine a powder as possible, and boiled with weak sulphuric acid. The insoluble portion is washed, and lastly heated with aqua regia diluted with water, but having been previously made in the proportion of 6 parts of hydrochloric acid of 21° and 1 part of nitric acid of 36°. This is an important point. The liquid containing the chlorids of iron, gold (and even of copper, for it is difficult to remove this metal entirely by a single ebullition with sulphuric acid), is placed in contact with iron, which precipitates the gold and copper; the precipitate is collected, washed, dried and calcined, to oxydize the copper. The gold may be separated from the oxyd of copper and oxyd of iron (for there is always a little of the latter precipitated in the cementation) by sulphuric or hydrochloric acid; but the separation, either by fusion or by chlorine or mercury, is preferable. With the chlorid the metal is reduced by heat, with amalgam the mercury is volatilized. The process above described is applicable to all pyrites which contain gold. The expenses attending the extraction of 2 lbs. of gold from the Chessy ores, after deducting the value of the copper obtained, do not exceed four hundred francs.

2. *The Table Land of Thibet*, (Athen., No. 1146.)—In April last we had occasion to speak of the first fruits of Dr. Hooker's mission to explore the botanical and physical character of the Himalaya. He had ascended the eastern extremity, within sight of the great snowy range, of which the peak Kinchin-junga, altitude 28,172 feet, is the loftiest yet known in the world,—and was anxiously waiting in the environs of Darjeeling, with the view of reaching the great table-land of Thibet, and determining the questions submitted to him by Humboldt relative to its elevation and snow lines.[*] Owing to the jealousy with which the frontiers are guarded by the Chinese and Sikkim tribes, and the difficulty of obtaining provisions and guides, it was some months before Dr. Hooker could make the pass. This, however, has been effected:—as the following letter describes.

Tungu, N.E. Sikkim, alt. 13,500 ft., July 25, 1849.

I have at length carried my point, and stood upon the table-land of Thibet, beyond the Sikkim frontier, at an elevation of 15,500 ft., at the back of the great range of snowy mountains. The pass is about ten miles north of this. We have Thibetan ponies, mounted thereon *à la Tartare;* but I walked a considerable part of the way, collecting many new plants. The Thibetans come over the frontier in summer to feed their Yaks, and reside in horse-hair tents. I entered one and was much amused with a fine Chinese-looking girl, a jolly laughing wench, who presented me with a slice of curd. These people eat curd with herbs, milk, and Fagopyrum bread—only the richer can afford to purchase rice. They have two sorts of churn: one is a goat-skin, in which the cream is enclosed and beaten, stamped upon and rolled; the other is an oblong box, a yard in length, full of rhododendron twigs, frosted with butter—and maggots. Some miles farther we reached the tents of Peppin, the Lachen Soubah, and were most graciously received by his squaw and family. The whole party squatted in a ring within the tent, myself seated at the head on a beautiful Chinese mat. The lady of the Soubah made tea, adding salt and butter, and each produced our Bhotea cup, which was always kept full. Curd, parched rice, and beaten maize were handed liberally round. Our fire was of juniper wood, and the utensils of clay, moulded at Dijarchi, except the bamboo churn, in which the tea, salt, and butter were churned previous to boiling. * * Presently a tremendous peal, like thunder, echoed down the glen. My companions started to their feet, and cried for me to be off,

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[*] "Que je suis heureux d'apprehendre [says Humboldt] que vous allez pénétrer dans ces belles vallées de l'Himalayah, et même au-delà vers Ladak et les plateaux de Thibet, dont la hauteur moyenne, non confondue avec celles des cîmes qui s'élèvent dans le plateau même, est un objet digne de recherche. * * Eclaircir le probléme de la hauteur des neiges perpétuelles à la pente méridionale et à la pente septentrionale de l'Himalayah en vous rappellant les données que j'ai réunies dans le troisième volume de mon Asie Centrale."

—for the mountains were falling and a violent storm was at hand. We pursued our way for five or six miles in a thick fog; the roar of the falling masses from Kinchin-jow on the one hand and Chomoimo on the other being truly awful. Happily, no fragment can enter the valley, by reason of the low hills which flank the river along whose bed we were journeying. Violent rain ensued, and drenched us to the skin. Gradually, as we ascended, the valley widened; and at the altitude of about 15,000 feet we emerged into the broad, flat table-land, composed of range after range of inosculating stony terraces, with a little herbage, amongst which the Lachen river meanders. Five hundred feet farther we found ourselves at the top of a long flat ridge, connecting the north-west extreme of Kinchin-jow with Chomoimo,—and here stood the boundary mark. Happily, the weather cleared. Northward the plateau dipped by successive very low ridges, overhung with a canopy of the vapors that had deluged us. Easterly was the blue sky and low ridges of the lofty table-land, which here backs the great range. To the west the spurs of Chomoimo and much mist veiled the horizon. Southeast Kinchin-jow, a flat-topped mass of snow, altitude 20,000 feet, rose abruptly from rocky cliffs and piles of débris. Southwest was Chomoimo, equally snow; while southward, between these mountains, the plateau dipped into the funnel-mouth head of the Lachen valley. Here I had an opportunity of solving the great problem—the Elevation of the Snow Line. Strange to say, there was not a particle of snow to be seen anywhere *en route*, right or left, nor on the great mountains for 1,500 feet above my position. The snow line in Sikkim lies on the Indian face of the Himalayan range, at below 15,000 feet,—on the Thibetan (northern) slope at above 16,000! I felt greatly delighted, and made a hasty sketch of the surrounding scenery:—somewhat rude, for at this great elevation my temples throb, and I retch with sickness.

Just above 15,000 feet all the plants are new; but the moment you reach the table-land nine-tenths of them disappear. Plants that are found at 12–13,000 feet on the Indian approaches to Thibet, did not ascend to the top of the Pass; still, as I always expected, at the turning point where the alpine Himalayan vegetation is to be soon replaced by Thibetan sterility, there is a sudden change in the *Flora*, and a development of species which are not found farther south, at equal altitudes in the Himalaya. We made a fire of Yak dung dried, and blew it up with bellows of goat skin, armed with a snout of Yak's horn. My poor Lepchas were benumbed with cold. I stayed an hour and a half on the Thibetan side of the frontier, and obtained good barometrical observations, and others with boiling water,—but the latter process is infinitely the more troublesome. On our return the weather cleared magnificently, and the views of the great mountains already named rising perpendicularly exceeded any that I ever beheld. For 6,000 feet they rise sheer up and loom through the mist overhead; their black wall-like faces patched with ice, and their tabular tops capped with a bed of green snow, probably from 200 to 300 feet thick. Southerly down the glen the mountains sunk to low hills, to rise again in the parallel of the great chain, twenty miles south, to perpetual snow, in rugged peaks. We stopped again at Peppin's tent for refreshment, and I again took horse. My stubborn, intractable, unshod Tartar pony never missed a foot. Sharp rocks, deep stony torrents, slippery paths, or pitch darkness, were all the same to him. These ponies are sorry looking beasts; but the Soubah, who weighs sixteen stone, rode his down the whole thirty miles of rocks, stones, streams, and mountains; and except to stop and shake themselves like a dog, with a violence that nearly unhorsed me, neither his steed nor mine exhibited any symptoms of fatigue. Fever rages below from Choontam to Darjeeling. My people behave admirably, and I never hear a complaint; but I find it very hard to see a poor fellow come in, his load left behind, staggering with fever, which he has caught by sleeping in the valleys, eyes sunk, temples throbbing, pulse at 120, and utterly disabled from calling up the merry smile with which the kind creatures always greet me. We have little rain, but much mist; and I find great difficulty in keeping my plants in order. Do not be alarmed for me about fever, for I shall not descend below 6,000 feet. I have not been below 10,000 feet for the last two months. I lead a hard, but healthy life; and know not what it is to spend a lonely-feeling hour, though without a soul to converse with. Arranging and labelling plants, and writing up my journal, are no trifling occupation, and I am incessantly at work. JOSEPH DALTON HOOKER.

3. *On the Classification of Colors.* Part II. By Professor J. D. FORBES, (Proc. R. Soc. Edinb., ii, 214.)—The object of this paper is chiefly one of nomenclature. Every one has felt the difficulty of describing with precision the innumerable hues which occur in nature and in art; and which it is equally desirable for the optical philosopher, the artist, and the manufacturer, to be able to refer to in a clear and definite manner. But such a nomenclature or classification must proceed upon some admission as to the manner of compounding complex hues out of simple ones; and, therefore, the author first treats of the (so-called) Primary Colors. He admits it as highly probable, that all known colors may be formed out of red, yellow, and blue; although, when we attempt to compound pigments, we have a very notable loss of light, and also an unavoidable impurity, which is most visible in the compound tints. The author, in passing, endeavors to explain clearly why the union of pigments never can produce a perfect white, although the colored light of the spectrum does so; for, by adding blue light to yellow light, we not only change the color, but we increase the illumination; whereas, by adding a blue to a yellow pigment, whilst we change the color, we at the same time reduce the luminousness of the surface, the blue particles being far less reflective than the yellow ones. Inferring from Newton's empirical rule, the quantities of red, yellow, and blue light, which should combine to make white light; and adopting Lambert's results as to the reflective powers of the brightest pigments, the author concludes, that the mean illumination of a disk put in rapid revolution, and containing colored sectors, will be 4·57 times *less* than if it reflected the whole incident light, or it will reflect only about *half* the light which white paper does under the same illumination, therefore it will appear relatively *grey* under any given external illumination.

The author then states, that the triangular arrangement of colors first proposed by Mayer, and farther carried out by Lambert, appears to afford the clearest and truest mode of displaying at a glance the modification of color due to the varying proportion of the three primary elements. In this triangle, perfect red, yellow, and blue, occupy the three corners; and these colors graduate into one another, according to the simple law of the distance of any point in the triangle from the three corners. The sides of the triangle are occupied by binary colors or compounds, by two and two; the interior is occupied by triple compounds; and the centre of gravity of the triangle ought to be a neutral grey.

Hence it will appear, that any hue not purposely diluted with black or white, is composed of a compound of a binary color with neutral gray. Hence a convenient nomenclature suggests itself as follows: the first column containing the binary colors.

RED.	Greyish Red.	Grey Red.	Red Grey.	Reddish Grey.	Grey.
Orangish Red,	*	*			
Red Orange,	*	*	*		
Reddish Orange,	*	*			
ORANGE.	Greyish Orange.	Grey Orange.	Orange Grey.	Orangish Grey.	Grey.
Yellowish Orange,	*	*			
Yellow Orange,	*	*	*		
Orangish Yellow,	*	*			
YELLOW.	Greyish Yellow.	Grey Yellow	Yellow Grey.	Yellowish Grey	Grey.
&c.	&c.	&c.	&c.	&c.	&c.

These colors are supposed to be of the standard or maximum attainable intensity.

They may be diluted with white on the one hand, forming *tints;* or with black, forming *shades.*

Mayer's triangle may be repeated with these modifications; but as the color tends to extinction, either in the direction of perfect blackness or perfect whiteness, the number of compartments in the triangles may be diminished as the dilution of the colors increases. Thus, the whole may be formed into a double pyramid of color, converging to white above and to black below.

The author has been much indebted to Mr. D. R. Hay, the ingenious author of the "Nomenclature of Colors," and other works, not only for specimens of colored papers formed by the actual mixture of the three primary colors, but also for many valuable suggestions, of which, in the course of this paper, he has freely availed himself.

It is the author's wish to be able to obtain a series of colored enamels complete, according to Mayer's and Lambert's classification. Some he has already obtained from the Vatican Collection, (of which he gives a short description,) and he hopes to render it more complete.

4. *New Process for extracting Sugar from the Sugar-cane;* by M. MELSENS, (Phil. Mag., xxxvi, 62, from Gard. Chron., Dec. 15, 1849.) —The following account of the new and important method of extracting sugar from the sugar-cane, is abridged from the first of two long articles recently published in the *Courier de l'Europe.*

The great difficulty which has been experienced up to the present time in the preparation of sugar, has been owing to the rapidity with which, when dissolved in water, it alters by exposure to the air in hot climates. It must, however, be obvious, since the cells of the sugar-cane are themselves full of sugar dissolved in water, and this solution can be kept for a long time in them, without undergoing any alteration at all, that if the same conditions which exist in nature could only be obtained in practice, there is no reason why an artificial solution of sugar may not be kept unaltered for a considerable space of time; or in other words, why water should not be used for the purpose of dissolving the sugar out of the crude juice expressed from the cane.

The difficulties, indeed, are not owing to the sugar or to the water, but to the air, and the ferments produced by its action on the crude sap of the sugar-cane. The object of M. Melsens was then, to exclude the air from the sap when extracted from the cane, and to prevent the formation of any ferments which might change the character of the saccharine matter. This he has succeeded in doing by availing himself of the well-known affinity of sulphurous acid for oxygen gas. Sulphurous acid, however, alone was found not to answer the purpose; the sulphuric acid, produced by the absorption of oxygen by sulphurous acid, acting on the sugar, converts it into grape-sugar. This difficulty has been overcome by using sulphurous acid combined with a powerful base, which, as the sulphurous acid is converted into sulphuric acid, combines with the latter and forms an insoluble salt.

The acid sulphites, and more especially the bisulphite of lime, were employed by M. Melsens for the double purpose of preventing fermentation by the action of the sulphurous acid, and of neutralizing the sulphuric acid as fast as it formed by means of the lime.

Sugar-candy dissolved in cold water containing bisulphite of lime, even in excess, crystallized entirely, and without undergoing any change, by spontaneous evaporation, at a low temperature. Several other experiments of the same nature, but differing in their details, always gave the same result; in each the sugar crystallized out by spontaneous evaporation, without any loss either in quantity or in quality, and without any appearance of molasses. In these experiments, the sugar dissolved in water, containing bisulphite of lime in excess, was boiled, and then left to evaporate, sometimes after being filtered, sometimes without any filtration at all.

From the experiments which M. Melsens has made with bisulphite of lime, it is probable that if a cold solution of this salt were to be poured on the sugar-cane grinder, so as to mix with the juice the moment it is expressed from the cane, the sugar might be kept for some time, and might be exposed to the heat necessary for its clarification without any sensible loss or deterioration.

But this same salt also possesses the property of coagulating, at a temperature of 212°, milk, white of egg, blood, and yolk of egg mixed with water. At a temperature of 212°, bisulphite of lime acts as a clarifier. It separates the albumen, caseine, and other similar azotized matters which are found in the sugar-cane. This separation is effected without appreciable loss in the quantity, or deterioration in the quality of the sugar.

Bisulphite of lime, moreover, rapidly and tolerably effectually bleaches the colored substances found in the sugar-cane; it prevents the formation of other colored matters produced by the action of air on the pulp of the cane; it also stops the production of those which are formed during evaporation, and above all, of those which require for their development the joint action of air and a free alkali.

It seems that colored substances which, under ordinary circumstances, are formed spontaneously by the exposure of the pulp of the sugar-cane to the air, never make their appearance when bisulphite of lime is employed. By evaporating at a low temperature, bisulphite of lime mixed with—1, a common solution of sugar; 2, the crude sap of the sugar-cane; 3, the juice of beet-root; no coloration was produced. By an evaporation of the same substances at a high temperature, the coloration was scarcely visible; indeed, with red beet-root the color was completely destroyed, and the sugar obtained was perfectly white.

It seems, then, that bisulphite of lime can be employed in the extraction of sugar:—1st, as an antiseptic, preventing the production and action of any ferment; 2nd, as a substance greedy of oxygen, opposing any alteration that might be caused by its action on the juice; 3rd, as a clarifier, coagulating at a temperature of 212° all albuminous and other coagulable matters; 4th, as a body bleaching all pre-existing colored products; 5th, as a body opposing itself in a very high degree to the formation of colored substances; 6th, as a base capable of neutralizing any hurtful acids which might exist or be formed in the juice, and substituting in their place a weak inactive acid, namely, sulphurous acid.

M. Melsens is of opinion that sugar can be obtained from the sugar-cane with no other source of heat than a tropical sun, excepting only for the purpose of clarification; indeed, the bisulphite of lime prevents the crude juice of the cane, or the syrup obtained therefrom, from undergoing any changes; great rapidity in the process of crystallization, indispensable at present, becomes by using this salt unnecessary; and more than this, the quantity of sugar which is now lost in the bagasse, in consequence of the impossibility of washing it out unchanged, can be all collected by being dissolved in water charged with bisulphite of lime.

The only objection that can be made to the above process is, that the sugar obtained by means of bisulphite of lime has a sulphurous taste; this is true, but the taste is completely lost—1st, by crushing the sugar and exposing it to the air, whereby the little sulphite of lime which there may be is converted into a tasteless sulphate; 2nd, by exposing the sugar to an atmosphere containing ammonia; if this is done the sugar acquires a very agreeable flavor of vanilla, but is apt to become a little discolored; 3rd, by clarifying it until it loses ten per cent. of its weight; by this process a pure white sugar can be obtained, which will bear comparison with any sample produced at present. The last is the process recommended to be used on a large scale. The quantity of sugar fit for the market which can be obtained from the sugar-cane by adopting bisulphite of lime, as above recommended, is at least double that obtained by the usual processes.

In consequence of M. Melsens having made all his experiments on the sugar-cane at Paris, and therefore on a small scale, he is not able to state how bisulphite of lime can best be used in the large colonial sugar manufactories, but is compelled to leave the application of the principles on which his method depends to the intelligence of the manufacturers themselves.

In the preparation of beet-root sugar bisulphite of lime is quite as useful as in the extraction of cane-sugar; the way in which it is to be employed in the former is fully explained in the second article published in the 507th number of the *Courier de l'Europe*, to which we must refer those among our readers who desire any further information on the subject.

5. *Anniversary of the Royal Society of London.*—On St. Andrew's Day, 30th of November, the anniversary of this Society was held at Somerset House, the Earl of Rosse, President, in the chair. An able review of the progress of astronomical and physical science was delivered by the President, the obituaries of deceased fellows read, and the three honorary rewards in the gift of the Society were publicly bestowed. The Copley Medal to Sir Roderick Murchison for his masterly works on the Silurian System and Geology of Russia; one of the Royal Medals to Col. Sabine for his valuable magnetic observations; and the other Royal Medal to Dr. Mantell, for the important services rendered to geology by his various memoirs on the Iguanodon, &c., published in the Philosophical Transactions. We have great pleasure in observing that the two Vice Presidents of the Geological Society of London, received this most honorable reward the scientific Englishman can attain, at the same time; the one for his eminence as a Geologist, and the other as a Paleontologist: both Sir G. Murchison and Dr. Mantell were also elected into the new council of the Royal Society.

6. *Ray Society*, (Athen., No. 1142.)—The Sixth Anniversary of the Ray Society was held during the meeting of the British Association, at Birmingham. From the Report of the Council it appears that the Society keeps up the number of its members. During the past year this body published a fourth part of the great work of Alder and Hancock on the Nudibranchiate Mollusca, a volume of the Correspondence of Ray, and the first volume of a complete Zoological Bibliography, by Prof. Agassiz, assisted by Mr. H. E. Strickland. For the present year a volume of Reports and Papers on Botany is already published; and two illustrated works are in a state of great forwardness: the first, a Monograph on the British Entomostracous Crustacea, by Dr. Baird of the British Museum; the second, a Memoir on the British Freshwater Zoophytes, by Prof. Allman, of Dublin.

7. *Zoological Gardens, London*, (Athen.)—The total number of animals in the Zoological Gardens is 1352, of which 354 are mammalia, 853 birds, 145 reptiles. Sixty-five species were added during the past year. The total number of visitors for the year 1849 was 168,895, which is 25,265 more than in 1848, and 75,349 above the number in 1847.

8. *Mastodon angustidens.*—A nearly perfect specimen of this mastodon has been found about six leagues from Turin, in a bed of plastic clay containing fresh water shells and covered with sand. The skeleton is preserved in the Royal Museum at Turin and is one of the most perfect hitherto found in Europe.

9. *Development of Electricity by Muscular Contraction.*—The experiments of Du Bois Reymond have been repeated by Prof. Buff of Giessen with apparent success. In one trial, sixteen persons held each

other by moistened hands, and on all contracting simultaneously by the right, or the left arm, they formed as it were, a circuit of increased electromotive power. The effect on the needle was evident, and it was opposite according as the right or left arm was contracted: the direction of the current was always from the hand to the shoulder. It is essential that the muscular contraction should be increased or at least continued until the needle begins to return and then suddenly discontinued. The greatest deflection amounted to ten or twelve degrees.

10. *Influence of boracic acid in Vitrification*, (Comptes Rend., Oct. 22, 1849; Phil. Mag., Dec., 1849.)—MM. Maes and Clemandot have studied the effect of boracic acid in the manufacture of glass, and conclude that before long this material will be considered essential to the best glass for optical purposes. They have formed the glasses consisting of the borosilicate of potash and lime—of potash and zinc—of potash and barytes—of soda and zinc. These borosilicates are remarkable for their transparency and hardness.

OBITUARY.

11. Dr. Martin Gay, (in a letter to the Senior editor from Dr. C. T. Jackson, dated Boston, January 17th, 1850.)—It becomes my painful duty to announce to you the death of our much beloved friend, Dr. Martin Gay, who died of peritonitis on the 12th inst., at 1½ o'clock, P.M.

Dr. Gay was the eldest son of the late Hon. Ebenezer Gay, and was born in Boston on the 16th February, 1803, and at the time of his decease his age was 46 years, 10 months and 26 days.

He was educated at Harvard University. On leaving that Institution, he prosecuted his professional studies under the instruction of Dr. George C. Shattuck, an eminent practitioner in this city, and was graduated Doctor in Medicine on the 25th of August, 1826.

He was elected a Fellow of the American Academy of Arts and Sciences on the 14th of November, 1838.

In August, 1841, he received the degree of Master of Arts from Harvard University.

He was one of the original members of the Boston Society of Natural History, and filled successively the offices of Curator in Mineralogy and of Recording Secretary for several years.

In October, 1844, he was married to Miss Eleanor Allen, daughter of Frederic Allen, Esq., of Gardiner, Maine.

Dr. Gay was a successful practitioner of medicine, and occupied his leisure hours in chemical researches, and in the cultivation of the science of mineralogy. In analytic chemistry, especially in the department of medico-legal enquiry, he was regarded as one of our most faithful and accurate chemists.

His testimony in cases involving medico-chemical questions, was most implicitly relied upon in our courts of justice, and he was remarkable for the perspicuity and fairness of his evidence.

Devoted to the cultivation of science, he lost no opportunity for improving himself, and during his travels in Europe in 1842, he collected much valuable information and made the acquaintance of many distinguished chemists, mineralogists and geologists in France, Germany and Italy.

His moral character was held in the highest estimation by all who knew him. It was marked by integrity, kindness, courtesy, and a high sense of truth and honor.

His admiration of the true and beautiful in science, literature and the fine arts, was a distinguishing feature of his cultivated mind. Although naturally very amiable and mild in his manners, he was remarkable for his moral courage, and base or mean actions never failed to excite his indignation. Independent in his character, and relying on his own acute perceptions of truth, he cared little for the authority of others, when he was satisfied that they were in error.

As a physician he was beloved and respected by all who knew him, and his nice sense of professional honor, and his sincere regard for the rights of others, was well known and appreciated among his medical brethren. Our scientific friend is removed from among us, but he has left us a bright example in his pure and unspotted life, and in his noble devotion to the cause of science and of truth.

V. BIBLIOGRAPHY.

1. *Report of a Geological Reconnoissance of the Chippewa Land District of Wisconsin, and, incidentally, of a portion of the Kickapoo Country, and of a part of Iowa and of the Minesota Territory,* made under instructions from the United States Treasury Department; by DAVID DALE OWEN, M.D., U. S. Geologist for Wisconsin. 134 pp. 8vo, with numerous lithographs and geological sections.—This valuable document is occupied by the Reports of Dr. Owen, and his assistant, Mr. J. G. Norwood. The two regions particularly examined were first, along the Mississippi; and second, the interior and Lake Superior districts. The results, though only preliminary to a complete survey, are of great interest, both geologically and economically, as is true of whatever comes from the distinguished geologist whose name appears at the head of the survey. The illustrations of rock scenery, from Dr. Owen's sketches, are full of life and character. We cite the following facts.

The Kickapoo mines are situated between the Mississippi and Kickapoo and are connected with a magnesian limestone of the same character with that of the Mineral Point district. The ore is a peculiar one. It is of a light green color, waxy lustre and fracture, and very brittle, and is disseminated through ferruginous earthy matter composed chiefly of brown oxyd of iron. An analysis afforded protoxyd of copper 25·0, insoluble silicates with a trace of oxyd of iron 8·3, carbonic acid 5·0, water 11·2, peroxyd of iron 48·7, protoxyd of manganese 0·2, alumina 0·6, carbonate of lime 0·8=99·8. The position of the ore and rock indicates that it was once enclosed in a fissure in the magnesian limestone; but by decaying and denuding influences, the wall on one side has been removed. The ore is easily reduced and yields about twenty per cent. of copper.

With regard to the physical features of the country of the Lower Magnesian Limestone, Dr. Owen observes:—"The constant theme of remark, whilst travelling in the region of the upper Mississippi occupied by the lower magnesian limestone, was the picturesque character of the landscape, and especially the striking similarity which the rock exposure presents to that of ruined structures.

"The scenery on the Rhine, with its castellated heights, has been the frequent theme of remark and admiration by European travellers. Yet it is doubtful whether it is not equalled in actual beauty of landscape, by that of some of the streams that water this region of the far west. It is certain that though the rock formations essentially differ, nature has here fashioned, on an extensive scale, and in advance of all civilization, remarkable and curious counterparts to the artificial landscape which has given celebrity to that part of the European continent.

"The features of the scenery are not, indeed, of the loftiest and most impressive character. There are no elevated peaks, rising in majestic grandeur; no mountain torrents, shrouded in foam and chafing in their rocky channels; no deep and narrow valleys hemmed in on every side and forming, as it were, a little world of their own; no narrow and precipitous passes, winding through circuitous defiles; no cavernous gorges giving exit to pent up waters; no contorted and twisted strata, affording evidence of gigantic uplift and violent throes. But the features of the scene, though less grand and bold than those of mountainous regions, are yet impressive and strongly marked. We find the luxuriant sward, clothing the hill slope even down to the water's edge. We have the steep cliff shooting up through it, in mural escarpments. We have the stream, clear as crystal, now quiet and smooth and glassy, then ruffled by a temporary rapid, or when a terrace of rock abruptly crosses it, broken up into a small romantic cascade. We have clumps of trees, disposed with an effect that might baffle the landscape gardener, now crowning the grassy height, now dotting the green slope with partial and isolated shade. From the hill tops the intervening valleys wear the aspect of cultivated meadows and rich pasture grounds, irrigated by frequent rivulets that wend their way through fields of wild hay, fringed with flourishing willows. Here and there occupying its nook, on the bank of the stream, at some favorable spot, occurs the solitary wigwam, with its scanty appurtenances. On the summit levels spreads the wide prairie, decked with flowers of the gayest hue; its long undulating waves stretching away till sky and meadow mingle in the distant horizon. The whole combination suggests the idea, not of an aboriginal wilderness, inhabited by savage tribes, but of a country lately under a high state of cultivation and suddenly deserted by its inhabitants; their dwellings indeed gone, but the castle-homes of their chieftains only partially destroyed, and showing, in ruins, on the rocky summits around. This latter feature especially aids the delusion; for the peculiar aspect of the exposed limestone and its manner of weathering cause it to assume a resemblance somewhat fantastic indeed, but yet wonderfully close and faithful, to the dilapidated wall, with its crowning parapet and its projecting butresses and its flanking towers, and even the lesser details that mark the fortress of olden time.

"Bold exposures of rock, with a grassy bank beneath, such as are represented by the sketches, are, for the most part, only on the south and western sides of the hills; the northern and eastern declivities are more rounded and most generally overgrown with trees and shrubbery."

2. *The races of Man and their Geographical Distribution;* by Charles Pickering, M.D., of the Scientific Corps of the Exploring

Expedition under C. Wilkes, U.S.N., Commander; forming volume IX. of the Reports of the Expedition. 450 pp. 4to.—This volume is the result of a vast amount of research by one peculiarly well fitted for observation by his habitual accuracy and his experience as a Naturalist. Dr. Pickering, after four years exploration in the Expedition around the world, made a journey to Egypt, Persia and Hindoostan to complete his observations. The range of the work will be gathered from the subjects of the chapters which we here mention. 1. On the Races of Man; 2. Explanation of the Map, illustrating their distribution; 3. the Races of America; 4. the Malayan Race, including the Polynesian; 5. the Australian Race; 6. the Papuan, including the Feejees; 7. the Negrillo Race of the East Indies, New Hebrides, &c.; 8. the Telingan or Indian Race in Hindoostan, &c.; 9. the Negro Race, Africa; 10. the Ethiopian Race, Nubia, &c.; 11. the Hottentot Race; 12. the Abyssinian Race; 13. the White or Arabian Race; 14. the Associations of the Races and Numerical Proportions; 15. Relations between the Races; 16. The Geographical Progress of Knowledge; 17, 18. Migrations by sea and by land; 19. Origin of Agriculture; 20. Zoological deductions; 21 to 24. Introduced Animals and Plants of America—of the Islands of the Pacific—of Equatorial Africa—of Southern Arabia; 25. Antiquities and introduced Plants and Animals of Hindoostan; 26. Introduced Plants and Animals of Egypt, enumerated in chronological order.—Dr. Pickering's extensive knowledge of botany and zoology has enabled him to collect together a vast amount of information in these closing chapters, and to correct or elucidate the meaning of many of the names of plants and animals in Greek and Arabic, which are often mistranslated in our Lexicons, and which in some cases were misunderstood by the translators of the Bible.

3. *Elements of Natural Philosophy*, designed as a Text-Book for Academies, High Schools and Colleges; by ALONZO GRAY, A.M., Prof. Chem. and Nat. Phil. in the Brooklyn Female Academy, and Author of Elements of Chemistry, &c. 406 pp. 12mo, with 360 wood-cuts. New York. Harper & Brothers. 1850.—The author of the work before us has prepared a very convenient and well arranged work on the different departments of Natural Philosophy. He has condensed a widely extended subject into a small compass well fitted for the student. The work commences with the general properties of matter, and the forces which govern it, and then passes to the subject of motion, the mechanical powers, hydrodynamics, pneumatics including meteorology, sound, heat, steam, electricity, galvanism, magnetism and light or optics. Galvanism is here in its right place with other branches of physics.

4. *Sailing Directions;* by Lieut. M. F. MAURY, U.S.N., National Observatory, Washington, published by authority of Commodore Lewis Warrington, Chief of the Bureau of Ordnance and Hydrography. 20 pp. 4to. Washington. 1850.—Lieut. Maury in this paper has made out a series of directions for navigating the different oceans, especially with regard to selecting the route for sailing. There are several tables containing specific information on this point for different latitudes and longitudes. These tables relate particularly to the route from New York to clear St. Roque, Brazil, and also to the routes to Europe and the return.

5. *The Plough, the Loom and the Anvil;* T. S. Skinner, Editor.—This monthly periodical of practical and economical science, comes to us full of information and ably digested articles, original and selected. The first article in the January number before us, treats of the Harmony of Interests, Agricultural, Manufacturing and Commercial, in the United States, and is by H. C. Carey. It surveys the products of the country in these different departments with much valuable statistical detail, stating in tables the productions for successive years, of iron, coal, lead, woollens, &c., &c., and also illustrating the same by means of diagrams; and exhibiting a wide comprehension of the interests of the country in its various economical departments. Cotton Mills by Cotton Growers, Irish Peat, Charcoal and Sanitary Reform, are the subjects of other papers; and besides these, there are many shorter articles of practical value to the farmer and mechanic.

6. *Iconographic Encyclopædia of Science, Literature and Art*; by G. Heck, translated and edited by Prof. Spencer F. Baird.—Rudolph Garrigue, New York.—The plates of Part V. of this Encyclopædia, the last which has reached us, are devoted to illustrations of the departments of Reptiles and Birds. The sketches are forcible and characteristic, illustrating the habits and haunts of the animals as well as their forms.

7. *Foster's Geological Chart.*—It has been represented to us that the Geological Chart noticed in our last number had not been finished,—although the copy received was varnished and mounted in the usual finished style; and that therefore it was not a fair subject for criticism. A revised copy, as now ready for publication, having the signatures of Professors E. Emmons and W. W. Mather has been shown us by the author. It has undergone important changes, though not all we should wish to see made. Figures of American fossils have been substituted to a considerable extent for foreign; misplaced fossils in the formations and the succession of rocks have been set right, and the names of the New York series of Rocks have been introduced,—together with the *Taconic formation* of Professor Emmons.

8. *The Annual of Scientific Discovery*, or Year Book of Facts in Science and Art, edited by David A. Wells, of the Lawrence Scientific School, Cambridge, and George Bliss, Jr.—We would call attention to the notice of this work on our advertising sheet. It is to be issued in the month of March, in a duodecimo volume of 350 pages. The Prospectus which has been sent us, bears high testimonials from Professors Agassiz, Horsford, Wyman and Gould, of Cambridge.

Agassiz's Lake Superior, is also soon to be issued, from the same house in Boston, and we doubt not it will be sought for with avidity. The high importance of the work, the peculiar interest of the region, and the eminent attainments of the author, must give these results of Prof. Agassiz and his able coadjutors a wide distribution over both this country and Europe.

9. *The Astronomical Journal*, Cambridge.—Nos. 3 and 4, for January 7, and February 2, 1850, contain—Observations of Metis, by *Mr. James Ferguson.*—Observations of Metis, made at the Hamburg Observatory, by *Prof. Charles Rümker.*—On the Phenomena attending the disappearance of the Rings of Saturn, by *G. P. Bond.*—On the

Heliocentric place of Neptune, by *George W. Coaklay.*—Note on the parallelogram of Forces, by *Prof. Peirce.*—On the orbit of the Great Comet of 1843, by *Prof. J. S. Hubbard*, (continued).—Development of the Perturbative Function of Planetary Motion, by *Prof. B. Peirce.*

10. *Journal of the Academy of Natural Sciences of Philadelphia.*—Part IV, which is just issued, completes the 1st volume of the new series in 4to, (pp. 356.) We give here the contents of the volume.

Part I. Dec. 1847.—1. ROBERT W. GIBBES, M.D., on the fossil genus Basilosaurus, Harlan, (Zeuglodon, Owen,) with a notice of specimens from the Eocene Green Sand of South Carolina.

2. M. TUOMEY, State Geologist of South Carolina.—Notice of the discovery of a Cranium of the Zeuglodon, (Basilosaurus.)

3. RICHARD OWEN, Esq., F R.S.—Observations on certain fossil bones from the collection of the Academy of Natural Sciences of Philadelphia.

4. JOHN CASSIN.—Description of a new rapacious Bird in the Museum of the Academy of Natural Sciences of Philadelphia.

5. WILLIAM GAMBEL.—Remarks on the Birds observed in Upper California, with descriptions of New Species.

6. JOSEPH LEIDY, M.D.—(1.) History and Anatomy of the Hemipterous Genus Belostoma. (2.) Miscellanea Zoologica.

7. J. L. LE CONTE, M.D.—Fragmenta Entomologica.

Part II. August, 1848.—8. S. S. HALDEMAN.—Descriptions of North American Coleoptera, chiefly in the Cabinet of J. L. Le Conte, M.D., with reference to described species.

9. T. A. CONRAD.—Observations on the Eocene formation, and descriptions of one hundred and five new fossils of that period, from the vicinity of Vicksburg, Mississippi; with an Appendix.

10. JOHN CASSIN.—Description of a new *Buceros*, and a notice of the *Buceros elatus*, (Temm.,) both of which are in the collection of the Academy of Natural Sciences of Philadelphia.

11. JOHN CASSIN.—Descriptions of three new species of the genus *Icterus*, (Briss.,) specimens of which are in the Museum of the Academy of Natural Sciences of Philadelphia.

12. ROBERT W. GIBBES, M.D.—Monograph of the Fossil Squalidæ of the United States.

13. THOMAS NUTTAL.—Descriptions of Plants collected by William Gambel, M.D., in the Rocky Mountains and Upper California.

Part III. August, 1849. 14. ROBERT W. GIBBES.—Monograph of the Fossil Squalidæ of the United States.

15. T. A. CONRAD.—Descriptions of New Fossil and Recent Shells of the United States.

16. T. A. CONRAD.—Notes on Shells, with descriptions of new Genera and Species.

17. WILLIAM GAMBEL, M.D.—Remarks on the Birds of Upper California, with descriptions of new species.

18. SAMUEL GEORGE MORTON, M.D.—Additional Observations on a new living species of Hippopotamus.

19. JOHN CASSIN.—Descriptions of new species of Birds of the genera *Vidua*, Cuvier, *Euplectes*, Swainson, and *Pyrenestes*, Swainson,

specimens of which are in the collection of the Academy of Natural Sciences of Philadelphia.

20. S. S. HALDEMAN.—Cryptocephalinarum Boreali-americæ diagnoses cum speciebus novis musci leconliani.

21. CHARLES D. MEIGS, M.D.—Observations on the Reproductive Organs, and on the Fœtus of the Delphinus Nesarnak.

Part IV. January, 1850. 22. T. A. CONRAD.—Description of new Fresh Water and Marine Shells.

23. SPENCER F. BAIRD, Carlisle, Pa.—Revision of the North American Tailed-Batrachia, with descriptions of new genera and species.

24. JOHN CASSIN.—Descriptions of new species of the Genera *Micrastur*, G. R. Gray, *Tanagra*, Linn., and *Sycobius*, Vieill.

25. ROBERT W. GIBBES, M.D.—New species of Myliobates from the Eocene of South Carolina, with other genera not heretofore observed in the United States.

26. JOSEPH LEIDY, M.D.—Descriptions of two species of Distoma, with the partial history of one of them.

27. JOHN L. LE CONTE, M.D.—An attempt to classify the Longicorn Coleoptera of the part of America north of Mexico.

11. *Memoirs of the American Academy of Arts and Sciences*, New Series, vol iv, Part I, 220 pp., 4to, with twenty-six plates. Cambridge. 1849. The following are the titles of the papers herein contained.

1. ASA GRAY, M.D.—Plantæ Fendlerianæ Novi-Mexicanæ: An Account of a Collection of plants made chiefly in the Vicinity of Santa Fé, New Mexico, by AUGUSTUS FENDLER; with Descriptions of the New Species, &c.

2. CHARLES HENRY DAVIS, A.M., U.S.N.—Upon the Geological Action of the Tidal and other Currents of the Ocean. (With three Plates.)

3. S. S. HALDEMAN, A.M.—History and Transformations of Corydalus cornutus. (With a Plate.)

4. JOSEPH LEIDY, M.D.—Internal Anatomy of Corydalus cornutus, in its three stages of existence. (With two Plates.)

5. WILLIAM S. SULLIVANT, A.M.—Contributions to the Bryology and Hepaticology of North America. Part II. (With five Plates.)

6. WILLIAM CRANCH BOND, A.M.—Description of the Observatory at Cambridge, Massachusetts. (With six Plates.)

7. GEORGE P. BOND.—On some Applications of the Method of Mechanical Quadratures.

8. JAMES DEANE, M.D.—Illustrations of Fossil Footprints of the Valley of the Connecticut. (With nine Plates.)

The plates are of the first order of excellence. Those illustrating the transformations and anatomy of the Corydalus cornutus are of unrivalled delicacy, and the dissections by Mr. Leidy, who is distinguished for his skill in microscopic anatomy, are no where surpassed. The plates of fossil footprints by Mr. Deane are in a good style of lithography, and accurately represent the character of the impressions. The author figures some new species but without giving names. The article is an interesting sequel, if we may so consider it, to Pres. Hitchcock's elaborate paper in the preceding volume.

12. *Boston Journal of Natural History*, Vol. VI, No. 1.—The following is a list of the memoirs in this number:

I. E. DESOR. Embryology of Nemertes and Embryonic Development of Polynöe.

II. N. M. HENTZ. Araneides of the United States, with figures.

III. J. D. WHITNEY. Chemical Examination of some Minerals.

IV. J. D. WHITNEY. Examination of the Arkansite, Schorlomite and Ozarkite of Shepard.

V. S. L. BIGELOW, M.D. Habits of Salmo fontinalis.

VI. W. O. AYRES. Description of a new genus of Fishes, Malacosteus.

VII. J. L. LE CONTE, M.D. On the Pselaphidæ of the United States.

VIII. SAMUEL KNEELAND, Jr. Dissection of Crocodilus lucius.

IX. T. S. HUNT. Chemical examination of the new mineral Algerite, with a description by F. Alger.

X. F. ALGER. Examination of a Sapphire from Cherokee Co., Georgia.

XI. JEFFRIES WYMAN, M.D. On the Cancellated Structure of the Bones of the Human Body.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.—Occultations visible in the United States during the year 1850. Computed by John Downes. 26 pp. 4to. *Washington*, 1849.

PROF. BELL: A History of British Reptiles, 2nd edition, with 50 wood engravings. 8vo. *London*, 1849. 12*s.*

L. L. BOSCAWEN IBBETSON: Notes on the Geology and Chemical Composition of the various strata of the Isle of Wight, with a map in relief colored geologically. 8vo. *London*, 1849. 7*s.* 6*d.*

PROF. OWEN: On Parthenogenesis, or the Successive Production of Procreating Individuals from a single Ovum. 8vo. *London*, 1849. 5*s.*

A. E. KNOX: Ornithological Rambles in Sussex, with 4 lithographs. Post 8vo. *London*, 1849. 7*s.* 6*d.*

E. FORBES and S. HANLEY: A History of British Mollusca; parts 13 to 24. 8vo. *London.* 2*s.* 6*d.* plain; royal 8vo, colored, 5*s.*

H. DOUBLEDAY: A Synonymic list of British Lepidoptera. 8vo. *London*, 1849. 2*s.*

QUARTERLY JOURNAL OF THE GEOLOGICAL SOCIETY.—No. 19 of this Journal is occupied with a memoir by Murchison on the Alps, Appennines and Carpathians, 160 pages. No 20, contains a memoir on the Eocene of Hampshire by Mr. Moore; on a Siliceous Zoophyte by Bowerbank; on Platysomus by P. Egerton; on Neritoma by Mr. Morris: on the Gypsum of Plaister Cove by Mr. Dawson; on Footprints in Sand by Lyell; on the Crag at Chillesford, by Mr. Prestwich; on Erect Sigillariæ, with drawings of the roots by Mr. Brown; on the Geology of Asia Minor by Mr. Hamilton; on Tylostoma by Mr. Sharpe; on Fossil Reptiles of New Jersey by Prof. Owen, with a translation of Bronn's Palæontological Statics.

TRANSACTIONS OF THE ROYAL SOCIETY OF EDINBURGH, vol. xvi, Part V, 1848–1849. —Art. 34. Biographical Notice of the late Thomas Chalmers; *E. B. Ramsay.*—35. Theory of rolling Curves; *J. C. Maxwell.*—36. An account of Carnot's Theory of the Motive Power of Heat, with Numerical Results deduced from Regnault's Experiments on Steam; *W. Thomson.*—37. On the Effects of Pressure in lowering the freezing point of Water; *J. Thomson.*—38. On the gradual production of Luminous impressions on the Eye and other Phenomena of Vision; *W. Swan.*

MAKERSTOUN MAGNETICAL AND METEOROLOGICAL OBSERVATIONS FOR 1845 and 1846. 420 and lxxii pages, 4to, with numerous Charts; forming volume xix, part 1, of the Transactions of the Royal Society of Edinburgh. Edited by John Allan Brown, Esq., director of the Observatory of Edinburgh. 1849.

ERRATUM.

In the January No., page 4, line 11 from bottom, for 'zinc,' read 'wire.'

The next No. of this Journal will be published on the first of May.

CONTENTS.

SCIENTIFIC INTELLIGENCE.

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April, 1849.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XXXI.—*A brief Memoir of the late Walter Folger, of Nantucket;* by WILLIAM MITCHELL.

AMONG men of genius, those who have shared largely of nature's gifts, and manifested a high order of intellect in reference to those inquiries which are hidden from ordinary minds, the late Walter Folger of Nantucket, is entitled to a prominent rank. He was born in the 6th month, (June,) 1765. His father, also named Walter, was among the wealthier class of that day, and one of the first who engaged in the manufacture of sperm candles, since become so extensively the business of the place. He was descended from Peter Folger, one of the earlier settlers of the island, the maternal grandfather of Franklin, and the poet whose memory the Doctor so fondly cherished. Walter, senior, was much distinguished in early life for mechanical and mathematical talent, and at a later period when withdrawn from business, though eclipsed in every department by his son, he was sure to be found wherever any mechanical operation was in progress, that involved novelty of art or excellence of execution. On his mother's side the subject of this memoir was descended directly from Mary Starbuck, a matron of great notoriety in the history of the island; the first convert to the principles of the society of Friends, and the minister by whose influence so large a portion of those isolated people became members of that body of professing christians Of this distinguished lady, we find an account in the journal of a traveling minister of the society, who visited the island in the early part of the last century. "There was," says he, "on the island, one Nathaniel Starbuck, whose wife was a wise discreet woman, well read in scripture and not attached to any sect; but in great reputation throughout the island for knowledge in matters of religion, and an oracle among them on that account, insomuch that they would not do any thing without her advice and consent therein."

Although his family were numerous, the means of the father were quite adequate to furnish his son with liberal instruction; but education in that day, was but lightly esteemed by the islanders, a state of things forming a striking contrast with the agreeable circumstances of the present day, and his youth, with the exception of a few weeks occasionally spent in very indifferent schools, mostly taught by females, was suffered to pass away without that instruction which, with such materials to work upon, would have been of so much value to science.

In these schools he soon comprehended all that was taught, and spent most of his time in alternately assisting the pupils and instructing the teachers. The first study, in those branches in which he became distinguished, to which he directed his attention, was that of land surveying, in which, without the least personal assistance, he became exceedingly skillful. In the winter of 1782–3, he attended an evening school, in which he studied navigation and gauging, and readily acquainted himself with these branches. Nothing of a mathematical character seemed ever to present any difficulty to his mind. He mastered Algebra and Fluxions, without assistance, and while in his teens he read Euclid, as he would read a narrative, no problem arresting his progress; and yet so little did he know of language, or of any thing appertaining to it, that he had reached the years of manhood, as he often confessed, before he knew the definition of the word *grammar*. He afterwards accidentally met with an old volume of La Lande's large astronomical work, in the hands of a castaway sailor and purchased it, and to enable him to read it, he studied the French language, and with it the English, and was therefore able to read the French authors with ease. From this time he applied himself with great assiduity to the principal departments of physical science. As a practical mechanic and optician, he had few superiors, and in his own town certainly no equal. Every species of machinery on which he placed his eye, he seemed at once to comprehend. During most of the year 1783, he was afflicted with ill health, and much of the time confined to his bed begging constantly for books, which seemed the only needful opiate. There were few books at hand adapted to his taste; but his father finally succeeded in obtaining for him a work on Navigation, to which for the first time, was appended Dr. Maskelyne's method of obtaining the longitude at sea by means of lunar distances. This delighted him, and at the age of eighteen, prostrated with sickness, he familiarized himself with the problem, and the engagement so diverted his mind from his infirmities that he speedily regained his strength. He immediately applied all his influence to the encouragement of the use of this method among his fellow-townsmen, then universally engaged in the prosecution of whaling voyages. To numbers he gave personal instruction, and the first American ship-master who determined his longitude by lunar observations, is said to have been one of his pupils.

Soon after this period, he busied his mind in designing a clock, which, while answering the ordinary purposes of time-keeping, should exhibit various phenomena connected with the solar and lunar motions. Having completed the plan, he submitted it to his father, for whose judgment in mechanics he had the highest regard, and receiving his sanction, he commenced the work at the age of twenty-two, and devoting only his leisure amid other engagements, finished it in the course of the second year. This clock now stands in the family parlor a monument of mechanical ingenuity;—brown with age and now somewhat antiquated in its appearance, it is still a wonder. Nothing but the glass which covers its face, owes its construction to another hand, and its mechanical execution would be creditable to a professed workman. But its chief excellence is in the phenomena which it exhibits. The diurnal motion of the sun is represented by a circular metallic plate, so adjusted that it is seen through a slit in the dial plate, at a greater or less meridian altitude, as the declination changes; rising and setting as in nature, and changing the time in conformity to the latitude, change of declination and equation on each day, giving also through the entire day, the time of his rising and setting and place in the ecliptic. The moon is represented by a spherule exhibited to the eye in the same manner; but by having one hemisphere colored, and by a process much more complicated, shows with great faithfulness, not only the rising, setting and southing of the moon, with the time of full sea at Nantucket; but also the chief phenomena dependent on the obliquity of the moon's path to the ecliptic, and the revolution of her nodes, such as the hunter's and harvest moon, &c. Some of these involve a motion of the works through a period of eighteen years and two hundred and twenty-five days, and the wheel by which the date of the year is advertised is so constructed, that its revolution is only completed in one hundred years, though necessarily suspended ten years of that period.

For the year 1790, he made the necessary calculations and published an almanac; he had prepared also the ephemeris of 1791, with some very curious calculations on the annular eclipse of that year, the formation of the ring occurring precisely at sunrise; but these he never published.

In concert with several observers on the continent, among whom were Bowditch and Jefferson, he made special preparation, to observe the beginning and end of the solar eclipse of 1806, total in Boston and nearly so at Nantucket. The day was cloudless and the results satisfactory.

Probably the most valuable observations that he ever made were those on the comet of 1807—the first comet he had ever seen. On the first appearance of this body, he commenced taking a series of angular distances to the various fixed stars near which it passed. Then angles were taken with a sextant, in the use of which he was very skillful. Having been in the habit for many years of adjusting this instrument for the seamen of his native town, no one could use it more dexterously. His application to this work, as to every undertaking, was unremitting; he followed it through the whole period of its visibility, and in the latter part of autumn, while the comet was circumpolar, by obtaining angles through the whole night above and below the pole, he was able to detect its parallax, as well as its motion and position.

These observations were never published, and it now may be well doubted whether a vestige of his notes remain, the labor having been performed chiefly for his own gratification. The great comet of 1811 did not escape his attention, and his observations met with a better fate. He was induced to publish them in detail, and they were so numerous that the angles alone, when reduced, occupied an entire page of a Boston newspaper. With his expertness in the use of the sextant, and the sharp nucleus of that beautiful comet, his results were exceedingly accurate, and were so esteemed by Dr. Bowditch who used them in calculating its elements.

In earlier life he had constructed a number of small telescopes; but at the age of fifty-four he undertook the construction of a reflector of considerable size, and finished it in the succeeding year. This telescope is a Gregorian, the larger speculum is five inches, and the smaller, one inch in diameter. Its focal length is five feet, with one eye-piece magnifying not less than three hundred. It is not mounted equatorially, nor has it any arrangement for measures; but it is furnished with rack work for slow azimuth and altitude movement. The stand is of oak and has four legs on the plan recommended by the elder Tulley, and it is exceedingly steady—illustrating the advantage of this method for firmness no less than safety. The tube is of sheet iron and very neatly finished. The stand, which was made by his son, is the only part which was not formed by his own hands. In grinding the large speculum he dispensed entirely with the bed of hones, using the grinding powder after it was worn very fine on the pewter tool. In reference to its figure, there is doubt whether its curve is parabolic. He objected to that form and demonstrated that it is not the best except for objects whose distance is infinite. When the specula were finished, they were placed for trial in a rude tube of deal board mounted on a temporary support and directed to the planet Jupiter; and whatever may have been its subsequent performances, which were certainly no better than what might have been anticipated,—in this first trial its performance was astonishing. For light, distinctness of vision, and clearness of outline, it is scarcely surpassed by the larger and far more expensive instruments of the present day. While in this tube and with this temporary adjustment, he viewed the moon under favorable circumstances of weather, three days after the change, and detected that delicate thread of corpuscular light which was seen by Schröter in the early part of the year 1792 with a reflector of nearly the same size, and he described it almost in the words of the German astronomer, though he had never seen the paper of Schröter and knew nothing of the discovery. When the telescope was completed and mounted, his neighbors thronged his house to obtain a sight of the moon or other celestial objects, and although a severe tax upon him, he at all times gratified their wishes with the most enduring patience.

On the occasion of the return of the Encke comet in 1829, when the theory of Encke was so strikingly verified, he became interested in the subject of a resisting medium, and for his own satisfaction constructed a set of tables for the determination of the place of the comet for any period past or future within the limit of a thousand years. The labor in the construction of these tables was immense; but with his usual untiring zeal and application, he accomplished it, before the comet was beyond the reach of the telescope. The figures made in this work were so numerous that he often exhibited the sheets containing the rough computations as a curiosity. These tables he always declined publishing though often solicited to do so, and they remain to this day among the fragments of his industry.

He kept for many years a meteorological journal, using a barometer and thermometer of his own construction, both of which were remarkable for their accuracy. Indeed he was never satisfied with the use of any instruments unless he was entirely confident of their utmost accuracy, and to be certain of this, he was compelled to form them with his own hand. In the prosecution of his meteorological inquiries he convinced himself of the truth of the gyratory theory of Redfield and defended it with energy. In the more vigorous period of his life, he was a contributor to the mathematical periodicals of the day, solving the more difficult problems and proposing others. Among his correspondents in science, were Doctors Bowditch, Prince and Oliver, and President Jefferson.

Having at different periods engaged in the study of the law and acted some years as an attorney, he received the appointment of judge of the county court, and so far as a profound regard to justice is concerned, no appointment could have been more judicious. He knew nothing of dissimulation; nothing could influence him from the straightest line of uprightness. In his morals and in his dealings with men, he seemed to know nothing but the exactness of his mathematics.

He interested himself also in the politics of the day; was a member of the legislature of his native state several years during the period of the most rabid party divisions. As in science so in politics, he was a friend of Jefferson, and belonged to the old democratic party, and was twice elected to Congress. While at Washington he was not unmindful of his favorite themes, and it was proverbial among his colleagues, that in the recess of the sittings or when his seat was vacant, he could always be found at the Patent Office.

While his conscientiousness was a sufficient guaranty that no item of duty would for a moment, under any circumstances, be neglected, we are not among those who believe that the square and dividers are adapted to political purposes, however desirable a measure of the exact may be in the government of men and policy of the state; and the history of La Place is not the only comment upon this philosophy.

In the most laborious investigations, his patience was without limit. Nothing seemed capable of diverting him from his purpose, nor were the wants of his life deemed of any consequence to him when engaged in the solution of a mechanical or mathematical problem. Time was no object to him either in the prosecution of his own inquiries, or in imparting knowledge to his less learned neighbors and townsmen. But the object of this memoir is rather to commemorate the genius and acquirements of Folger than to comment upon his moral qualities. In reference to the latter, however, much might be said of his rigid virtues and abstemious habits; and although like Count Rumford he seemed at times soured and disappointed that men did not conduct themselves more in conformity with his own exact views, yet it was easy amid all this to perceive traces of good and benevolent impulses. He died on the 8th of the 9th month, 1849, at the age of 84.

Art. XXXII.—*On the Application of Photography to the Self-registration of Magnetical and Meteorological Instruments;* by Captain J. H. Lefroy, R.A., F.R.S., Director H. M. Magnetical and Meteorological Observatory at Toronto, Canada.

The successful application of the principle of self-registration by means of the action of light upon sensitive paper, or upon silvered plates, to observations in magnetism and meteorology, may be instanced as one of the most important indirect results of the great stimulus given to such inquiries by the encouragement and support extended to them for the last ten years by the governments of Great Britain, of Russia, and of various other countries, by the augmented attention of scientific bodies, and in short, by the more general recognition of their claim to an honorable place among the pursuits of science. Nor is it easy to foresee the full extent to which this principle may be destined in the end to supersede the tedious processes of personal observation, or the imperfect ones of delineation and description. In terrestrial magnetism, more particularly, it has been brought to perfection at a peculiarly appropriate time. From eight to ten years of laborious observations, have accumulated, probably, almost every thing that is essential for determining the numerical elements of its different periodical laws, and for a comparison of their operation in distant parts of the globe; but in spite of these observations, hourly, or two-hourly, by day and night, in spite of special observations upon all magnetical disturbances detected, and of term days designed to detect them but on which they seem to have made it a point not to occur; in spite of the extraordinary patience of Colonel Boileau in observing at Simla, not every hour, but every fifteen minutes, and of the perseverance with which Dr. Bache, at Philadelphia, multiplied his observations at the critical hours of each of the elements, in spite, in short, of all the efforts which have been made to obtain a full knowledge of the fluctuations of these most inconstant objects, it cannot be doubted that by far the greater, and perhaps the more instructive portion of all their changes, eluded the vigilance of the observers. In this state of things, therefore, a method which secures a minute and continuous graphical record of every change, and which can be put in practice with comparatively little difficulty or expense, is an acquisition to the science, second perhaps only to the invention by Gauss and Lloyd of the instrumental means upon which its previous rapid progress has been so largely based. The following description of the Photographical Instrument of Mr. Brooke, is based principally upon that gentleman's communication to the Royal Society in 1847,* and the advice and instructions with which the writer has been favored by him from time to time, in the establishment of one at Toronto. The various changes in detail which have been suggested by experience since the date of the paper referred to, and the possibility that the present communication may promote the establishment of other registers on this continent, will afford, it is hoped, a sufficient apology for its want of originality.

"In order to render any method of photographic registration practically useful, it is essential that the three following indications should be fulfilled.

"First, to obtain an easily managed artificial light of sufficient intensity to affect photographic paper, especially at those periods when it is of most consequence to obtain a continuous register, namely, when the position of the magnet is undergoing great and rapid variations.

"Secondly, to prepare by a ready process a photographic paper sufficiently sensitive to receive the feeble impressions of artificial light, and at the same time sufficiently durable to retain those impressions during a period of at least twelve hours, as a more frequent attention to the apparatus would probably interfere with the ordinary arrangements of an observatory.

"Thirdly, to magnify the movements of the magnet by some optical arrangement, so that the variations may be indicated with sufficient minuteness and accuracy."

The union of the three conditions is represented by a suspended magnet carrying a metallic reflector, by which a ray of light from a fixed lamp is thrown on the surface of a sheet of prepared paper, rolled round a glass cylinder, and made to revolve by a time piece.

The first of them, namely, that which relates to the light, was in the experiments of the first two or three years, attained by the employment of a camphine lamp. Mr. Brooke has recently succeeded in producing traces by the light of an oil lamp, which, although somewhat more expensive, is free from the inconveniences apt to attend the use of camphine. The camphine lamps, however, being still in use at Toronto, I proceed to describe them. The form of the lamp is square, two and a half inches on the side, one and a half deep; each contains about a quarter of a pint of the fluid, and is calculated, with *perfectly good camphine*, to burn twelve hours without requiring attention—in general it will be necessary to attend to it every six hours, by cutting off the charred end of the wick and refilling. A circular opening about 1·2 inch in diameter is made at the top near the centre of the side which is presented in front, this is stopped with a bone or

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* "Description of an apparatus for the Automatic Registration of Magnetometers and other Meteorological Instruments by Photography." By Charles Brooke, M.B., F.R.S., &c. Philos. Trans., 1847.

ivory disk, and through the latter passes, by a narrow cut, made for the purpose, the burner or support for the wick, which is flat, half an inch wide and one-eighth of an inch in thickness. Common ball cotton may be used for the wick, by drawing as many lengths through the burner as fill it closely, but not tightly. A movable ring or collar with a set screw, allows the burner to be fixed at any required height, while, the stopper being movable, it can also be turned to form any required angle with the face of the lamp. Let us then suppose the lamp to be placed behind a screen containing a narrow vertical slit through which the light is to pass, and to slide in a groove so as to be always presented in precisely the same position; let us suppose also the screen in question to be fixed to the stand which supports the lamp. To begin, then, with the regulation of the light, the burner is first to be fixed at such a height that the top of the wick shall be exactly level with the bottom of the slit; it is then to be turned in azimuth so as to be presented edgewise at an angle of about 80° with the screen, or at such an angle as to give a cone of rays very slightly wider than the mirror. The support of the chimney of the lamp is then to be applied, and its height regulated so that the diaphragm by which the combustion is promoted, shall be about 0·10 inch below the top of the wick. Lastly, the chimney is added to the support, and the adjustments of the lamp are completed by applying the short cylindrical shade which fits under the legs of the chimney, and prevents all lateral diffusion of the light. The employment of camphine, although desirable on grounds of economy, as well as for the brilliancy and whiteness of its light, is attended with serious inconveniences. The fluid deteriorates very rapidly at summer temperatures 'by the absorption of oxygen, which converts a portion of the camphine into resin, which is held in solution in the remainder, and is deposited on the wick,' in fact it becomes perfectly useless; unless, therefore,

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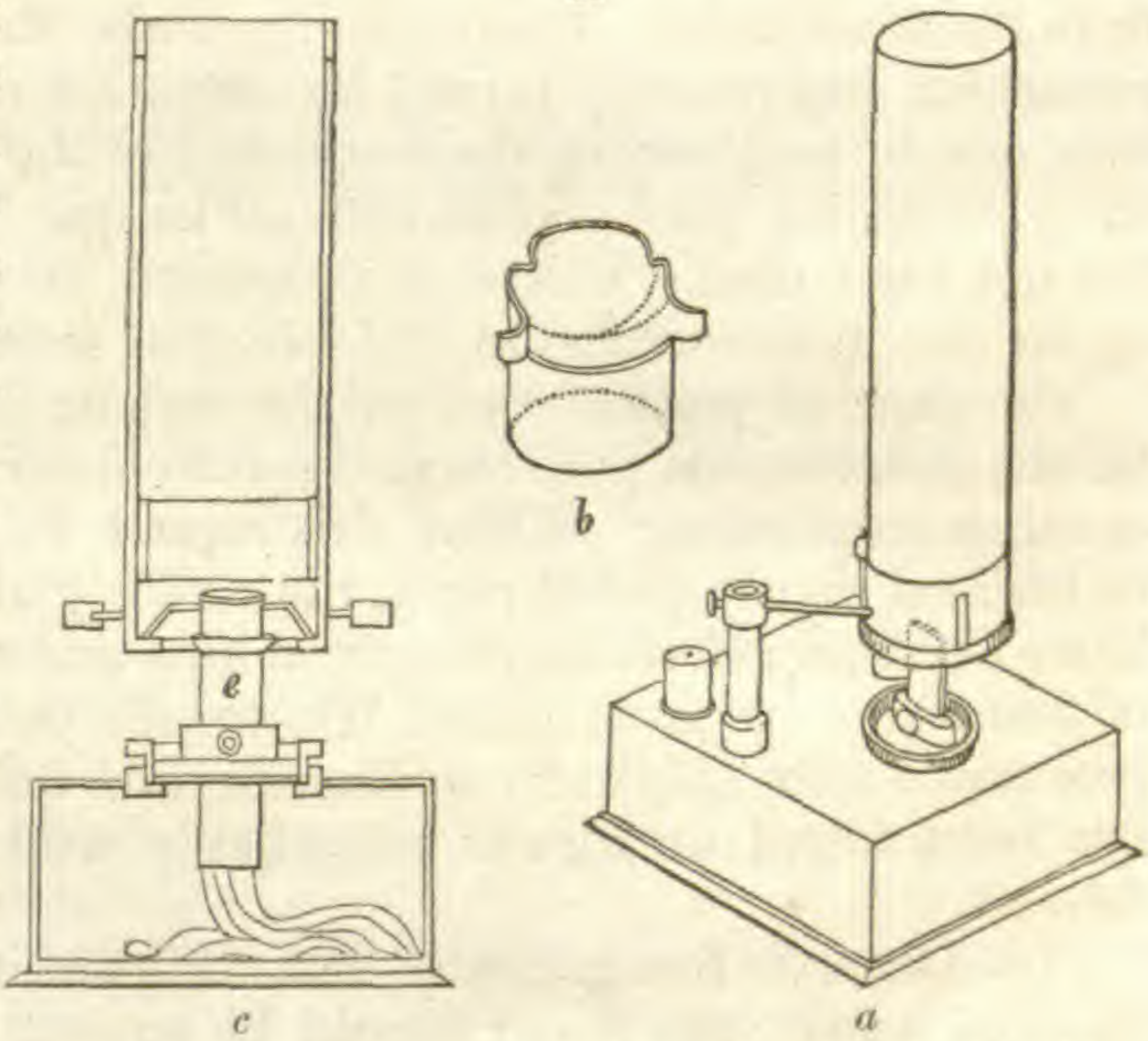

a. Lamps and chimney.—*b.* Ring placed under the chimney to cut off strong light.—*c.* Section of lamps, shewing the burner (*e*) and the diaphragm in the chimney.

the position of the observer enables him to procure constantly, fresh supplies of newly distilled fluid, he must expect trouble from this source. It has more than once happened that the resin about the wick and surface of the lamp has conducted the flame to the whole body of the camphine, which then burns with violence, but this ought not to occur if the lamp is *kept clean;* a more common inconvenience is its smoking, which occurs when the wick is too long, or the burner too high or too low relatively to the fixed diaphragm; great nicety is required in these points; but with bad camphine the utmost care can scarcely give security from the annoyance. Upon these grounds, Mr. Brooke, as already remarked, has recently turned his attention to devising a substitute, and by heightening the sensibility of the paper, has succeeded in producing good results with oil lamps. Gas, it is believed, has not been tried; where at command, it will probably prove by far the most convenient and effectual source of light.

The paper at present used for the register is prepared expressly for the purpose, the pulp being carefully freed from acid, alkaline, or saline substances. Where this cannot be procured, it should be the best highly glazed paper, not recently made, of the ordinary letter size before doubling, free from lime and other impurities, and of fine fibre. A paper called Whatman's yellow wove folio post procurable from importers in Canada, and bearing the date 1842, has been found to answer remarkably well. It is prepared as follows.

(1.) Dissolve five grains of fine isinglass in one fluid ounce of *distilled* water; the water should be poured boiling on the isinglass, and then set before the fire, and stirred occasionally until the latter is dissolved; perhaps this will require ten or fifteen minutes. As a portion is lost by evaporation, and afterwards in filtering, it is convenient to increase the quantity of both by one half, that is, to take an ounce and a half of water, and seven or eight grains of isinglass: while this is dissolving, weigh out twelve grains of the bromid and eight of the iodid of potassium, put both salts into a deep glass, such as a large wine glass. Extreme nicety in the quantities is not required, the effects having been produced with proportions varying from ten to sixteen grains of the bromid, and from two to eight grains of the iodid. The isinglass being sufficiently dissolved, filter one fluid ounce in quantity on the salts, through white blotting paper or filtering paper. The salts may be stirred with a glass stick, and the solution then set aside until cold.

The paper for a register of one element is cut lengthwise into slips of half the width of the sheet, each being about fifteen inches long, by four and three-quarters wide: if two elements are registered together, the undivided sheet is used. Having marked one side, for distinction secure the paper, with the unmarked side upwards, by a pin at each corner, to a clear pine board, rather larger than itself, and with a soft wide camel's hair brush kept exclusively for this purpose, apply the above solution uniformly and somewhat sparingly to its surface, taking care not to leave on it enough to run when the board is held to the fire, in which case yellow stains will be produced in consequence of a determination of the sulphuret of silver to parts which were too much wetted. Hold the paper on the board promptly to the fire so as to dry the solution uniformly and rapidly, and leave the salts very much on the surface; care must be taken not to scorch the paper. In brushing the paper, in this, as in all subsequent processes, it is well to take pains not to allow any of it to run over the edge, to the reverse side, where it leaves unsightly stains. Paper thus prepared, is not affected by light, and will keep a considerable length of time, but as it performs best when fresh, the inventor recommends the preparation of only a week's supply at once. An ounce of solution is sufficient for twelve or fifteen slips; on one occasion a paper of three months old at Toronto, yielded a good curve, but in general they present neutral patches to a greater or less extent, if kept too long.

The next step is to render the paper sensitive. For this purpose, prepare another slip of wood; secure a slip of the prepared paper to this, in the same way as before; exclude daylight, and make use of a lantern glazed with red or yellow glass, then pour into a capsule about a teaspoonfull of the following solution.

(2.) Dissolve fifty grains of nitrate of silver in one ounce of distilled water; apply it to the paper lightly and carefully, brushing first longitudinally, then across; it is scarcely necessary to say that each solution must have its own brush, its own cup, and even its own cloth for drying the cup and brush.* The paper being uniformly wetted, roll it immediately round the glass cylinder, which must be previously wiped dry, and secure it, where the ends overlap, by a little gum dissolved in acetic acid. If but one lamp is used, it is necessary to make a couple of pencil marks across the junction of the folds, to furnish a base line. The light being then allowed to fall on the paper at any chosen moment of time, the trace commences. The above directions apply to the ordinary process when camphine is used; to give the paper the additional sensibility required with an oil lamp, Mr. Brooke directs to rinse the paper in water after applying the nitrate of silver, holding it by the two ends and shaking it a little, under the surface of the water in the dish. It is then to be laid on a cloth, and the water pressed out of it, by passing a glass rod or piece of tube two or three times over it, with gentle pressure. (To avoid the contact of organic matter with the prepared surface.) About half a teaspoonful of the nitrate of silver solution is then poured on the paper,

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* A small covered box having a place for each cup, each bottle, and each brush, will be found convenient. The cups should be further distinguishable by some difference of shape or color, and the brushes marked.

and the glass rod again passed lightly over it, which diffuses the solution over it; after which it is applied to the cylinder as before; by this process the sensibility of the paper is said to be much increased, and it keeps a cleaner surface. To present at one view the different chemical processes, we will suppose the cylinder to be now left to complete one revolution (of twelve hours) or two, as the case may be, the paper has then to be removed, the impression to be developed, and then fixed. For this purpose a common large dish is required, which should be placed before a fire until moderately warm. Excluding daylight as before, remove the cylinder carefully from its supports, take off the paper with as little fingering as possible, and lay it on the dish; no indication of the trace will be perceived, unless the disk be more than duly heated, in this case the lines sometimes appear faintly without farther treatment, but the paper darkens too much afterwards. It has to be now brushed with

(3.) Twenty grains of crystallized gallic acid, dissolved in one ounce of distilled water* when it appears in a minute or two. When the impression is sufficiently distinct, which will generally be in the space of five minutes, the gallic acid must be washed off by repeated sluicings with soft water, assisted by a soft brush. In a cold place, or with a cold dish, a longer time is required; in short the whole process seems to succeed best, like most photographic processes, at a high temperature, although the trace has been developed at a temperature low enough to convert the solution into a film of ice. When the uncombined nitrate of silver and gallic acid are thoroughly washed off, the light may be admitted without danger; it then remains to fix the impression by transferring the paper to a clean dish or board, and brushing it with about one table spoonful of the usual solution, namely,

(4.) Twelve grains of hyposulphite of soda to one ounce of distilled water. It will be observed that rather a larger quantity of this solution is laid on the paper than of the previous ones. If an insufficient quantity be applied, or it be not uniformly distributed, the paper is apt to acquire a dirty brown stain, in patches, passing into black, which latter it ultimately becomes when no hyposulphite is applied; in this case, the margin of the previously dark lines becomes the lightest portion; after allowing the hyposulphite a few minutes to act, it must be thoroughly washed off, by repeated sluicings of water, assisted as before, with a soft brush, otherwise it enters into a new combination which spoils the specimen: the paper may then be placed between the folds of clean white blotting paper until dry, when the process is completed.

We may now return to the mechanical details. The magnet employed is about two feet long, one inch and a quarter

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* One ounce of water will not hold twenty grains of gallic acid in solution at ordinary temperatures; it is necessary to dip the bottle in boiling water, or heat a small portion of surcharged solution, in a test tube.

wide, and a quarter of an inch in thickness: it is suspended with the broad side vertical, in a brass stirrup carrying a divided circle (*a*) by which the position of detorsion of the thread is made to coincide with the meridian, and two keepers (*b*, *b*) capable of

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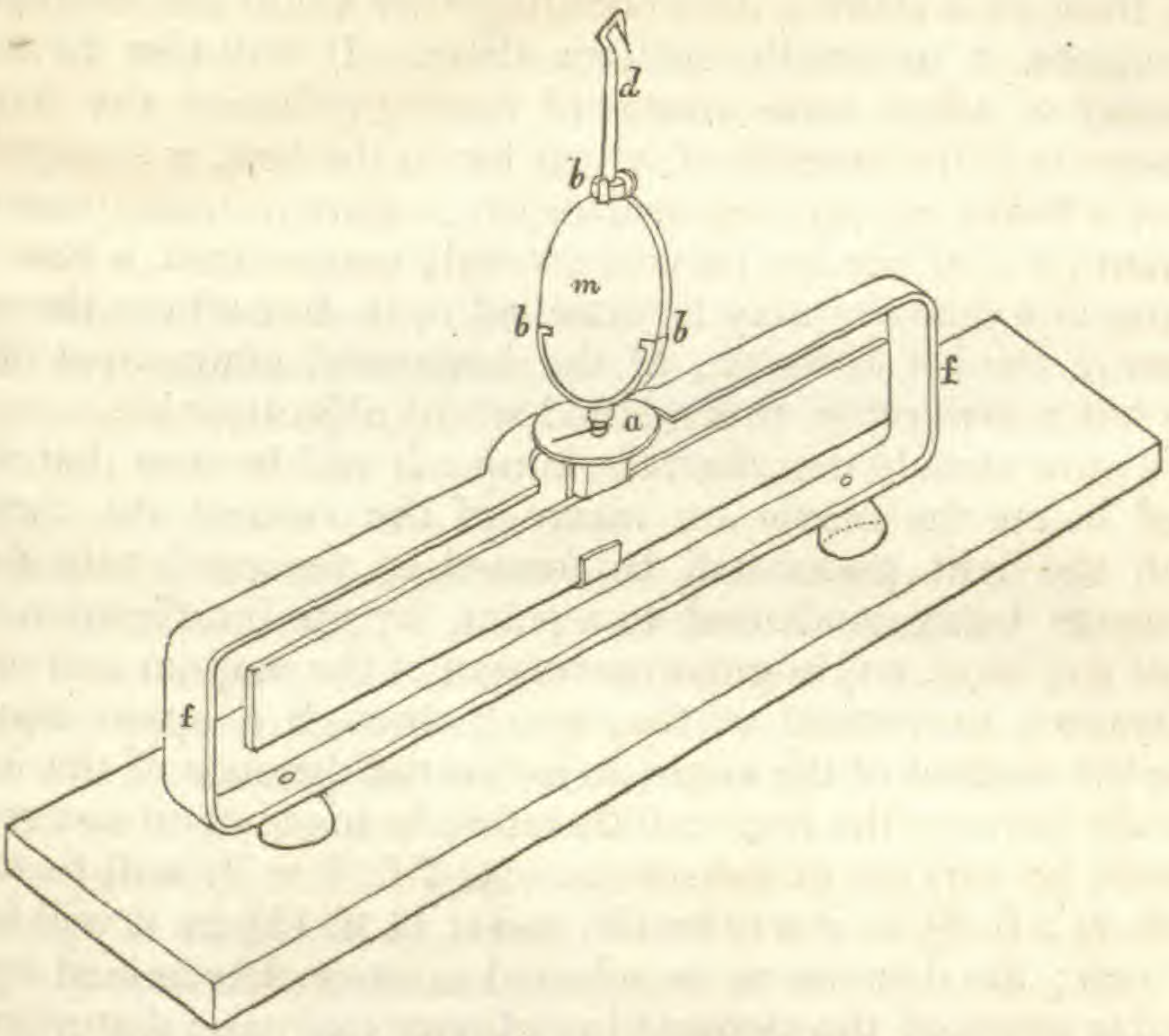

sliding on the stem (*d*) for the purpose of holding a metallic reflector (*m*). This important part of the apparatus is a small speculum weighing about one pound, four inches in diameter, and of about sixteen inches focus; it can be set to any required height on the stem (*d*) and be made to form any required angle with the axis of the magnet. The whole suspended weight amounts to about four and a quarter pounds, requiring a strong silk suspension; hence that the effect of torsion may be moderate it is desirable to have it of considerable length.* At Toronto, three wooden pillars, firmly fixed in the ground, and passing through the floor (without contact) carry a triangular frame on which is erected a light tripod stand, which passes through an upper floor, and supports the reel to which the suspension silk is attached, allowing a length of about ten feet. Stone pillars would be preferable, and have indeed been prepared for another instrument, a bifilar, on the same principle, which will, it is hoped, be brought into operation in the course of the present spring; it is probable that many interesting enquiries will arise out of oscillations so minute, that

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* A long silk suspension is, however, liable to the inconvenience of varying sensibly in different hygrometric states of the atmosphere, thereby disturbing the adjustment of the light sufficiently in some cases to make it ineffective. A fine metallic suspension, as was originally used by M. Gauss, for his declinometer, if very long, would probably be preferable to silk.

nothing but extreme care, in cutting off every source of external or mechanical agitation, will give security to them. Mr. Brooke has given a curious lithograph of a trace produced under extreme "local disturbance," namely, a *quadrille party* in the house adjoining, which is sufficient to shew that if the tremor communicated from such sources does not altogether annul the magnetical movements, it materially modifies them. It will also be found necessary to adopt some means of rapidly reducing the natural movements of the magnet, of which by far the best, is the application of a heavy copper ring or damper, as shown in the preceding diagram (*f*); if the bar be very strongly magnetized, a fine wire dipping into mercury may be attached to it, but where the magnetism of the bar is feeble, or the horizontal component of the force has a low value, this method seems objectionable.

We have already described the lamp. It will be seen that when placed before the mirror an image of the vertical slit through which the light passes will be formed in the conjugate focus: this image being condensed to a point, by the intervention of a lens of any kind, any angular movement of the magnet and mirror will cause a movement of that point through a space equal to twice the tangent of the angle, to radius the distance of the image from the mirror; the trace can therefore be made upon any required scale, by varying that distance. At 7 ft. 2 in. it will be 20′ to 1 inch, at 9 ft. 6½ in. it will be 15′, and at 11 ft. 11¼ in. it will be 12′ to 1 inch; the distance to be selected must be determined by the probable range of the element in ordinary magnetic disturbances, for since very great ranges are of rare occurrence and seldom more than momentary, it does not seem expedient to reduce the scale sufficient to include them, at the sacrifice of distinctness in the more usual movements.* The scale at present in use at To-

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* The width of the half sheet of paper is sufficient for a range of 40′ of declination and ·008 of horizontal force, upon the largest scales likely, under any circumstances, to be adopted, namely 10′ of declination and ·002 of horizontal force, to one inch. It appears from observations at Toronto, from 1840 to 1849 inclusive, embracing altogether about 3050 days, and including 164 occasions of extra observations, and 118 term days, that great ranges may be expected at that station in the following proportion.

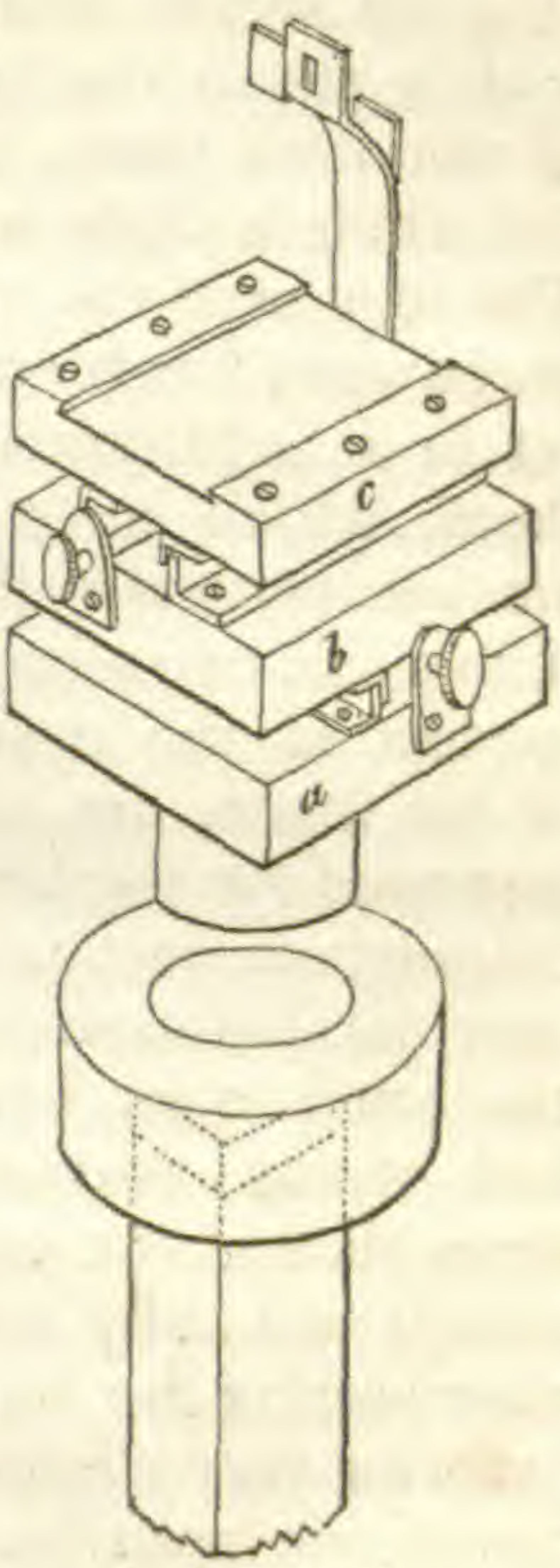
Range of Declination.	
Less than 40′	2978 days.
From 0° 40′ to 0° 50′	28
0° 50′ to 1° 0′	12
1° 0′ to 1° 10′	4
1° 10′ to 1° 20′	7
1° 20′ to 1° 30′	2
1° 30′ to 1° 40′	2
1° 40′ to 1° 50′	1
1° 50′ to 2° 0′	4
2° to 3°	6
3° to 4°	2
More than 4°	3

Range of Horizontal Force.	
Less than ·008	2974 days.
From ·008 to ·010	17
·010 to ·015	19
·015 to ·020	7
·020 to ·025	9
·025 to ·030	3
·030 to ·035	7
·035 to ·040	3
·040 to ·045	2
·045 to ·050	1
·050 to ·055	2
More than ·055	11

On 211 of the term days and disturbances, the range of declination fell within the above limits, (40′) and on 207 of them, the range of horizontal force fell within the ronto is 20′ to an inch, the light being thrown in such a way as to divide the space unequally, and allow the greatest range to the east, the direction in which the principal movements occur.

The lamp is supported by a tripod stand about three feet high, with an elevating lever for raising the top, which consists of three distinct parts: the lowest of these (*a*) turns in azimuth round a pivot, the second (*b*) slides by a slow motion screw, in a groove, on the face of the first, the third (*c*) slides in like manner on the second, but transversely: by these arrangements, first, the luminous slit can be set at any required height, secondly, it can be turned in azimuth until the brightest part of the ray falls on the centre of the mirror, thirdly, its distance from the mirror can be adjusted until a sharp focal image is formed on the cylinder, lastly, it can be moved laterally, so as to carry the image to any part of the paper required; this effect can be produced also by turning the mirror itself a little, but not with the same facility. The upper plate is provided with a groove, into which the lamp is made to fit, thus securing its being replaced after each change in precisely the same position; it also carries the screen. The slit through which the light passes is about 0·4 (four-tenths) inch high and from one to two-hundredths of an inch wide; the width can be varied at pleasure by a sliding piece and slow-motion screw.*

3.



Lamp stand.

The stand for the support of the cylinder, requires, like that of the lamp, some means of adjustment in height. If a barometer is connected with the apparatus, a ready means of attaching it so that the index may pass through the table top near the cylinder, must also be considered; both objects may be obtained by adding a solid table top about sixteen inches square to a tripod stand similar to that of the lamp, the feet of which should rest on a solid support.

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limit allowed for that element. It is to be expected that many more disturbances in proportion will be recorded by the photographic process than were observed, but not of the more extreme degrees, or such as to alter materially the above scale of relative frequency.

* The position of the stand for the lamp must be such that the cone of rays reflected from the mirror shall not quite clear the chimney, which cuts off a portion of one edge of it, while a portion of the other edge is cut off by a screen slipped a little before the mirror: seen therefore from the centre of the cylinder, the chimney should hide a small segment of the mirror on one side, and the screen a similar segment on the other.

The cylinder consists of an ordinary French glass shade, blackened on the inside, about fourteen and a half inches in circumference and ten inches high. One end is closed by a metal cap provided with a concentric axis, three inches long, a bent arm or crank is attached to the axis by a set screw, and engages with a slit in the hour hand of the time piece, by which the whole is made to revolve. The weight of the cylinder is borne upon five friction rollers set in a light frame; two of them, which carry the axis, are set vertically facing the time piece, two more, of smaller size at the opposite end of the frame, are sufficiently separated for the body of the cylinder to rest upon them, near its hemispherical end; the other is set horizontally, and works against a small brass plate at the base of the axis; the whole should be carefully turned and truly pivoted. In the arrangement of the inventor, after placing the paper on the cylinder as here described, a second cylinder very slightly larger is slipped over it, and retained in a concentric position, by pressure upon a few coils of tape wound round the capped end of the inner cylinder and kept wet; the object is to protect the paper and keep it damp, for which purpose, also, a piece of wet lint is placed between the cylinders at the point. An accident to the external cylinder led to the adoption of a different plan at Toronto, which has been found so convenient that the former one has not been reverted to. The external cylinder is replaced by a case of copper, of about the same size and shape, but divided along the axis into two halves, one of which is fixed to the frame carrying the friction wheels, (of which, the two carrying the axis, run altogether outside of it, the others enter it through narrow cuts, sufficiently to carry the cylinder clear); the other half forms a covering removable at pleasure. The light is admitted through two narrow slits, which may be glazed if desired. The advantages of the arrangement are these. The time piece has but half the weight to turn; the paper is immediately accessible; the loss of light in passing through the external cylinder is avoided, since it is found in practice unnecessary to glaze the opening, the impressions are therefore darker; the paper may be applied, and removed with great expedition, and without exposure to stains from contact with the

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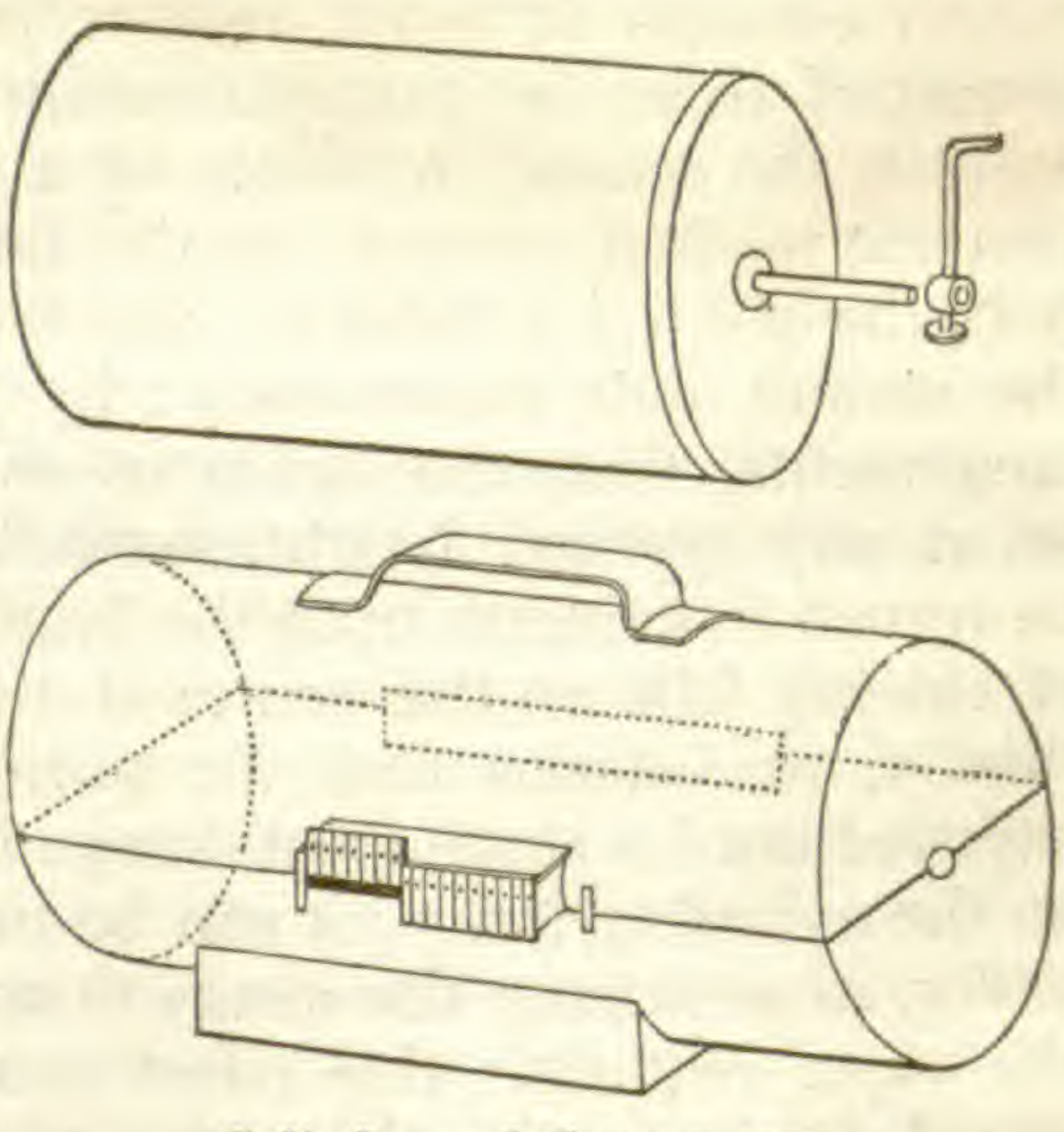

Cylinder and Copper case.

wet edges of the external glass cylinder; lastly, we are enabled, by the employment of the sliding screens described below, to make use of nearly the whole width of the paper for barometric changes, instead of being restricted to about one-half of it. It should be added that by making a shallow well in the fixed half of the cylinder, a large surface of wet lint may be exposed immediately under the paper, which is found to keep it damp enough under all circumstances, even when the slits are open.

The barometer employed, is a syphon, "constructed with a column of mercury of a little more than one inch in diameter. As the weight of an entire column of this size would be inconvenient, and as it would be difficult to obtain a tube more than three feet long of so large a bore, both ends of which were of the same internal area, two adjacent short pieces of a very nearly cylindrical tube, have been united to the extremities of a tube of small bore, and form the ends of the instrument which contain the surfaces of the mercury," thus shewing the variations of pressure by an equal change of half the amount in either tube. These changes are communicated to a long and slender index or lever by means of a float, attached to a short arm at right angles to it, both being centred on a light wheel of metal, carefully pivoted, and both being counterpoised. The float actually employed is the bulb of a mercury thermometer, the stem of which passes through a cap adapted to the open end of the syphon, and is guided by three small friction rollers.* A screen of card or very thin metal, provided with a narrow slit exactly thirty inches from the centre of motion, is attached to the upper end of the long index, covering an opening in the copper case of the cylinder; a lamp being then fixed behind the screen, the pencil of light which falls on the paper through the slit left for the purpose, will, it is evident, follow every change in the position of the index, or of the surface of mercury in the syphon. A lens similar to that which is used to bring the elongated image of the slit reflected from the mirror of the magnet to a point, is also used here to bring the image of a horizontal slit in a corresponding screen before this lamp, to a focus on the paper. It forms a bright line across its whole width, which is however intercepted by the barometer screen on one side, and by an independent screen on the other, allowing to reach the paper, only the variable pencil passing through the former and an invariable one, for the purpose of tracing a base line through a fixed opening in the latter.

The tube of the barometer has a vertical movement, to allow an adjustment of the level of the mercury at the foot of the syphon, to the same horizontal plane, so that whatever be the pres-

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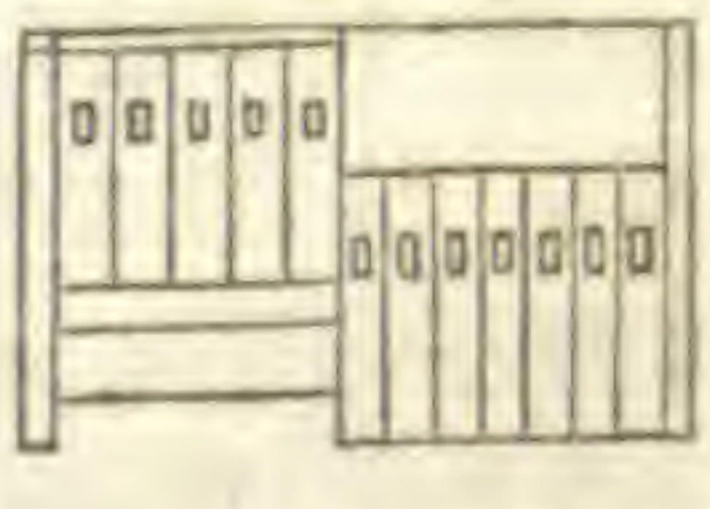
* These have been generally dispensed with, at Toronto, and the end of the syphon left open: unless very truly turned, and perfectly centred, they are apt to impede rather than assist the motion of the stem of the float.

sure at the time of commencing a trace, the long index is set vertically. By varying the ratio of the lengths of the two levers we may enlarge the scale of the trace to any extent; for this purpose there are distances marked on the short arm, corresponding to a scale of three, four, and five times the actual change, and the axis to which the arms are fixed can be moved nearer to, or further from the float as required. The nature of the scale must in general depend upon the probable extent of the barometric changes in twelve or twenty-four hours; it may be greater in the summer than in the winter months, but there will always be some changes exceeding the range of the instrument, or rather, the width of paper available for their registration. As, for instance, when the barometer falls or rises an inch in twenty-four hours: in such cases the index may be brought afresh to the vertical position during the progress of the register. Not to interfere with the magnetical curve, the barometer should be so placed as to form its trace rather on one side of the paper, thus reducing the space available in that direction to about one-third of its width; but by a particular contrivance connected with the copper case already described, we are enabled, without liability to exposure, to command nearly the entire width in the other direction. This contrivance consists of a set of twelve narrow parallel sliders, occupying in width about 1½ inch, moving vertically in a frame attached to the upper half of the cylinder, and capable of being raised or lowered at pleasure. At the commencement of a trace, we may suppose half of them to be raised; the remainder being down, the screen at the top of the index completely excludes all other light from the paper than the pencil passing through its own slit; but if the barometer falls beyond a certain amount, the edge of the screen will at length pass beyond the last slider, leaving a portion of the paper fully exposed; in such a case, one or more sliders are put down: if on the other hand the barometer rises to a certain amount, the light will at length fall on the space covered by the sliders, and it becomes necessary to raise some of them; in this way, the black bands caused by the accidental exposure of the paper, under extreme movements of the barometer, may be avoided.



The cylinder, with the two fixed lenses, the time piece, and the upper end of the barometer index, are all included under a second or external case, provided with apertures for the admission of the rays of light, and with a lid at the top to allow access to the sliding screens of the barometer. The apertures are of the same width as the fixed lenses, and each provided with double sliders by which they can be contracted at pleasure; that appropriated to the magnetical trace is protected by a long rectangular tube, the effect of which is so complete, that "not the slightest difference can be perceived on the paper whether bright daylight is freely admitted into the room or wholly excluded."

Every part of the apparatus from which light can be reflected, directly or indirectly, to the paper, is carefully blackened.

I have described the apparatus at some length, because with the exception of the speculum, the cylinder itself, the time piece, and the tube of the barometer, all of which must, at present, probably, be procured from Europe, there is nothing which an ingenious mechanic might not execute at a small cost; the fixed lenses should perhaps be added; but a simple substitute for them may be found in a well blown cylinder of thin glass filled with alcohol, as was indeed employed by Mr. Brooke in his first instrument. The more expensive lenses at present in use are manufactured by Lerebours of Paris, and may be described as lenticular prisms having a double convex section, but forming a flat bar, which is from seven to eight inches long and one inch and a quarter wide for the magnetical curve, and about five inches long for that of the barometer and base line. Each lens is mounted on a light frame which slides in a groove so as to admit of adjustment of focus. The focus is rather improved by covering a portion of the margin of the lens.

It is advisable on the first adjustment to bring the centre of the mirror, of the cylinder, and of the slit before the lamp, into the same horizontal plane, and to establish some marks for its recovery in successive adjustments, as much of the perfection of the focus depends upon this circumstance. If it is found that the mirror when thus adjusted, throws the image of the slit too high, or too low, its own inclination must be altered by introducing a small wedge of cork behind it. Small derangements produced by spontaneous alterations in the length of the suspension silk may be corrected by raising or lowering the lamp, and must be carefully attended to.

A perfectly good trace, according to the experience of the writer, presents a sharp edged dark line, of a purple tint, upon a yellowish ground. The lineal value of one hour in time, is one inch and two-tenths (nearly), the value of a full revolution appears to differ in different traces (from unequal expansion and contraction of the paper) to the amount in the most extreme cases of about one-tenth of an inch, upon a total length of nearly fourteen and four-tenths; but it will be evident that the precise equality of the different hours will depend in some measure upon the regularity of the cylinder's form, and the precision with which it is centered. There appears to be considerable diversity in the character of the traces produced by different observers, owing both to differences of treatment, and to impurities in the chemical materials. The yellow ground alluded to, is probably the effect of the large proportion of iodid of potassium employed, the object of which is, to insure the permanence of the effect for the long period of twenty-four hours, during which a part of it, at least, is to be maintained upon the surface of the paper; when a less quantity of iodid is used, the paper appears to have a neutral tint: in this case, the beginning of the trace can sometimes be with difficulty developed. The greatest care must be taken not only to prevent the least intermixture of substances, and to confine each vessel, and each cloth, as well as each brush strictly to one use, but also to wash all the brushes very carefully in pure water after use, not only for their preservation, but because the presence of deposit from old solutions, even of the same kind, has an injurious effect.

A room of 12 × 15 feet is all that is absolutely needed for a single instrument. It will be found very desirable to have a small cistern of soft water in it, provided with a stop cock, and with a sink and waste water pipe attached; the sink should have a lid to allow the paper to be kept in darkness, when convenient, without darkening the room: if to this we add two or three broad shelves, or small tables and conveniences for washing the hands, its equipment will be complete.

The future comparison of traces will be greatly facilitated if they all include the same period of absolute time. Each register at Toronto begins at 20′ after 6^h of Göttingen mean time, and terminates at 6^h 0^m of the following day, being nearly at Toronto noon.

"A continuous registration of the variations of the thermometer has been obtained by intercepting the focal line of light formed on the paper, by the stem of a thermometer having a wide flat bore, a sufficient quantity of light passes through the empty portion of the bore to darken the paper, but it is entirely excluded from the portion occupied by the mercury. The register, therefore, consists of a light and dark space, separated by a well defined boundary line the distance of which from the base line will furnish the required indication. This particular application of the apparatus, prefers no claim to novelty, as a very similar means of registering the variations of the thermometer has been already published, (Engineer's Magazine, Nov., 1845,) and is here introduced merely as forming a necessary part of a complete automatic meteorological registration."

Allusion has been made at the commencement of this article, to the action of light upon silvered plates, as one of the modes of effecting the self-registration of magnetical instruments. The apparatus referred to is the invention of Mr. Ronalds, and although capable of employing either paper or metallic surfaces, is properly designed for the latter, and is essentially a daguerreotype. An instrument on this principle was sent from England for the Magnetic Observatory in August last, but by accident to the vessel, has not yet been received there, and cannot now be brought into operation before June, 1850. It is intended to register the horizontal force, and differs essentially in many respects from the apparatus of Mr. Brooke. A bifilar magnet adjusted in the ordinary way, carries a light movable screen, passing before the object glass of a camera, which faces a north window, at the distance of four or five feet. It acts therefore by refraction, instead of reflection. The ray which passes through the screen is received upon a silvered plate prepared by the common daguerreotype process, somewhat modified to adapt it to a slow and long continued action. The plate is made to travel slowly before the light in a vertical plane, by the action of a time piece: the distance of its surface from the centre of the magnet being about thirty-four inches, a sufficiently large scale is allowed to render sensible very small movements of the horizontal force, provided a due degree of sensibility is given to the balance of forces by which the magnet itself is held in equilibrium. In other words, provided the ratio $\frac{F}{G}$, in the common notation, is made to approach nearly to unity. Mr. Ronalds has succeeded, in the climate of London, in producing effects by natural light so late as 8 P. M. in the summer. For the nocturnal portion of the curve a powerful argand lamp is employed.

The relative merits, in practice, of the two valuable and ingenious inventions now described, can scarcely be stated at present. That of Mr. Brooke has probably the advantage in economy and facility; that of Mr. Ronalds will, it is expected, prove capable of a higher degree of precision, and it offers a convenience of which the inventor has already availed himself. Any trace of unusual interest can at once be engraved on the plate, thus giving the utmost possible accuracy and facility to graphical comparisons. It is not intended however under ordinary circumstances to retain the impressions, but after recording every particular of interest, and tabulating the hourly or other ordinates, or taking a copy of the traces, to clean them off and make use of the plate again as long as the silvering lasts.

In conclusion the writer begs leave to add that should the foregoing account lead to the establishment of any instruments of the kind, he will have pleasure in giving any further information in his power in answer to personal enquiry. Without presenting facsimiles, it is difficult to convey an idea of the interest attaching to many of the movements which have been registered, but the important information which such records are calculated to afford as to the periodicity of certain movements, the nature and degree of local anomalies in disturbances of the magnetical elements, the effect of Aurora, and many other enquiries, will occur immediately to any one interested in terrestrial magnetism, and it is hoped secure the adoption of a register upon one or the other principle, by more than one of the numerous scientific establishments in the United States.

Toronto, January 21, 1850.

Postscript.—In the foregoing account of the instrument of Mr. Brooke, it has been assumed that the arm of the cylinder is connected directly with the hour hand of the time piece, making it therefore revolve once in twelve hours. The effect of this arrangement is, that when the paper is left on for twenty-four hours, we have two traces, which sometimes intersect in such a manner, as to make it difficult to distinguish to which revolution portions of them are due. The writer has recently succeeded, by a very simple arrangement, in making the cylinder revolve but once in twenty hours, and thus remedying this inconvenience. Two small grooved wheels mounted on a light frame, one having a diameter exactly double that of the other, are connected by a piece of fine silk twist. The smaller one being then connected with the hour hand, by a crank, and the larger one with the cylinder, it is evident that the object is effected.

This reduces the time scale to six-tenths of an inch for one hour, which is fully equal to the scale that has been generally adopted in the engraved diagrams of term day and other movements, and is considered large enough for almost every purpose to which diagrams can be applied, while it gives great facility to comparisons, and a much more distinct representation of the diurnal curves.

ART. XXXIII.—*Influence of the known Laws of Motion on the Expansion of Elastic Fluids;* by ELI W. BLAKE.

THAT under the controlling influence of the known laws of motion, elastic fluids must expand according to some definite and invariable law, is an obvious truth and one which has often been recognized by mathematicians. But the determination of that law is a problem which hitherto, it is believed, has not been solved. There are many interesting points in mechanics and physics, in relation to which the present state of knowledge is imperfect, which depend for their correct and complete development, in part at least, on a solution of this problem. It is therefore a point of some interest to science. It is our purpose in this article to solve this problem; and we shall do so by employing a method similar in part to that employed in solving the problem of the propagation of pulses in elastic media, ii ser., vol. v, p. 372, of this Journal.

Before entering upon the investigation we will here state one curious and remarkable fact which the investigation discloses. We advert to it here because a fact so much at variance with preconceived notions may be interesting to those readers who will not care to follow out the mathematical details of this article.

When a fluid passes by free expansion from one state of density to another, we should naturally suppose that it must pass through all the intermediate states of density that can be assigned between the two. Such appears to have been the notion of every writer who has made reference to this point; and at first view it would seem absurd to suppose that the fact could be otherwise. But such is not the way in which elastic fluids expand. On the contrary the parts of the fluid successively and *instantaneously* change their density, to the extent of one half (when free to expand to that extent) *without passing into the intermediate states.* As vapor is thrown off from the surface of water in a tenuious state *ab initio*, and without having first passed into those states of density which are intermediate between the density of the water and that of the vapor, so a column of rarefied fluid is thrown off from the front of a denser column; each infinitesimal element of the highest order of the denser column, being successively and instantaneously transformed to the more rare state. And as the change of density is instantaneous, so likewise the entire velocity due to that change is imparted instantaneously to each element successively.

But to proceed with the investigation; suppose a straight tube of uniform calibre extending indefinitely in both directions from a given point. Suppose the tube on one side of this point to be filled with a column of fluid of the density D, indefinitely expansible, and always maintaining the same ratio between its density and elastic force when it expands; and suppose the other portion of the tube a perfect vacuum. It is required to determine the law according to which the fluid expands into the vacuum; so that we may be able to assign the precise state of the fluid, in respect to density and velocity, at each and every point of the tube after the lapse of any given time from the commencement of expansion.

Since the elastic force is always as the density, D may represent both the density and the elastic force. The force D acts during the first instant in every part of the column, and in *every direction;* and therefore during that instant every part of the column is kept in equilibrio except the first element. Consequently in the first instant expansion takes place in the first element only; and as the whole force D acts during that instant, the parts of this element must receive such velocities that the sum of their momenta shall be equal to that due to the action of the constant force D during that time. It is obvious that the termination of the first instant coincides with the commencement of motion in the second element; also that motion will not commence in the second element until the density in front of it has been to some extent reduced. Let the ratio in which it is reduced before motion begins in the second element be represented by $\frac{1}{x}$. Then the density of the posterior part of the expanded element at the end of the first instant is $\frac{D}{x}$. Now for reasons which will soon be apparent, all the other parts of the expanded element, whatever may be their present state of density, may be considered as having passed first into the density $\frac{D}{x}$. But at the same time that the grade $\frac{D}{x}$ began to form in front of the column, that grade itself must have begun to expand *again* in the same ratio, forming another grade $\frac{D}{x^2}$. And at the same time that the grade $\frac{D}{x^2}$ began to form, that likewise must have begun to expand in the same ratio forming a grade $\frac{D}{x^3}$, and so on ad infinitum. The grades therefore will correspond to the terms of an infinite series in decreasing geometrical progression. All of them originate *simultaneously* in the first element; and yet every grade respectively may be considered as having passed into and out of all the grades which precede it; inasmuch as each in its origin is a *constituent part* of that which precedes it. The fluid which passes into any one of these grades in the first instant does not all of it pass into the next in the same time; for equal quantities by *measure* expand in equal ratios in equal times; and since a given quantity by measure in any one grade becomes a larger quantity by measure when expanded into the next grade, a portion will have been left at the end of the first instant in each grade which has not expanded into the next. Hence at the end of the first instant the first element of the column will have been distributed into portions or grades, having their respective densities corresponding to the terms of the infinite series

$$\frac{D}{x}, \frac{D}{x^2}, \frac{D}{x^3}, \frac{D}{x^4}, \text{\&c.} \qquad \text{(A)}$$

If we extend this series backward one term we obtain the series

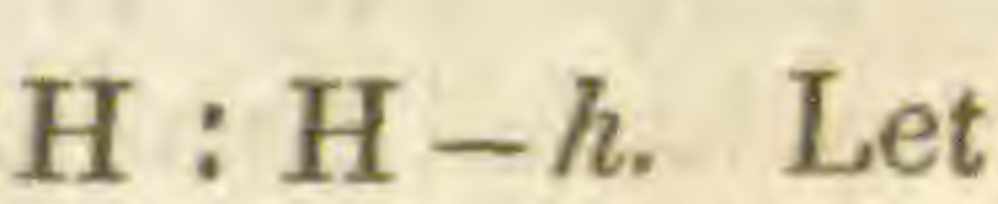
$$D, \frac{D}{x}, \frac{D}{x^2}, \frac{D}{x^3}, \frac{D}{x^4}, \text{\&c.} \qquad \text{(B)}$$

Since equal quantities by measure pass out of each of these states in a given time, if s be the space occupied by the original element, and if we multiply each of the terms of the series (B) by s, then the terms of the resulting series $Ds, \frac{Ds}{x}, \frac{Ds}{x^2}, \frac{Ds}{x^3}, \frac{Ds}{x^4}$, &c. (C) will severally express the quantities of fluid that expand from each grade respectively into the next. Now since fluids expanding in equal ratios acquire equal velocities, equal velocities are acquired in each of these expansions. If then we find that velocity and by it multiply the sum of the series (C), the product will be the sum of the momenta generated in, or imparted to, the parts of the first element in the time in which the point of expansion recedes through s.

If the quantity Ds be expanded from the density D to the density $\frac{D}{x}$, the space it will occupy will be increased in the inverse ratio of these densities; and therefore $\frac{D}{x} : D :: s : sx$. Hence s and sx are respectively the spaces occupied by the element before and after the first expansion. Now the velocity which the mass Ds receives in this expansion, is obviously that which would carry it over the difference between these spaces in the time in which the expansion takes place; that is, the velocity imparted in the first expansion is $sx - s = s.\overline{x-1}$; and the same velocity is imparted in every other expansion. If then we multiply the sum of the series (C) by $s.\overline{x-1}$, the product will be equal to the sum of all the momenta generated in the parts of the element. This product is Ds^2x. Therefore Ds^2x is the entire amount of momentum which the force D is competent to generate in the time in which the point of expansion recedes through s.

We will now proceed to find another expression for the momentum which the force D is competent to generate in the same time, in order that by comparing it with that just found, we may ascertain the value of x.

Let H be the height of a column of fluid of the density D, whose weight is equal to the elastic force D; and let $H - h$ be the height of another column of the same density whose weight is equal to the elastic force $\frac{D}{x}$. Then $D : \frac{D}{x} :: H : H - h$. Let mn be the space occupied by the first element at the density D, and ms that which it occupies when expanded to the density $\frac{D}{x}$. Since the spaces occupied by the element in these states are inversely as the densities,



$mn : ms :: \frac{D}{x} : D :: H - h : H$, and therefore

$ms - sn : ms :: H - h : H$; whence we obtain $H = \frac{h \times ms}{sn}$.

In the time in which the point of expansion recedes through mn, the element Ds receives a velocity which will carry it over sn in the same time. If then mn represent the velocity of the point of expansion, *sn* will represent the velocity imparted to the fluid by the first expansion. Consequently, the retrogressive velocity of the point of expansion must be such that in the time in which it passes over any space, the force $D-\frac{D}{x}$ may give to all the fluid in that space the velocity *sn*. Hence the point of expansion will run over *h* in the time in which the force $D-\frac{D}{x}$ will give to all the fluid in *h* the velocity *sn*. But the force $D-\frac{D}{x}$ is equal to the *weight* of all the fluid in *h*. Therefore the point of expansion runs over *h* in the time in which the mass *h* would in falling by its own gravity acquire the velocity *sn*. The time in which a falling body acquires the velocity *sn* is to that in which it would acquire the velocity of the point of expansion, or *mn* as *sn* to *mn*; and the spaces over which the point of expansion would run in these times are in the same ratio. Therefore putting S for the space which the point of expansion would run over while a falling body would acquire the velocity of the point of expansion, we have $sn:mn::h:S$, or, $sn:ms-sn::h:S$; whence we obtain $S=\frac{h\times ms}{sn}-h$. But we have before found $H=\frac{h\times ms}{sn}$. Therefore $S=H-h$; that is, the point of expansion will run over $H-h$ in the time in which a falling body will acquire the same velocity. Consequently the velocity of the point of expansion is that which a body will acquire by falling through $\frac{H-h}{2}$.

If the force D act on the mass H during the time that mass would fall through H, it would give that mass a velocity which would carry it over 2H in the same time, because the force D is equal to the weight of the mass. The mean velocity of a body falling through H is that which will be acquired by falling through $\frac{H}{4}$. If then the point of expansion moved with the velocity acquired by a body in falling through $\frac{H}{4}$, in the time of passing over H, the force D would be competent to give to all the fluid in H a velocity which would carry it over 2H in the same time; and consequently in the time of passing over *s* it would give to the mass D*s* a velocity which would in the same time carry it over 2*s*. But the point of expansion as before shown, moves with the velocity acquired by falling through

$\frac{H-h}{2}$. Now the velocity due to $\frac{H}{4}$ is to that due to $\frac{H-h}{2}$ as $\sqrt{\frac{H}{4}}$ to $\sqrt{\frac{H-h}{2}}$; and the times in which the point of expansion would move over s with these velocities, are inversely as these velocities, or as $\frac{1}{\sqrt{\frac{H}{4}}}$ to $\frac{1}{\sqrt{\frac{H-h}{2}}}$. But $D : \frac{D}{x} :: H : H-h$, and therefore these times are as $\frac{1}{\sqrt{\frac{D}{4}}}$ to $\frac{1}{\sqrt{\frac{D}{2x}}}$, or as 2 to $\sqrt{2x}$. The velocity which the force D can impart in these times is as the times respectively. And since it has been shown that in the former of these times the velocity $2s$ will be imparted by the force D, we have $2 : \sqrt{2x} :: 2s : \frac{2s\sqrt{2x}}{2} = s\sqrt{2x}$. That is, the *velocity* which the force D is competent to impart to the mass Ds in the time in which the point of expansion recedes through s, is $s\sqrt{2x}$. Consequently the *momentum* which the force D can impart in the same time is $Ds^2\sqrt{2x}$. But we have before found this momentum to be Ds^2x. Therefore $Ds^2x = Ds^2\sqrt{2x}$; whence $x = \sqrt{2x}$ and $x = 2$.

Having thus found the absolute value of x, if we substitute this value for x in the series (A) we shall have, for the densities of the several parts or grades into which the first element will have been distributed at the end of the first instant, the respective terms of the following series, viz., $\frac{D}{2}, \frac{D}{4}, \frac{D}{8}, \frac{D}{16}, \frac{D}{64}$, &c.

We found the velocity of the point of expansion to be that which a body will acquire by falling through $\frac{H-h}{2}$; the value of h being dependent on the value of x. But when $x=2$, $\frac{H-h}{2} = \frac{H}{4}$. Therefore the absolute velocity of the point of expansion is that which a body will acquire by falling through $\frac{H}{4}$, or one fourth of the subtangent of the fluid.

Since the extent of the element is doubled by the first expansion, the velocity of the first grade will be equal to the velocity of the point of expansion, or that due to one fourth of the subtangent; and an equal additional velocity is imparted in each succeeding expansion. If then v represent the velocity due to one fourth the subtangent of the fluid, the absolute velocities of the several grades respectively will be expressed by the respective terms of the series v, $2v$, $3v$, $4v$, $5v$, &c.

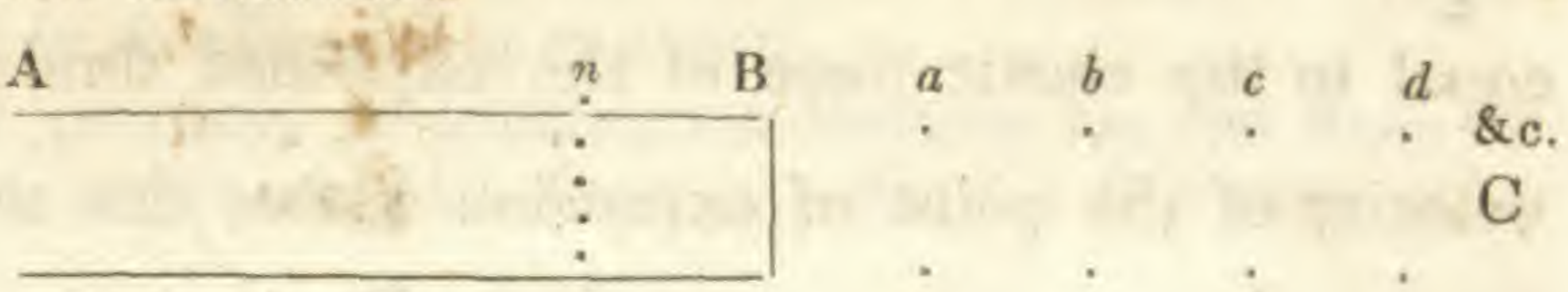
Since one element $=s$ by measure passes from each grade into the next, and becomes $=2s$ in the next, the length of each grade at the end of the first instant $=2s-s=s$. That is, the length of each grade is equal to that of the original element; and the *place* of the first grade is that which was occupied by the original element; the other grades succeeding it in continuous order.

Having now ascertained the state of things at the end of the first instant, let us inquire what takes place in the second instant.

It is obvious that during the second instant the front of the second element of the column, and also the front of each grade respectively is a point of expansion from which one element $=s$ by measure passes into the next grade. Thus in the second instant each grade receives an addition of $2s$ to its rear and loses $1s$ from its front. The same takes place in every succeeding instant. Since the increment of the length of the grades for each instant is s, the velocity of the increase is v. The length of the grades is therefore always equal to the space through which the point of expansion has receded in the column. Thus while the length of the grades increases with the uniform velocity v, their number, velocity and density remain unchanged. Consequently no other gradations of density can exist in front of a column expanding into a vacuum, but those which correspond to the terms of the infinite geometrical series $\frac{D}{2}, \frac{D}{4}, \frac{D}{8}, \frac{D}{16}$, &c.; and no other gradations of velocity but those which correspond to the terms of the infinite arithmetical series v, $2v$, $3v$, $4v$, &c.

The point of expansion in the column recedes with the velocity v; and since the length of the first grade is always equal to the space through which that point of expansion has moved, it follows that the point of expansion from the first into the second grade is stationary. And since the second grade increases in length with the velocity v, the third point of expansion moves forward with the velocity v; and since all the other grades increase in length with the same velocity v, the velocities of the several points of expansion will be expressed by the following series $-v$, 0, v, $2v$, $3v$, $4v$, &c.

In order to give a synopsis of the results to which we have come, let AB be a column of fluid of the density D, expanding into a vacuum toward C. Let the velocity due to a height equal to one fourth of the subtangent of the fluid be v. Suppose expansion to have commenced at B, and the point of expansion to have receded to any distance n. Set off from B an infinite number of spaces Ba, ab, bc, cd, &c., each equal to Bn. Then the points n, B, a, b, c, d, &c., are the places of the points of expansion, and the boundaries of the several grades, or parts having different degrees of density and velocity, into which the original mass Bn has been distributed.



Between these points respectively the densities are $\cdot\ \frac{D}{2}\ \cdot\ \frac{D}{4}\ \cdot\ \frac{D}{8}\ \cdot\ \frac{D}{16}\ \cdot\ \frac{D}{64}\ \cdot$ &c.

The velocities are $.\ v\ .\ 2v\ .\ 3v\ .\ 4v\ .\ 5v\ .$ &c.

These points move toward C with the velocities $-v$ 0 v $2v$ $3v$ $4v$ &c.

and relatively to each other, and to the fluid, with the velocities v v v v v v

As corollaries from the preceding investigation we may state the following propositions.

1. No other gradations of density can exist in front of a column of fluid which is expanding towards a vacuum except those which are found by successive divisions of the original density by 2.

2. The change of density in the fluid in passing from one of these grades to the next is not *gradual*, but *instantaneous;* so that the grades are constantly separated from each other by a mere imaginary plane.

3. No other velocities can exist among the parts of a fluid which is expanding toward a vacuum but such as are multiples of the velocity which a body will acquire by falling through one fourth of the subtangent of the fluid.

4. The velocity imparted to the particles of an expanding fluid is not the result of a continual and gradual acceleration, but of successive instantaneous increments equal to that which a body will acquire by falling through one fourth of the subtangent of the fluid.

It now remains to consider the mode of expansion when the fluid is not free to expand indefinitely, but has its expansion arrested at some given density d.

It is obvious that if d correspond in value to any of the terms of the series, the manner of expansion up to that point will be the same as if the expansion were continued indefinitely. There will therefore be in the expanding fluid, in such case, so many grades corresponding to the terms of the series, as there are of complete terms intervening between D and d. But let us inquire what takes place when d does not correspond to any of the terms of the series. First, suppose d to be greater than the first term. Then from what has been before shown, the velocity of the point of expansion is that which a body will acquire by falling through $\frac{H-h}{2}$ when $H-h$ is the height of a column whose weight is equal to the elastic force of the expanded fluid; also that the velocity of the point of expansion is that due to the height $\frac{H}{4}$ when the expansion is from D to $\frac{D}{2}$. These velocities are as $\sqrt{\frac{H}{4}}$ to $\sqrt{\frac{H-h}{2}}$ and since $H : H-h :: D : d$, those velocities are as $\sqrt{\frac{D}{4}}$ to $\sqrt{\frac{d}{2}}$. The velocity due to $\frac{D}{4}$ is v. Hence we have $\sqrt{\frac{D}{4}} : \sqrt{\frac{d}{2}} :: v : v\sqrt{\frac{2d}{D}}$ = velocity of the point of expansion in this case.

Let us next find the velocity of the fluid. The times of running over s by the point of expansion, with the velocities $\sqrt{\frac{D}{4}}$ and $\sqrt{\frac{d}{2}}$ are inversely as these velocities; and the velocities imparted to the mass Ds in these times are as the products of the times by the respective forces. When the velocity of the point of expansion was $\sqrt{\frac{D}{4}}$ the force was $\frac{D}{2}$ and the velocity of the fluid was v. The force in the present case is $D-d$. Hence we have

$$\frac{\frac{D}{2}}{\sqrt{\frac{D}{4}}} : \frac{D-d}{\sqrt{\frac{d}{2}}} :: v : v\sqrt{2}\cdot\frac{D-d}{\sqrt{Dd}} = \text{velocity of the fluid in this case.}$$

Secondly, suppose the value of d to fall between any two consecutive terms of the series. It is obvious that we have now only to substitute in the expression last found that term of the series which is next greater than d for D, and it will then express the acceleration due to expansion from the last complete term into the fractional grade.

To find the retrogressive velocity of the point of expansion, relatively to the fluid, in the grade which precedes the fractional grade, we must make the like substitution of the last complete term for D in the quantity $v\sqrt{\frac{2d}{D}}$ found above. The retrogressive velocity of the point of expansion in the grade which precedes the fractional grade is greater than in the other grades, and of course that grade will be shorter than the others in the same ratio. This is the only modification which a fractional grade produces in those that precede it. In all other respects the mode of expansion, up to the fractional grade, corresponds to the view presented in the foregoing synopsis.

We are now prepared to construct a formula for the final velocity of a fluid which expands from any density D to any other density *d*.

Let V be the final velocity; *v* the velocity due to a height equal to one fourth the subtangent of the fluid; *n* the number of complete terms of the series $\frac{D}{2}, \frac{D}{4}, \frac{D}{8}, \frac{D}{16}$, &c., which intervene between D and *d*.

Then *vn* is obviously the velocity of the grade which precedes the fractional grade, if there be a fractional grade. When the first grade is fractional we found its velocity to be $v\sqrt{2}\cdot\frac{D-d}{\sqrt{Dd}}$; and we also found that to suit this expression to the case of a fractional grade occurring elsewhere in the range of the series, we are to substitute for D that term of the series which is next greater than *d*. Now the value of that term will be $\frac{D}{2^n}$. Making the substitution accordingly, the expression for the additional velocity due to expansion into the fractional grade becomes, after reducing, $v\sqrt{2}\cdot\frac{D-2^nd}{\sqrt{2^nDd}}$. By adding this quantity to *vn* we obtain the final velocity of the fluid, resulting from its expansion from any density D to any other density *d*. Hence the formula is

$$V = v\,.\,\overline{n+\sqrt{2}\cdot\frac{D-2^nd}{\sqrt{2^nD_d}}}\,.$$

When there is no complete term of the series between D and *d*, $n=0$ and the above formula becomes $V=v\sqrt{2}\cdot\frac{D-d}{\sqrt{Dd}}$.

When there is no fractional grade, that is, when *d* is equal to some term of the series, that part of the formula beyond *n* equals 0, and then the above formula becomes $V=vn$.

From the general principles here developed it is obvious that, as in expansion, so likewise in *condensation*, the transition of an elastic fluid from one density to another is not by gradations which may be represented by a curve, but abrupt, instantaneous, *per saltum vel saltus*. Pulses, therefore, which are propagated in elastic fluids partake of the same character; that is, the condensation and subsequent reëxpansion of the successive elements through which the wave moves is instantaneous. This fact was not known when the article on the propagation of pulses, referred to at the commencement of this article, was written. It however does not affect the validity of the reasoning in that article.

XXXIV.—*On the Rotation of the Plane of Polarization of Heat by Magnetism;* by MM. F. DE LA PROVOSTAYE and P. DESAINS.*

SHORTLY after the brilliant discovery of Prof. Faraday of the rotation of the plane of polarization of light by magnetism, M. Wartmann announced† that he had tried the same experiment with radiant heat. He employed the heat of a lamp, which he partially polarized by making it pass through two piles of mica crossed at right angles. The electro-magnets and a cylinder of rock-salt were placed between these piles, and consequently very near the thermo-electric apparatus. The galvanometer, on the contrary, to be preserved from the action of the electro-magnets, was removed to a great distance; but the result was a considerable increase in the length of the circuit, and a diminution of sensitiveness.

Notwithstanding all these inconveniences, which he clearly pointed out, and which he was not able to overcome, M. Wartmann thought he observed that the needle of the galvanometer, after having attained a fixed deviation under the influence of the radiation not intercepted by the piles of mica, was again displaced and took a fixed position different from the first when the current was established, which seemed to indicate a rotation of the plane of polarization of heat.

At Paris, some persons having vainly attempted to reproduce these phenomena, we have considered that it would be useful to revert to these experiments, and to point out a method which permits of making them succeed with facility.

We have introduced into M. Wartmann's process three principal modifications:—1st, we employ solar heat; 2ndly, we take for polarizing apparatus two prisms of achromatic spar; 3rdly, and this appears to us indispensable, instead of placing the principal sections at 90°, we arrange them so that they make an angle of nearly 45°.

The employment of spars and solar light permits of removing the electro-magnets to a great distance from the thermo-electric pile. With respect to the arrangement of the prisms, the law of Malus shows all the advantages which it presents. In fact, let us take for unity the deviation which the solar ray transmitted through the principal parallel sections would produce. The deviation, when the prisms form an angle of 45°, will be $\cos^2 45^\circ = \frac{1}{2}$. If the current is set in action, and it produces a rotation of

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* From the Annales de Chimie et de Physique, October, 1849,—cited from Phil. Mag., xxxv, 481.

† Institut, May 6th, 1846, No. 644.

the plane of polarization equal to δ, the deviation will be, according to the direction of the current, $\cos^2(45^\circ-\delta)$ or $\cos^2(45^\circ+\delta)$, and we shall then have, for the difference of the effects observed when the current is made to pass in a contrary direction,

$$\cos^2(45^\circ-\delta)-\cos^2(45^\circ+\delta)=\sin 2\,\delta.$$

On placing the principal sections at 90°, the difference of the deviations would be only

$$\cos^2(90^\circ-\delta)-\cos^2 90^\circ=\sin^2\delta,$$

or

$$\cos^2(90^\circ+\delta)-\cos^2 90^\circ=\sin^2\delta.$$

Now $\sin^2\delta$ is considerably less than $\sin 2\delta$. If, for example, we suppose $\delta=8^\circ$, $\sin^2\delta$ is equal to more than fourteen times $\sin 2\delta$.

The eye, it is true, appreciates readily the transition from darkness to light, but not so the difference in brightness of two luminous images. This is not the case with the thermoscopic apparatus. There is therefore, when heat is concerned, a great advantage in proceeding as above directed.

The following are the details of the experiment: the solar ray, reflected by a heliostat, traverses at first a doubly-refracting achromatic prism. The extraordinary bundle was intercepted: the ordinary bundle traverses the electro-magnet of M. Ruhmkorff's apparatus, and a flint-glass of 38 millimetres in thickness between the poles of the electro-magnet. It afterwards encounters, at about $3^{m}\cdot 50$, the second prism of spar, bifurcates again, and gives two images, one of which may be received on the thermo-electric pile placed at four metres from the electro-magnet. The galvanometer was still a little further removed from this disturbing force. It was ascertained, by direct and repeated experiments, that on establishing the current there were no phenomena of induction, and that the electro-magnets had no appreciable action on the magnetic needle which, under their influence, remained at zero in a state of perfect rest. In order to understand this, it must be borne in mind that the two opposite poles are very close together, and that they act simultaneously upon a system already very distant and almost completely astatic. It might be feared that the electro-magnet, without action on the needle at zero, acted on the needle already displaced by the action of the calorific radiation. This would be possible in fact, if, in its first position, the needle had the same direction as the line which joins its centre to the electro-magnet, and if, when it deviates, it made a notable angle in that direction. In our experiments, precisely the inverse condition was realized; so that the component of the magnetic action diminished more and more during the movement of the needle, and became perfectly null when it attained its greatest deviation. If therefore it had no action in the first case, such ought for a stronger reason to be the case in the second.

By means of a commutator the electric current could be made to pass, now in one direction, now in another, through the wires of the electric magnet. We shall designate the two currents by the abridged expressions *Current* A, *Current* B.

The following are the deviations observed:—

Experiments of September 22.

(A Muncke's battery of 50 elements with large surfaces, but already worn, was employed.)

FIRST SERIES.

	Deviations.
Current A,	21·0
Without current,	19·0
Current A,	21·4
Without current,	18·6

SECOND SERIES.

(Acid was added.)

Without current,	20·5
Without current,	20·6
Current B,	18·6
Without current,	20·9
Current A,	23·6
Current B,	18·8
Current A,	22·0
Current B,	18·0
Without current,	19·9

THIRD SERIES.

Current B,	17·4
Current B,	17·1
Current A,	19·5
Without current,	18·3

Experiments of September 29.

(A Bunsen's battery of 30 elements, well-cleaned and amalgamated, was employed.)

FIRST SERIES.

	Deviations.
Without current,	12·0
Current A,	14·9
Current B,	8·6
Without current,	11·7
Current B,	8·8
Without current,	11·8

SECOND SERIES.

	Deviations.
Without current,	18·4
Current B,	14·9
Current A,	21·7

It is to be remarked, that here, if the principal sections of the prisms were perpendicular, the deviation, at first null, would scarcely attain one semi-division when one of the currents was made to act.

Lastly, to obviate every objection, a third series of experiments was made by taking away the prism of flint-glass, and observing the deviations produced by the solar ray, when, as before, the electric current was made to pass in the wires of the electro-magnet, now in one direction, now in another.

	Deviations.
Current A	16·5
Current B	16·8
Current A	16·8

As should be the case, the deviations are equal, which proves that the electric current and the magnet change the deviations in acting on the flint-glass and not in acting on the needle of the galvanometer.

The above experiments establish, we believe, in an irrefragable manner, the rotation of the plane of polarization of heat under the influence of magnetism.

ART. XXXV.—*Historical account of the Eruptions on Hawaii;*

by JAMES D. DANA.*

THE island of Hawaii has a nearly triangular outline with the three sides fronting severally, west, southeast, and northeast. The western side is about 85 geographical miles in length, the southeast 65, and the northeast 75 miles. The whole surface pertains to the slopes of three lofty volcanic summits, Mount (or Mauna) Loa† constituting its southern portion, 13,760 feet in height, Mount Kea, long extinct, covering the northern portion, 13,950 feet in height, and Hualalai towards the western shores, estimated at 10,000.

The voyager approaching Hawaii, while admiring the sublimity of its swelling heights, is struck with the unbroken surface of the island. Lofty peaks and alternating valleys and ridges are so generally characteristic of mountain scenery, that he views the even and gentle slope of the summits Loa and Kea with a degree

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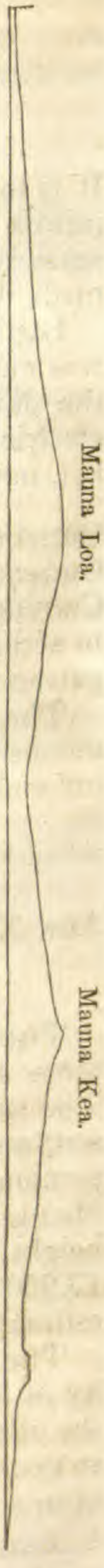
* Extracted and condensed from the Author's Exp. Expd. Geological Report.

† This name is often written *Roa.* L and r are interchangeable letters in the Hawaiian dialect. The l sound is most common, and is adopted in the written language of the islands.

of amazement. The former rises with a scarcely perceptible inclination, (see annexed cut,) without a break in the surface apparent in the distant view; then gradually rounds over, and declines on the opposite side with the same gentle declivity. The eye following along, up and down the sides of Mount Kea, meets with the same slopes, and only few traces of indentations. Mount Loa is a flat dome. Mount Kea rises to the same altitude, and differs only in having the summit somewhat pointed.



OUTLINE VIEW OF HAWAII, FROM THE EASTWARD.

From these descriptions the statement will be appreciated that the heights of Hawaii are not peaks in a mountain range, but three isolated domes or low cones, united by a confluence of lavas at base. The surface of the island is not a mass of broken mountains, but the simple slopes of these elevations. Yet on an actual scramble over the sides, there are found extensive ravines and ridges of lava which impede the progress: and numerous craters form large elevations usually ranging between three and nine hundred feet in height. There are also numerous gorges on the eastern and northern foot of Kea, which extend from the sea half-way up the mountain, and are from three hundred to a thousand feet in depth. The Kohala range on the north, which is the only part not conformable to this system, faces the interior of the island with a nearly vertical front, while northward the slopes are less abrupt and are profoundly intersected by valleys.

Mount Kea has an average slope of 7° 46′. The slope of Mount Loa on the south averages 7° 33′; on the west 5° 28′; on the east, to Kilauea, (a distance of 19·8 miles from the axis,) 6° 42′; making 6° 30′ the average for the dome. From Kilauea to the sea, the slope averages but 1° 28′, equivalent to 135 feet to the mile. The following map of a part of Hawaii* will assist in conveying an idea of the form of Mount Loa, the position of the crater at summit, and of Kilauea on its east-southeastern flank, 3970 feet above the sea.

We may hence assume 6° 30′ as the average inclination of the great dome. This gives for the base of the dome a breadth of forty-five and three-fourths miles. This however is only the central portion of the mountain: for the slopes spread very much below,

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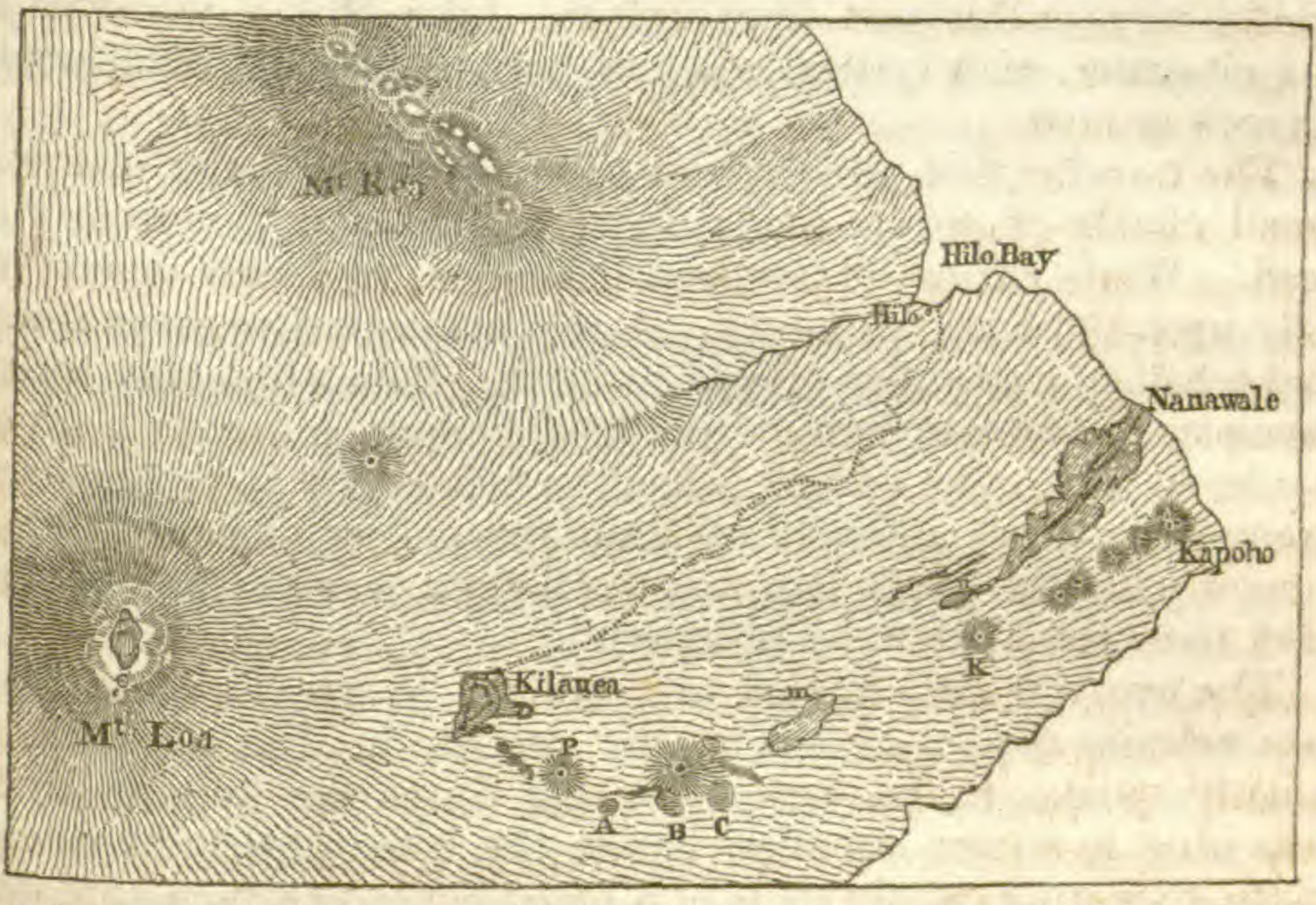
* This map is reduced from the chart published with the Narrative of the Expedition.

diminishing eastward to a single degree, so that the region of volcanic action subordinate to Mount Loa, is about seventy miles in width, or includes the entire breadth of the island, from east to west. The main part of the mountain, if considered a portion of a great sphere,* will correspond to a segment 13,760 feet deep, cut from a globe four hundred miles in diameter; or in form, to a segment about one-twelfth of an inch deep from a globe twelve inches in diameter: and in such a segment as last referred to, the terminal crater would be represented by an indentation one-fifteenth of an inch broad, and Kilauea by another one-tenth of an inch broad; and both about a fifteenth of their breadth in depth. The dome, consequently, instead of having slender walls at top, has a horizontal thickness of full twenty miles, eighteen hundred feet vertically below its summit.†



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* It varies a little from a segment of a sphere, the upper parts being slightly more prominent.

† For comparison with other lofty volcanic mountains we here mention a few other inclinations, as determined in different instances.

The peak of Teneriffe has an average inclination of 12° 30′, the proportion of height to diameter being given as 1 to 9.

Etna, according to Elie de Beaumont, has an average inclination of 8 degrees. M. von Buch makes the ratio of height to circumference as 1 to 34, giving the angle 10½ degrees. The Chimborazo dome, according to Humboldt, is only 673 toises through at a level of 153 toises (or 978 feet) below the centre of top.

It is much to be regretted that artists, when sketching mountains, are not content with giving them their actual slopes instead of attempting improvements by straightening up their sides, and sharpening their summits. Even in works of science, the same errors are common. We never see a drawing of Jorullo, which does not give the peak actually impossible slopes, taking Humboldt's own facts as a criterion. Drawings of Vesuvius and Etna, in the most prominent of our geological treatises, are equally objectionable. A simple outline, if correct, gives reliable information; and is far more valuable to science, than one improved to suit the fancy, though sketched with the skill of a master.

The two craters of Mount Loa are still active. The summit crater, called Mokua-weo-weo, measuring 13,000 and 8000 feet in its diameters, has a depth of 784 feet along its western precipice. Kilauea, the crater of most renown, is marked by no conical elevation; and the declivities of the parent mountain hardly vary in this part from a plain. Like Mokua-weo-weo it is a pit-crater, with vertical sides of horizontally stratified basaltic rock or lava.

The traveller first perceives his approach to the crater in a few small clouds of steam rising from fissures not far from his path. While gazing for a second indication he stands unexpectedly upon the brink of the pit. A vast amphitheatre seven miles and a half in circuit has opened to view. Beneath a gray rocky precipice of 650 feet, forming the bold contour, a narrow plain of hardened lava, (the "black ledge,") extends like a vast gallery around the whole interior. Within this gallery, below another similar precipice of 340 feet, lies the bottom, a wide plain of bare rock more than two miles in length.

The eye naturally ranged over the whole area for something like volcanic action, as it is usually described. But all was singularly quiet. In the dark plain that forms the bottom, there was little to attract attention beside the utter dreariness of the place, excepting certain spots of a blood-red color which appeared to be in constant yet gentle agitation. Instead of a sea of molten lava "rolling to and fro its fiery surge and flaming billows," we were surprised at the stillness of the scene. The incessant motion in the blood-red pools was like that of a cauldron in constant ebullition. The lava in each boiled with such activity as to cause a rapid play of jets over its surface. One pool, the largest of the three then in action, was afterwards ascertained by survey to measure one thousand five hundred feet in one diameter, and a thousand in the other: and this whole area, into which the Capitol grounds at Washington might be sunk entire, was boiling, as seemed from above, with nearly the mobility of water. Still all went on quietly. Not a whisper was heard from the fires below. White vapors rose in fleecy wreaths from the pools and numerous fissures, and above the large lake they collected into a broad canopy of clouds, not unlike the snowy heaps or cumuli that lie near the horizon in a clear day, though changing more rapidly their fanciful shapes. On descending afterwards to the black ledge, at the verge of the lower pit, a half-smothered gurgling sound was all that could be heard from the pools of lava. Occasionally there was a report like musketry which died away, and left the same murmuring sound, the stifled mutterings of a boiling fluid.

Such was the general appearance of Pélé's pit in a day view, at the time it was visited by the author.*

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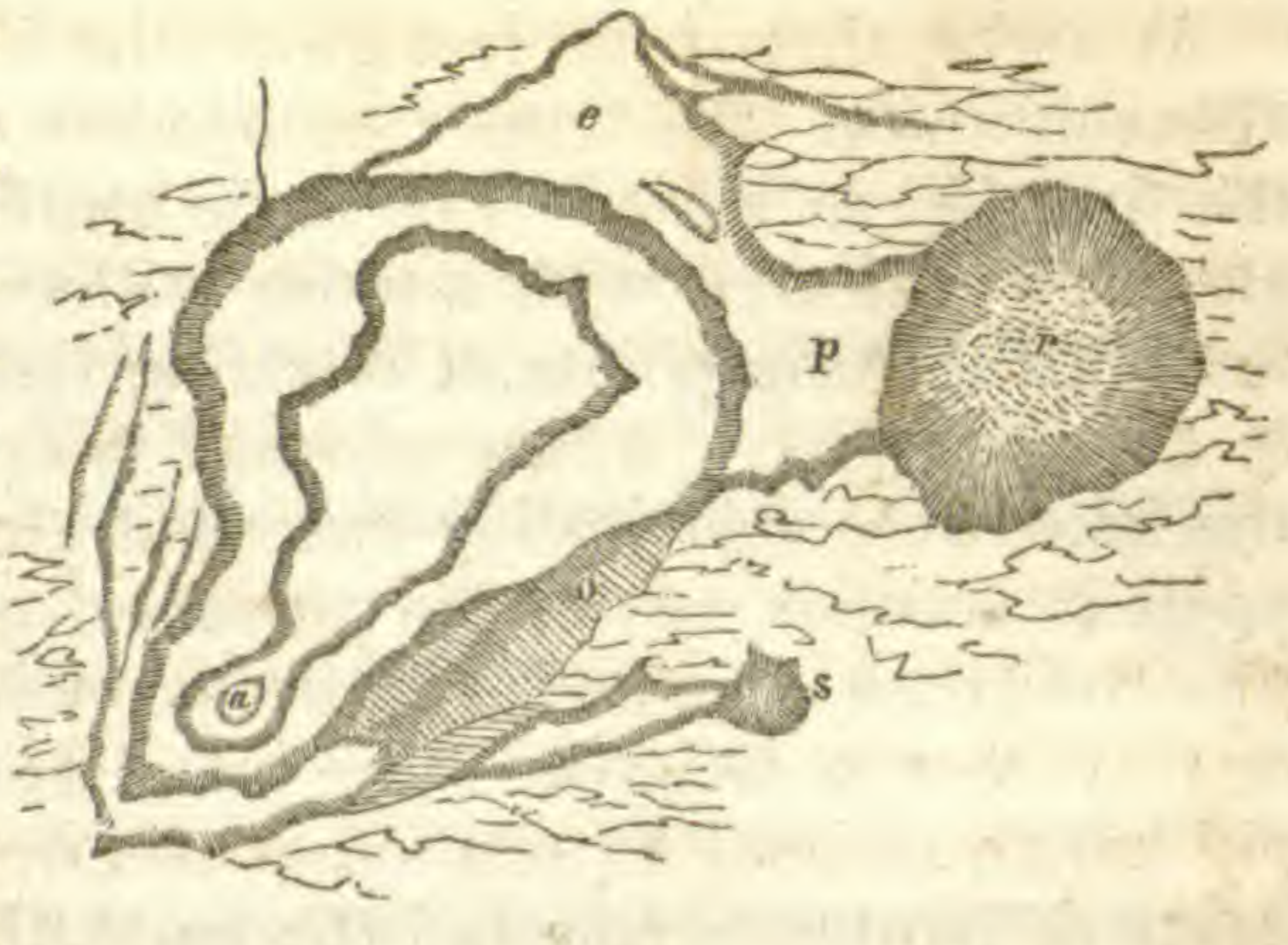
* In November, 1840.

At night, though no less quiet, the scene was one of indescribable sublimity. We were encamped on the edge of the crater, with the fires full in view. The large cauldron, in place of its bloody glare, now glowed with intense brilliancy, and the surface sparkled with shifting points of dazzling light, occasioned by the jets in constant play. A row of small basins on the southeast side of the lake were also jetting out their glowing lavas. Two other pools in another part of the pit tossed up their molten rock much like the larger cauldron, and occasionally burst out with jets forty or fifty feet in height. The broad canopy of clouds above the pit which seemed to rest on a column of wreaths and curling heaps of lighted vapor, and the amphitheatre of rocks around the lower depths, were brightly illumined from the boiling lavas; while a lurid red tinged the distant parts of the inclosing walls and threw into deeper shades of darkness the many cavernous recesses. And over this scene of restless fires and fiery vapors the heavens by contrast seemed unnaturally black, with only here and there a star like a dim point of light.

The next night streams of lava boiled over from the lake, and formed several glowing lines diverging over the bottom of the crater. Towards morning, there was a dense mist, and the whole atmosphere seemed on fire. The lakes were barely distinguished through the haze, by the spangles on the surface that were brightening and disappearing with incessant change.

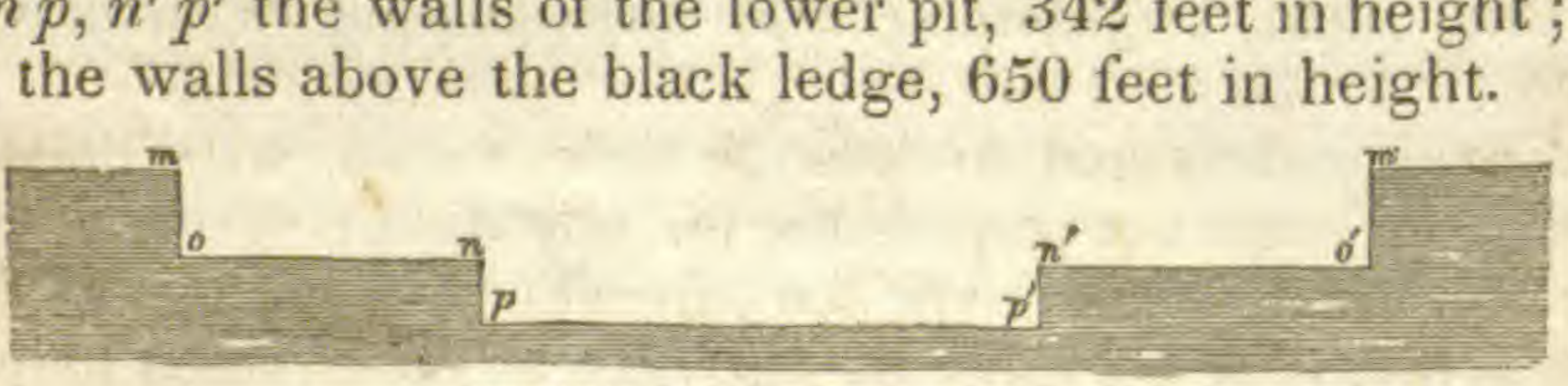
We have endeavored to describe these views, with literal correctness. We are not responsible for any disappointment the account may create, as we could see only what was actually before us. Pele was in one of her sober moods. Yet we have reason to believe that this is her usual state, and assuredly there is a terrible grandeur even in her quiet. The action when most roused has been much exaggerated in its character; for boiling and overflowing, with occasional detonating explosions, constitute in every condition the characteristic features: in its greatest violence, the cauldrons are more numerous and extensive, the spouting cones multiply in number, the explosions are loud and frequent, and the sheets of lava at each overflow spread through the whole crater. Such a scene over an area seven and a half miles in circuit, must be terrific beyond description, although the "sea" be no sea; and the "waves" but the agitations of violent ebullition and frequent overflowings.

The accompanying bird's-eye view of Kilauea, reduced from the surveys of the Expedition, shows its oblong-ovate form and general features, though giving no adequate idea of its magnitude. The longest diameter lies nearly northeast and southwest, and is sixteen thousand feet in length; the average breadth is seven thousand five hundred feet. The pit includes, therefore, an area



of nearly four square miles,* thus exceeding in extent many a city of one hundred thousand inhabitants. Yet on looking into it from above, it is difficult to realize its size, as there is no object within or about it which can serve for comparison. No one would imagine that two hundred such structures as St. Peter's at Rome could be accommodated within its walls, or that the lofty dome of this cathedral would stand with its pinnacle but little above the black ledge. The great lake of boiling lava (*a*), 1000 feet by 1500, as above mentioned, is a small object in such an area.

A better idea of the internal form of the pit will be obtained from a transverse section here represented. It is taken in the line of the shorter diameter; a section through the longer diameter on the same scale (a third of an inch to a thousand feet) would not have room on the page; *m m'* is the whole breadth of the crater; *o n*, *o' n'*, the black ledge; *p p'* the bottom of the lower pit; *n p*, *n' p'* the walls of the lower pit, 342 feet in height; *m o*, *m' o'*, the walls above the black ledge, 650 feet in height.



VERTICAL SECTION OF KILAUEA.

The walls of the crater (*m o*) are vertical, or nearly so, through the most of their circuit. There is a break with several fissures in the northeast corner, (in the figure above, the *upper* side is *north*,) where is the usual place of descent; and on the southeast side (*o*) there are two or three sloping declivities, on which one of the famous sulphur banks is situated.

Without continuing with these details relating to the crater of Kilauea, we proceed to an account of the eruptions of which we have knowledge.

The first eruption of this crater of which tradition gives any definite knowledge, occurred about the year 1789, during the wars and conquests of Ka-meha-meha. It took place between Kilauea and the sea in a southeasterly direction. It is said to have been accompanied by violent earthquakes and rendings of the earth: and an eruption of cinders and stones from the opened fis-

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* As nearly as can be ascertained from the map of the crater the area is three and two-thirds square miles, or 100,000,000 square feet.

sures. It was so violent and extensive that the heavens were completely darkened; and one hundred lives are supposed to have been lost. There are now, over a large area near Kilauea a few miles distant to the south and southeast, great quantities of a light pumice-like scoria, with stones and sand, which are believed to have been thrown out at this time.*

The famous outbreak of lavas, in 1823, and the features of the crater after it, are described by Mr. Ellis in his Polynesian Researches.† A large tract of country in Kau, the southern district of Hawaii, was flooded, and the stream, where it reached the sea, as I am informed by Rev. Mr. Coan, was five to eight miles wide. The earth is said to have been rent in several places, and the lavas were ejected through the fissures, commencing their course above ground some miles south of Kilauea. There was no visible communication with the lavas of this crater at the time; but the fact of their subsiding some hundred feet simultaneously with the eruption is satisfactory evidence of a connection. The crater after the eruption, as described by Mr. Ellis,‡ had the same general

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* The following account of this eruption is from a "History of the Sandwich Islands," by Rev. I. Dibble, published at Lahainaluna (island of Maui) in 1843. It was taken by the author from the lips of those who were part of the company, and present in the scene. The army of Keoua, a Hawaiian chief, being pursued by Kamehameha, were at the time near Kilauea. For two preceding nights, there had been eruptions, with ejections of stones and cinders. "The army of Keoua set out on their way in three different companies. The company in advance had not proceeded far before the ground began to shake and rock beneath their feet, and it became quite impossible to stand. Soon a dense cloud of darkness was seen to rise out of the crater, and, almost at the same instant, the thunder began to roar in the heavens, and the lightning to flash. It continued to ascend and spread around until the whole region was enveloped, and the light of day was entirely excluded. The darkness was the more terrific, being made visible by an awful glare from streams of red and blue light, variously combined through the action of the fires of the pit and the flashes of lightning above. Soon followed an immense volume of sand and cinders, which were thrown to a great height, and came down in a destructive shower for many miles around. A few of the forward company were burned to death by the sand, and all of them experienced a suffocating sensation. The rear company, which was nearest the volcano at the time, suffered little injury, and after the earthquake and shower of sand had passed over, hastened on, to greet their comrades ahead, on their escape from so imminent peril. But what was their surprise and consternation, to find the centre company a collection of corpses. Some were lying down, and others were sitting upright, clasping with dying grasp their wives and children, and joining noses (the mode of expressing affection,) as in the act of taking leave. So much like life they looked, that they at first supposed them merely at rest, and it was not until they had come up to them and handled them, that they could detect their mistake." Mr. Dibble adds, "A blast of sulphurous gas, a shower of heated embers, or a volume of heated steam, would sufficiently account for this sudden death. Some of the narrators who saw the corpses affirm, that though in no place deeply burnt, yet they were thoroughly scorched."

† Polynesian Researches, vol. iv., p. 211.

‡ Mr. Ellis, and many that have followed him in describing Kilauea, make much use of the word "flames," as though flames were actually seen. It is an excusable mistake, where the scenes are so startling and so far beyond description. An account appeared in a public print at Honolulu, about the time of the arrival of the squadron, in which "flames" were called in to give vividness to the description. It is needless to say that none were seen there by the writer, although the condition was the same as for the month previous.

features as when visited by the Expedition. The black ledge continued completely around the crater, and was "three or four hundred feet" above the bottom. The pit was, however, in a more active state: for the southwest and northern parts are represented as vast floods of lava, and there were fifty-one small cones with craters, twenty-two of which gave out vapors, and some ejected lavas. Ellis remarks that the crater appeared as if, a short time before, the lavas had been as high as the black ledge.

In June, 1832, an eruption took place both from Kilauea and the summit crater of Mt. Loa. The only eruption, at this time, of the lavas of Kilauea to the surface, of which we have definite account, occurred in the east wall of the crater. A deep fissure was opened in the wall, (near *p*, figure on page 352,) from which streams flowed out, part back into Kilauea down the steep slope, and part across into the "Old Crater" (*r*), which, at the time, was overgrown with wood. It is important to trace out, as far as we are able, the changes which preceded it.

a. The first published account of the crater subsequent to Ellis's, is that of the Rev. C. S. Stewart, who visited it in July, 1825.* He states that it was nearly in the condition represented by Ellis in 1823. The bottom was several hundred feet below the level of the black ledge. Fifty-six conical craters were counted, and the action was violent and noisy. A plan of the crater at this time, by Lieutenant Malden, is given by Byron. The black ledge is represented as very much narrower than at present, so that the lower pit occupied nearly the whole width of the crater: the height of the ledge is stated at four hundred feet. The plan represents numerous cones over the bottom, and the two largest occupy together the whole transverse diameter of the crater, which would give for each a diameter of three thousand feet or more at base.†

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* Journal of a Voyage to the Pacific Ocean, and Residence at the Sandwich Islands, in the years 1822–1825, by C. S. Stewart; 12mo, 1828. New York. p. 355.

† A reduced copy of Lieutenant Malden's plan is annexed, as it will give increased interest to the facts observed by the Expedition. A, is a cliff of eighty feet; B, a cliff of one hundred and fifty feet; C, Lord Byron's encampment; E, the point on the black ledge where they descended to the bottom; 1, the crater in action visited by Lord Byron; 2, a sulphur cone; 3, crater that broke out at the time of the visit, 29th of June; 4, crater brilliantly in action; 5, the largest crater; 6, a deep fissure; 7, deepest and most precipitous part of crater. The whole crater is not represented. The largest cone (5) is nearly half the diameter of the lower pit, and must have been three or four thousand feet in breadth.

b. In December of the same year, Rev. A. Bishop observed that the crater had filled up much since the visit he made with Mr. Ellis, and he estimates the amount of change as four hundred (?) feet. There were a large number of cones "fifty to one hundred feet high," besides lakes boiling with much agitation, "every now and then sending forth a gust of vapor and smoke, with great noise." He adds, "the natives remarked that after rising a little higher the lava will discharge itself, *as formerly*, towards the sea *through some aperture under ground*."*

c. In October of 1829, Rev. C. S. Stewart made a second visit to the crater, and found, as he states, that the lower pit, instead of being four or five hundred feet deep, as when he before saw it, was but two hundred feet. He remarked that it had filled up at least two hundred feet. It was more quiet than in 1825, but there were still several boiling lakes of lava, and some cones in great activity.†

d. In September of 1832, when the Rev. J. Goodrich visited Kilauea, the eruption had taken place.‡ He says that every thing had changed. The lavas, which previously had increased so as *to fill up to the black ledge, and fifty feet above,* about nine hundred [four hundred ?] feet in all, had sunk down again nearly to the same depth, leaving, as usual, a boiling cauldron at the south end. The earthquake of *January preceding* had rent in twain the walls of the crater, on the east side, from top to bottom, producing seams from a few inches to several yards in width, from which the region between the two craters was deluged with lava. About half way up the precipice there was a rent a quarter of a mile in length, from which immense quantities of lava boiled out directly underneath the hut formerly occupied by the party of Lord Byron. The position of Byron's hut is seen at C, on the figure at the foot of the preceding page, and near p, on the figure on page 352.

From these accounts, it is probable that in addition to the ejections from the east wall, which are insufficient to account for the subsidence in the lower pit, there must also have been a subterranean outlet beneath the sea, as the native with Mr. Bishop had predicted. This elevation of the lava a thousand feet above the lower pit, with its discharge from the very wall of the crater, is worthy of special note.

The next eruption to that of 1832, was the one already referred to, that commenced on the 30th of May, 1840, the lavas of which, where they reached the sea, were in some places still hot when visited by the author in the November following.

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* Missionary Herald, xxiii, 53.

† Visit to the South Seas, 2 vols. 12mo. New York, 1831.—ii, 78.

‡ American Journal of Science, xxv, 199.

The only published accounts of the crater subsequent to that just mentioned by Mr. Goodrich, and previous to this eruption, are those of Mr. Douglass,* Captain E. G. Kelley, (from statements by Captains Chase and Parker,)† Count Strzelecki,‡ and Captain John Shepherd.§

a. Mr. Douglass was at Kilauea in January, 1834. The pit, by his measurements, was one thousand feet deep, and the black ledge and lower pit appear to have been in the same condition as when seen by Mr. Bishop. There was a lake of boiling lava in the north end, three hundred and nineteen yards in diameter, besides the large one in the south end. The movement of the lavas to the southward (a consequence of the ebullition) was estimated to have a velocity of three and one-fourth miles per hour.

b. Captains Chase and Parker visited the crater in 1838, four years after Mr. Douglas. At that time, as the sketch made by them on the spot indicates, the lavas had so increased that the lower pit was almost obliterated, the bottom having risen nearly to a level with the black ledge. This will be understood from the figure on page 352: all the bottom pit between *p n* and *p′ n′* had become filled up, by the successive overflowings, to within forty feet of the top, and over the four square miles of area, the fires were in great activity. There were six boiling lakes of lava, and twenty-six cones from twenty to sixty feet high, eight of which were throwing out cinders and red hot lava. Standing by the side of one of these lakes, they looked down more than three hundred feet upon its agitated surface: "after a few minutes the violent struggle ceased, and the whole surface of the lake was changed to a black mass of scoria; but the pause was only to renew its exertions, for while they were gazing at the change, suddenly the entire crust which had been formed commenced cracking, and the burning lava soon rolled across the lake, heaving the coating on its surface like cakes of ice upon the ocean surge. Not far from the centre of the lake was an island which the lava was never seen to overflow." These interesting facts illustrate several points of special importance in volcanoes, viz. (1) The rapidity with which lava cools; (2) The frequent rise of temperature that takes place even in boiling lakes, arising from a new gushing from the source below; (3) the formation of clinkers, well compared to the breaking up of ice. From the account of Captain Kelley, it appears that the whole bottom of the crater was not in fusion. On the contrary, the greater part was black lava, over which they travelled to the brink of some of the pools;

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* Jour. of the Roy. Geog. Soc., vol. iv.

† American Journal of Science, xl, 117; with a drawing of the crater, which shows that the obliteration of the lower pit was nearly complete.

‡ Hawaiian Spectator, i, 436.

§ Athenæum, Nov. 14, 1840; Roy. Geog. Soc. of London, 1840. Captain Shepherd evidently misunderstood the mode of action at the crater.

yet at times floods of lava covered a large portion of the whole area. The pools were in violent agitation, and "hissing, rumbling, agonizing sounds, came from the depths of the dread abyss."

c. When seen by Count Strzelecki in the same year, it was still in the condition above described. There were six lakes, one, as he states, of 300,000 square yards area, and five of about 5,700 square yards each. The great lake was in violent action.

d. Captain Shepherd was at the crater, Sept. 16, 1839. There were "numerous small cones, twenty to thirty feet high," "lakes of molten matter in violent agitation," besides a "great lake," one mile long and half a mile broad. The party, (notwithstanding the activity, be it observed,) *descended into the crater*, and visited several of the cones and small lakes on their way to the great lake. This lake was in "violent ebullition," underwent constant changes of brightness, and in some places flowed on, "leaving ridges of scoria on the northern shore."

e. We learn from the natives, that, for a week previous to the outbreak, the whole interior was a fearful scene of fiery deluges and ejections. There was no black ledge; for the lavas, by their overflowings, since 1832, had not only filled up the central pit, but accumulated over the ledge, and all was one vast theatre of intense action. The mountain was thus charged. The pressure on the sides below from the lavas and confined vapors had become immense. As a natural consequence fissures opened, and the lavas were drawn off; the centre of the great pit consequently sunk down three hundred and fifty or four hundred feet, which was its condition when visited by us.

There was no great earthquake, no shaking of Mount Loa. At Hilo not the faintest rumbling was heard or felt; and only slight quiverings to the south. It was a simple tapping of the great cauldron, Kilauea; and after it, the crater became comparatively inactive. Its black hardened surface, and the one or two boiling pools which remained over the vast area, exhibited the subdued quiet of exhaustion.

The first appearance of the lavas at the surface occurred in a small crater called *Arare*, about six miles from Kilauea, A, (map on p. 349,) as was ascertained soon after by the Rev. T. Coan.* The light was seen at a distance; but there were no inhabitants living in that vicinity, and it was set down for a jungle on fire. The next day another outbreak was distinguished farther towards the coast; and general alarm prevailed among the natives, now aware of the catastrophe in progress. Other openings followed, and by Monday, the first of June, the large flow had begun

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* Missionary Herald, 1841, volume xxxviii, p. 283. The author was over the portion of the eruption towards the sea in November. Subsequently it was examined by Captain Wilkes, Mr. J. Drayton, and Dr. C. Pickering; and by means of their investigations a map of the region was made out.

that formed a continuous stream to the sea, which it reached on the third of June, destroying the small village of Nanawale. This flood issued from several fissures along its whole course, instead of being an overflow of lavas from a single opening; it started from an elevation of 1244 feet, as determined by Captain Wilkes, at a point twenty-seven miles distant from Kilauea, twenty-two miles from the first outbreak, and twelve from the shores. The interval between the first appearance of the lavas and this flood presents a few patches of ejections, and some steam fissures.

The extent of these patches was not accurately ascertained. Dr. Pickering mentions one small one, just before the last outbreak; and another, much larger, (*n*) covering probably three or four square miles, was observed by him a short distance above. A still larger patch, (*m*) according to a native report, exists about half way from the "Big Crater" (C) and the last outbreak; while still another, on the same authority, was seen just north of the "Big Crater." It is very remarkable, as stated by Dr. Pickering, that the line of fracture and lava patches should have cut through a high hill just north of the "Deep Crater" (B), and thus avoided this large pit where it might have been supposed there would have been the least resistance to fracture. The natives state that the lavas rose to a height of three hundred feet in the pit-crater Arare, the first point of outbreak, and then sunk again when the next outbreak took place; and the appearance of scoria within the crater satisfied Dr. Pickering that the lavas had risen at the time to the height mentioned.

The scene of the flowing lavas, as affirmed by those who observed it, beggars description. As we learn from an eye-witness, the lavas rolled on, sometimes sluggishly, and sometimes violently, receiving at times fresh force from new accessions to the fiery stream, and then almost ceasing its motion. It swept away forests in its course, at times parting and enclosing islets of earth and shrubbery, and at other times undermining and bearing along masses of rock and vegetation on its surface. Finally it plunged into the sea with loud detonations. The burning lava, on meeting the waters, as Mr. Coan states, was shivered, like melted glass, into millions of particles, which were thrown up in clouds that darkened the sky, and fell like a storm of hail over the surrounding country. "Vast columns of steam and vapors rolled off before the wind, whirling in ceaseless agitation, and the reflected glare of the lavas formed a fiery firmament overhead. For three weeks this terrific river disgorged itself into the sea with little abatement. Night was converted into day on all eastern Hawaii. The light rose and spread like the morning upon the mountains, and its glare was seen on the opposite side of the island. It was distinctly visible for more than one hundred miles at sea; and at the distance of forty miles fine print could be read at midnight."

At three spots on the coast, probably over three opened fissures whence lavas issued, the sands continued to be thrown up, until as many rounded or nearly conical elevations were formed, the largest of which was found to be 250 feet in height, and the smallest about 150 feet. They consist of a finely laminated tufa, like tufa craters. The coast is said to have been extended nearly a quarter of a mile beyond its former limits.

TUFA HILLS, NANAWALE.

The stream, as it appeared in November, consisted in its different portions of all the kinds of lava tracts elsewhere observed. In some portions, especially the upper, there were fields of the smoother variety, (the pahoihoi,) with the usual ropings and twistings of the surface; and there were some miniature cones, a few yards in height, out of which the lavas spouted for a while after the rest had become quiet. Large tracts were covered with sand; and walking over them, the feet often broke through into steaming chambers, suggesting caution to the traveller. Other large portions consisted of clinkers, a fact which might have been inferred from the description given of the varying rate of the moving lavas. In some portions they were in huge angular blocks; in others in slabs laid with much regularity against one another. There were numerous caverns and fissures still sending up clouds of steam; and in many, the rocks were yet glowing within a few feet of the surface. A piece of paper was instantly ignited. Small sulphur-banks, with deposits of alum and other salts, were met with in several places.

The islets of forest trees in the midst of the stream of lava were from one to fifty acres in extent, and the trees still stood and were sometimes living. Captain Wilkes describes a copse of bamboo which the lava had divided and surrounded; yet many of the stems were alive, and a part of the foliage remained uninjured.* Near the lower part of the flood, the forests were destroyed for a breadth of half a mile either side, and were loaded with the volcanic sand; but in the upper part, Dr. Pickering found the line of dead trees only twenty feet wide. The lavas sometimes flowed around stumps of trees, and as the tree was gradually consumed, it left a deep cylindrical hole, sometimes two feet in diameter, either empty or filled with charcoal.† Towards

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* Narrative Exp. Expd., iv, 184.

† Similar facts to those here stated were observed by M. Bory de St. Vincent at the Isle of Bourbon.—*Voyage aux Isles d'Afrique*, 3 vols., 4to, Paris, 1804.

the margin of the stream, these stump-holes were innumerable, and in many instances the fallen top lay near by, dead but not burnt. Dr. Pickering also states that some epiphytic plants upon these fallen trees had begun again to sprout. The rapidity with which lava cools is still more remarkably shown in the fact that it was found sometimes hanging in stalactites from the branches of trees; and although so fluid when thrown off from the stream as to clasp the branch, the heat had barely scorched the bark.

The waters of the sea were so much heated that the shores for twenty miles were strewed with dead fish.

From the period, thirty-six hours, which the lavas required to reach the sea, an average velocity of four hundred feet an hour is readily deduced, as stated by Captain Wilkes. Yet, as the lavas issued from various fissures along the course,* the result cannot be correctly compared to an *overflow* of fluid: it is rather the rate of progress of the eruption than of the motion of a flowing liquid.

The thickness of the stream of lava here described was estimated by Dr. Pickering as averaging ten or twelve feet. In some places it was not over six feet. The whole area, judging from the surveys, covers about fifteen square statute miles; and reducing to feet and multiplying by the depth, 12 feet, gives for the amount of ejected lava 5,018,000,000 cubic feet; to which, if we add for the previous ejections of the same eruption three more square miles it gives 6,023,000,000 of cubic feet for the whole amount of lavas which reached the surface.†

We have a still more accurate means of estimating the amount of lavas which passed from Kilauea, in the actual cubic contents of the emptied pit. The area of the lower pit, as determined by the surveys of the Expedition, is equal to 38,500,000 square feet. Multiplying this by 400 feet, the depth of the pit after the eruption,‡ we have 15,400,000,000 cubic feet for the solid contents of the space occupied by lavas before the eruption, and therefore the actual amount of the material which flowed from Kilauea. This is two and a half times the amount obtained from the estimated extent of the eruptions. The difference may be accounted for partly on the ground that fissures were filled as well as surfaces overflowed, and also that there may have been eruptions beneath the sea not estimated. This amount is equivalent to a triangular ridge eight hundred feet high, two miles long, and over a mile wide at base.

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* On this point we cite the following passage from the Narrative by Captain Wilkes, (iv, 184):—"There are many fissures along the whole line, as will be perceived by the dark places on the map. I feel confident that from each of these an ejection had taken place, and that the lava had in some cases flowed in a contrary direction to the general course of the stream."

† Allowing an average depth of but ten feet, the calculation would give for the whole amount 5,000,000,000 cubic feet.

‡ As the measurements of the Expedition were made eight months after the eruption, we have allowed somewhat for the increase during that time, and also for cavities emptied beneath the ledge.

The lava of the eruption is remarkable for the large proportion of chrysolite, amounting in some parts to nearly one half, and occurring in coarse grains often a fourth of an inch thick. It is consequently very brittle, slabs being easily shattered to pieces by a tap of the hammer. The sands of the seashore produced by the eruption, consist largely of this mineral mixed with black grains of the comminuted lavas. In the abundance of chrysolite the lava is very unlike that formed in the crater either previous or subsequent to the eruption.

The sand-hills are examples of elevations thrown up suddenly over fissures of eruption. They consist of tufa of a rusty yellow color, and are distinctly and finely laminated. The sea is already encroaching on them, and has exposed the regular stratification of the interior, showing a steep inclination of the layers outward. Not a trace of tilting took place in the rocks beneath; they are simple cones of eruption, formed of ejected cinders. The sands are said to have been thrown out from the centre of each hill, while in progress; yet there is now no cavity at top. It appears that the action of the molten lavas as they met the sea must have been like the effect from a furnace of melted glass plunged beneath water. There was a violent explosion and eruption of fragments and steam, which fell around the centre of action; and owing to the water which ascended and descended with them, the structure became laminated like the alluvium of a river. Thus three "Monte Nuovos" instead of one were thrown up at a single eruption. The yellow color of the tufa is owing to the action of the steam and water on the ferruginous cinders, reducing some part of the iron to a hydrate.

Since leaving the Sandwich Islands, I learn from the Rev. Mr. Coan that the crater has again been gradually filling up. In November, 1841, there was little action except in the great lake. In February, 1842, the same condition of things continued, with only an increased state of activity. In July, 1844, Mr. Coan was near when the large lake overflowed its margin on every side, spreading out into a vast sea of fire, filling the whole southern part of the crater as far as the black ledge on either side, and obliterating the outlines of the cauldron. Two deep fissures opened, one on either side under the black ledge, and nearly encircled the whole southern area. The precipitous sides of one were two hundred feet in depth. These fissures soon became filled with the flood that was pouring over from the lake; and in one place "it fell in a cascade of fifty feet, producing a scene of terrific sublimity." In a letter dated June 25, 1846, Mr. Coan states that "the great lake is intensely active most of the time. The repeated overflowings have elevated the central parts of the crater 400 or 500 feet since 1840, so that some points are now more elevated than the black ledge." In a letter written in the next month to a friend from Rev. Mr. Lyman, the crater is described as having the whole interior filled, with some parts of the centre standing 100 to 150 feet above the black ledge. The large lake was still the centre of greatest activity.

It appears then at the last mentioned date to have been nearly in the condition sketched and described by Captain Kelley in 1839, previous to the eruption of 1840, except that the action had not reached the same degree of intensity.

Through a letter from Lieut. Henry Eld, U.S.N., we learn that in the spring of 1849, the bottom of the crater was still as last reported, but more raised. Yet instead of an increase of action, the crater was unusually quiet. The lavas had subsided in the great lake and it seemed as if the fires were in process of extinction. The action was far less than in 1840, when Lieut. Eld was at the crater with the officers of the Exploring Expedition.*

We conclude at this time with a mention of one or two deductions from the facts mentioned.

1. *Frequency of Eruptions.*—The last three eruptions of Kilauea have taken place in a period of nineteen years, or with intervals of eight or nine years. Between the years 1789 and 1823, there may have been a season of comparative quiet, as we learn from the natives of no great eruption. This evidence, however, is by no means decisive. They say, in general terms, that eruptions have taken place during all their kings, and assert that the crater has been in action from time immemorial. It is quite possible that in the above mentioned interval, there were submarine eruptions, if not subaërial; and very probably, the latter also may have taken place. The statement of the native to Mr. Bishop that the lavas, after reaching a certain height, would flow out as *they had formerly done under the sea*, is evidence that they were aware of this mode of emptying Kilauea of its lavas. In six years after 1840, the lower pit was again filled, and since then an eruption has been looked for.

2. *Phases of Volcanic Action.*—There can be no truth, at least as regards Mount Loa, in the principle reasoned out at length, in an able article on volcanoes, by Bischof,† that the phases of volcanic action depend on water gaining access to the central fires of the globe; for the evidence is certainly conclusive that the main action of waters is comparatively near the surface.‡

The phases of volcanic action at Kilauea are as follows:—

The centres of action, when most quiet, are reduced to a single one, which occasionally overflows. This overflowing

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* The papers have since reported an eruption, but I have not seen the report confirmed.

† *Natural History of Volcanoes*, by G. Bischof. Jameson's Edinburgh Journal, xxvi, 1839; American Journal of Science, xxxvi, 249, 250.

‡ We omit here the arguments on this point.

raises the bottom of the crater; the lavas continue to boil over, and go on accumulating, and elevating the area of action; the pressure is consequently gradually increasing; the action becomes after a while more intense, perhaps in part from the increasing pressure, and the increasing height to which vapors ascend before escaping; new centres of ebullition add to the effect; finally, after the bottom is raised 400 or 500 feet above its lower level, these centres are numerous, the ebullition is violent, the overflowings almost incessant;—at last the increased pressure, in addition to the force of rising vapors proceeding from the increased action, cause a rupture through the mountain's sides and the lavas flow out.

This is the history from a period of quiet to one of greatest activity. If the larger pool, after an eruption, should become crusted over, as happens with the smaller pools, the lava sinking far below the surface, there would seem to be a state of inactivity. But the same process going on, the surface would be gradually reached, and the work would be continued as above explained. This is mainly a result of the passage of vapors from below, inflating the lavas as they ascend, producing the appearance of ebullition, and occasioning thus the rising of the molten material, and the overflowings. The scoria is the froth of the surface still more inflated, like the scum on the surface of a boiling syrup. Lavas from fissures in Kilauea usually are not scoriaceous, while the overflowings of the lakes have a crust of scoria 4 to 10 inches thick.

To compare Kilauea with other craters, we must keep in mind this important point, proved by the absence of cinders in the crater, and the free ebullition there, that the lavas are remarkably liquid, while those of other craters are comparatively viscid. The ejections of the great lake of Kilauea are 60 feet in height, while those of Vesuvius during an eruption may be 10,000 feet; and this, though not a direct measure of their relative liquidity, is a consequence of it. With this principle in view, we may translate the language of Kilauea into that of Vesuvius or Etna. The phases of their craters may be of the same general nature, and be due to a similar mode of action, varied only by the simple fact of the greater or less viscidity of the lavas. There may be the same succession of effects with the same results; and periods of quiet and violent action may have the same mutual relations and dependence. We need look to no extraordinary influx of waters to occasion an eruption, as the eruption is a result of a progressive state of things, perhaps long in action. I do not here deny that such a paroxysmal influx of waters may at times take place, and has produced results. I urge only that they are exceptions; and that phases of quiet and violent activity would necessarily succeed one another without such intervention.

The same gradually acting cause will also produce occasional violent ruptures. For where the waters for a period find slow access to any centre of heat within the volcanic mountain beneath its cover of rocks, the vapors will gradually accumulate till the pressure breaks a way through the mountain, to give exit to the vapors together with the compressed lavas. The starting of a cork from a bottle of soda water and the escape of the liquid as well as carbonic acid gas, though a familiar incident, depends on a general principle, with regard to pressure, to which even the lavas of a volcano must be obedient. The sudden outburst of lavas through fissures in the very summit of the walls about Kilauea may be of this character. In many cases violent earthquakes should attend this mode of action.

ART. XXXVI.—*On the Chemical Equivalents and Notation of Laurent and Gerhardt;* by CHARLES GERHARDT.

(Translated for this Journal, from the Comptes Rendus des Travaux de Chimie, Jan., 1849, by T. S. HUNT.)

IN commencing the fifth year of these Comptes Rendus, in which I shall have for the future, the collaboration of M. Laurent, I wish to recall the principal features of the notation which we adopt in our system, and which appears to us at the same time more simple and more precise than the dualistic method. * *

The numerical value of our symbols is for the *metalloids*, the same as in the notation of Berzelius, but for the *metals*,[*] it is only one half. Thus we write, H^2O, SO^2, SO^3, P_2O_5, CO, CO^2, etc.; HCl, HBr, NH_3, have likewise the same significance, as in the ordinary notation: but in the metallic combinations, the symbol of the metal has but one half the value assigned to it in the Berzelian formulas.[†]

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[*] Except for arsenic, antimony, bismuth and uranium, which have the same value as in the Berzelian formulas.

[†] It will be recollected that the notation of Berzelius as followed by the French chemists, differs a little from that generally employed by the English and German writers. Berzelius, from a consideration of their combining volumes, was led to admit that oxygen and hydrogen unite to form water in the proportion of 1 : 2, and consequently to write the formula of the compound, H_2O. In accordance with this, he divided also the equivalents of the so-called halogen elements, chlorine, bromine and iodine, and designated the atom of hydrochloric acid, corresponding to water, by $H_2\,Cl_2$; his equivalents of nitrogen, phosphorus, arsenic, antimony, etc., are also one half those of the English chemists, but while admitting the atomic composition of water to be H_2O, he conceived the true equivalent of hydrogen to be *a double atom*, and thus made H_2 equivalent with K, Zn, etc. MM. Gerhardt and Laurent have divided in the same way the equivalents of the metals proper, making H the equivalent of K, Zn, etc.—*Translator.*

Examples.	*Notation of Berzelius.*	*Our notation.*
Sulphuret of hydrogen,	H_2S	$S\,(H_2)$
Sulphuret of potassium,	KS	$S\,(K_2)$
Chlorid of hydrogen,	$H_2\,Cl_2$	$Cl\,(H)$
Chlorid of potassium,	KCl_2	$Cl\,(K)$
Sulphuric acid,	SO_3, H_2O	$SO_4\,(H_2)$
Sulphate of potash,	SO_3, KO	$SO_4\,(K_2)$
Bisulphate of potash,	$SO_3, KO + SO_3, H_2O$	$SO_4\,(HK)$
Sulphate of zinc and potash,	$SO_3, KO + SO_3, ZnO$	$SO_4\,(ZnK)$
Nitric acid,	N_2O_5, H_2O	$NO_3\,(H)$
Nitrate of potash,	N_2O_5, KO	$NO_3\,(K)$

The principal difference consists in the notation of *salts*, which we regard as unital in their constitution, as systems in which the metal may be exchanged for another, without affecting the arrangment of the molecular structure. (We write generally the metal in parentheses.) According to this view, the *acids*, properly called, (the hydrated oxacids, and the hydracids,) are *salts*, in which the metal is represented by hydrogen; the oxyds and sulphurets have the same claim to the title of salts as the sulphates and nitrates. The so-called anhydrous acids we look upon as a peculiar class of bodies, (*anhydrids*,) which become acids by the fixation of the elements of water.

We farther assume that *one and the same body may have two or several equivalents*. According to us the idea of an *equivalent* implies that of a similarity of function, and it is known that one and the same element is often capable of playing the part of two or of several other very different elements; it may then happen that each one of these different functions corresponds to different proportions of the first element. On the other hand, we sometimes see different weights of the same metal, as, for example, iron, copper or mercury, replace the hydrogen of acids to form salts, which although containing the same metal, are different in their properties. The metals have then different equivalents. Some examples will make this important proposition more plain.

The ferrous and ferric sulphates are two salts which contain for the same quantity of oxygen and sulphur, different quantities of iron. If we express by $S=16$, the quantity of sulphur, by $O=8$ that of oxygen, and by $Fe=28$ the quantity of iron, we shall have,

$$\left.\begin{array}{ll}\text{Ferrous sulphate,} & SO_4\,Fe = SO_3, FeO \\ \text{Ferric sulphate,} & SO_4\,Fe\tfrac{2}{3} = 3SO_3, Fe_2O_3\end{array}\right\}\begin{array}{l}\text{Berzelian}\\ \text{formulas.}\end{array}$$

Thus in the ferric sulphate there are but two-thirds the quantity of iron which exists in the ferrous sulphate; but these two-thirds of Fe are the equivalent of H, K, Na, Zn, etc., and also of the Fe in the ferrous salts; but when two-thirds of Fe replace H in sulphuric acid, or K in the sulphate of potash, we obtain a salt which without ceasing to be a neutral sulphate, possesses properties very different from those of the ferrous sulphate where Fe entire, replaces H, K, Zn. The equivalent $Fe\frac{2}{3}$ then communicates to the sulphatic system properties as different from those of the ferrous sulphate, as would be those of a sulphate containing any other metal.

Again, in the mercurous and mercuric chlorids we have the same amount of chlorine united to different quantities of the metal.

$$\left.\begin{array}{ll}\text{Mercurous chlorid,} & Hg_2\,Cl_2 \\ \text{Mercuric chlorid,} & Hg\ \ Cl_2\end{array}\right\}\ \text{Berzelian formulas.}$$

Hg_2 in the mercurous salts is the equivalent of H, K, Na, Pb, etc., and equally of Hg in the mercuric salts. Mercury has then according to our view, two equivalents (*mercuricum* and *mercurosum*), as compared with other metals, which are to each other as 1 : 2, and each one of these has its peculiar properties.

To show in the formulas that $Fe\frac{2}{3}$, Hg_2, represent equivalents of H, K, Na, etc., we often replace the exponents by certain signs, employing the Greek letters α, β, γ, and δ, in place of the numbers 2, $\frac{2}{3}$, $\frac{1}{2}$, $\frac{1}{3}$. The equivalents of H in the following salts are then thus represented.

	$2 = \alpha$
Cu in the cupric salts.	Cu_2 or $Cu\alpha$ in the cuprous salts.
Hg " mercuric "	Hg_2 or $Hg\alpha$ " mercurous "
	$\frac{2}{3} = \beta$
Fe in the ferrous salts.	$Fe\frac{2}{3}$ or $Fe\beta$ in the ferric salts.
	$Al\frac{2}{3}$ or $Al\beta$ " aluminic "
Cr " chromous salts.	$Cr\frac{2}{3}$ or $Cr\beta$ " chromic "
Mn " manganous "	$Mn\frac{2}{3}$ or $Mn\beta$ " manganic "
	$\frac{1}{2} = \gamma$
Sn " stannous salts.	$Sn\frac{1}{2}$ or $Sn\gamma$ in the stannic salts.
Pt " platinous "	$Pt\frac{1}{2}$ or $Pt\gamma$ " platinic "
	$\frac{1}{3} = \delta$
	$Bi\frac{1}{3}$ or $Bi\delta$ in the bismuthic salts.
	$Sb\frac{1}{3}$ or $Sb\delta$ " antimonic "
	$Au\frac{1}{3}$ or $Au\delta$ " auric "

Upon this plan of notation we write the formulas of these salts as follows:

	Berzelian notation.	*Our notation.*
Alum,	$SO_3,KO + Al_2O_3,3SO_3+24$ aq.	$SO_4(K\frac{1}{2}\,Al\beta\frac{3}{2})+6$ aq.
Sulphate of potash,	SO_3,KO	$SO_4(K_2)$
Phosphate of soda,	$P_2O_5,2NaO,H_2O+24$ aq.	$PO_4(Na_2H)+12$ aq.
Biphosphate of soda,	$P_2O_5,NaO,2H_2O+2$ aq.	$PO_4(NaH_2)+$ aq.
Phosphate of lead,	$P_2O_5,3PbO$	$PO_4(Pb_3)$
Phosphate of alumina,	P_2O_5,Al_2O_3	$PO_4(Al\beta_3)$

The simplicity of the new notation is especially evident when applied to those salts which contain several metals, as in the natural silicates. Take for an example the formula of the chlorite of Slatoust, which in the notation of Berzelius is represented by

$$3MgO, SiO_3 + Al_2O_3, SiO_3 + 2(MgO, 4H_2O).$$

This we write,

$$SiO_3 (Al\beta_{\frac{3}{3}} Mg_{\frac{5}{3}} H_{\frac{4}{3}}),$$

and this formula reminds us at once that chlorite belongs to the silicates of the form $SiO_3 (M_4)$,* for $\frac{3}{3} + \frac{5}{3} + \frac{4}{3} = 4$.

The advantage of our notation consists then principally in this, that it expresses all the salts of the same genus in the same manner; each symbol appears but once in a formula. Consequently *we denote similar compounds in a similar manner.*

In the notation of organic substances, we take their volumes into consideration, when they are bodies which are volatile without decomposition. We denote these always by the same number of volumes, and the non-volatile compounds derived from them by similar formulas. Thus for the monobasic acids, we take as an equivalent the quantity which contains (H) one equivalent of basic hydrogen; this corresponds to two volumes of vapor. The derivatives (*non binômes,*) which do not perform the functions of salts, are represented by the same number of volumes; in case these derivatives are fixed, we take as an equivalent the quantity produced by one equivalent or yielding one equivalent, of the monobasic acid. For example,

	Berzelian notation.	*Our notation.*
Acetic acid, . .	$C_4H_6O_3, H_2O$	$C_2H_3O_2(H)$
Acetate of potash,	$C_4H_6O_3$, KO	$C_2H_3O_2(K)$
Ferric acetate, . .	$3C_4H_6O_3, Fe_2O_3$	$C_2H_3O_2(Fe\beta)$
Chloracetic acid, .	C_2O_3, C_2Cl_6, H_2O	$C_2Cl_3O_2(H)$
Chloracetate of potash, .	C_2O_3, C_2Cl_6, KO	$C_2Cl_3O_2(K)$
Ferric chloracetate,	$3(C_2O_3, C_2Cl_6), Fe_2O_3$	$C_2Cl_3O_2(Fe\beta)$
Alcohol, . . .	C_2H_6O	C_2H_6O
Aldehyde, . . .	$C_4H_8O_2$	C_2H_4O
Olefiant gas, . .	CH_2	C_2H_4

The bibasic acids not being volatile without decomposition, the law of volumes cannot be applied to them directly, but these acids give by decomposition, volatile anhydrids. We take then as the formula the quantity which yields two volumes of an anhydrid. These acids are therefore represented with two equivalents of basic hydrogen (H_2). Examples.

	Berzelian notation.	*Our notation.*
Oxalic acid, . .	C_2O_3, H_2O	$C_2O_4(H_2)$
Oxalate of potash,	C_2O_3, KO	$C_2O_4(K_2)$
Binoxalate of potash,	$C_2O_3, KO + C_2O_3, H_2O$	$C_2O_4(HK)$
Quadroxalate of potash, . .	$C_2O_3, KO + 3(C_2O_3, H_2O)$	$C_2O_4(H_{\frac{3}{2}} K_{\frac{1}{2}})$

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* We write silica SiO; $(SiO, 2M_2O, = SiO_3 (M^4).)$

In the same manner the tribasic acids are denoted with three equivalents of basic hydrogen, (H_3,) as in the following examples.

	Berzelian notation.	*Our notation.*
Citric acid, . .	$3C_4H_4O_4, 2H_2O$	$C_6H_5O_7(H_3)$
Acid citrate of potash,	$3C_4H_4O_4, KO+H_2O$	$C_6H_5O_7(KH_2)$
Second citrate of potash, . .	$3C_4H_4O_4, 2KO$	$C_6H_5O_7(K_2H)$
Third citrate of potash, . .	$C_{12}H_{10}O_{11}, 3KO$	$C_6H_5O_7(K_3)$

By analogy we represent the mineral acids also with H, H_2 or H_3, according as they are monobasic, bibasic, or tribasic.

Most chemists denote organic substances by formulas which are double those adopted by us, but all these formulas, when they are exact, may be divided by two and represented in our notation.

I finish this introduction by a table of the proportional numbers of the principal simple bodies, with the numerical value that is ascribed to them in our notation.

		H=1.	O=100.			H=1.	O=100.
H	Hydrogen, .	1·	6·25	Cl	Chlorine, .	35·5	221·87
Li	Lithium, .	6·4	40·16	K	Potassium, .	39·	243·75
B	Boron, . .	10·8	67·50	Sr	Strontium, .	44·	275·00
C	Carbon, . .	12·	75·00	Cd	Cadmium, .	56·	350·00
Mg	Magnesium,	12·	75·00	Sn	Tin, . . .	59·	368·75
Al	Aluminium,	13·7	85·63	Sb	Antimony, .	64·5	403·25
N	Nitrogen, .	14·	87·50	Ba	Barium, . .	68·	425·00
Si	Silicon, . .	14·	87·50	As	Arsenic, . .	75·	468·50
O	Oxygen, .	16·	100·00	Se	Selenium, .	78·5	490·90
Fl	Fluorine, .	18·6	116·85	Br	Bromine, .	80·	500·00
Ca	Calcium, .	20·	125·00	W	Tungsten, .	96·	600·00
Na	Sodium, .	23·	143·75	Pt	Platinum, .	99·	618·75
Cr	Chromium, .	26·	162·50	Hg	Mercury,	100·	625·00
Fe	Iron, . . .	28·	175·00	Pb	Lead, .	104·	650·00
Mn	Manganese, .	28·	175·00	Ag	Silver, .	108·	675·00
Ni	Nickel, . .	29·6	185·00	U	Uranium,	120·	750·00
Co	Cobalt, . .	29·6	185·00	J	Iodine, .	126·	787·50
Cu	Copper, . .	31·8	198·75	T	Tellurium,	128·	800·00
S	Sulphur, .	32·	200·00	Au	Gold, .	196·	1225·00
P	Phosphorus,	32·	200·00	Bi	Bismuth,	210·	1312·50
Zn	Zinc, . .	33·	206·25				

ART. XXXVII.—*The Natural Relations between Animals and the Elements in which they live;* by L. AGASSIZ.

AMONG the early attempts to arrange animals in a systematic order, we find almost universally, that the natural elements in which their different tribes live are introduced as the fundamental principle of their classification. During the sixteenth and seventeenth centuries, the great works published upon natural history by Gesner, Rondelet, Belon, Aldrovandi and others acknowledge this as the only basis of their arrangement of the animal kingdom. Even at a later period, when characters derived from the animals themselves, rather than from the external circumstances in which they dwell, had been introduced into our systems, we still find a prevailing influence of such considerations upon the circumstances of the natural subdivisions of animals. As soon however as the study of comparative anatomy had shed its brilliant light upon this question, those views were entirely abandoned, and the whole animal kingdom was finally arranged according to its internal structure. The introduction of this principle was hailed as a new era in the history of our science; and, after Cuvier had applied it to a general revision of the whole animal kingdom, it was and has been universally acknowledged as the only safe foundation of a natural classification of animals.

The recent progress in zoology, and of the various branches of natural history connected with it, has however opened the prospect of further improvements, even upon the basis on which our classification at present rests. For embryology is already displaying its vast influence upon zoological questions, and the time is not far distant, when its share in the natural arrangement of animals will be as large as that of comparative anatomy itself, and when information derived from all possible quarters shall have equally its due influence upon our natural methods. A desire to investigate the various questions bearing upon classification has led me to revise the subject of the natural relations which exist between animals, and the elements in which they live. The connection between animals and the surrounding media in which they live has of late been so entirely disregarded, that it is time to reconsider this question with all the attention its importance demands, since we find in it a decided relation to the structure and functions of all animals. For though it is plain that the mere living in water or upon dry land is in itself of slight importance, as there are so many animals which dwell in the two elements although having the same *identical* structure, it should not be overlooked that the greater number of aquatic animals have structural peculiarities common to all, and that the same is the case with the terrestrial or aërial animals. For instance, all those which live upon dry land breathe directly the atmospheric air, and have a respiratory apparatus adapted for direct introduction of this element into their systems, while aquatic animals breathe through apparatus of a different structure adapted to a permanent contact with aërated water. This circumstance alone would suffice to show that the natural relations of animals with the elements in which they naturally dwell, is in direct connection with at least some of their structural peculiarities. But there are other circumstances which may lead to the conviction that this connection has not merely reference to the structure of their respiratory apparatus, but influences their whole organization. The greater pressure under which aquatic animals are maintained throughout their life modifies, in many other respects, their organization. In many of them the surrounding element has largely a direct access into the cavities of the body or even into their tissues; so that a direct and universal influence of the surrounding media must be acknowledged throughout the animal kingdom as soon as we take into consideration all their peculiarities. This influence will be appreciated more correctly, if we consider it separately in each great group of the animal kingdom as established upon anatomical evidence.

After removing the Whales from the Fishes, it will be plain that the Cetacea must be considered simply as an aquatic type of the class of Mammalia, and that the connection which exists between them and the element in which they live will not affect at all the views which we shall entertain about that class, and only allow us to consider within more natural limits, the true relation which exists between fishes and the natural element in which they are found. The circumstance that so many birds are aquatic in their habits will no longer prevent us from considering the class of Birds as a most natural group in the animal kingdom, the limits of which are well defined by anatomical evidence; and the relations of aquatic birds to the waters upon which they alight or in which they dive, will only be considered within the limits of a well circumscribed natural group. The same may be said of Reptiles; and the circumstance that so many of their types are almost entirely aquatic, while others are terrestrial, will by no means prevent us from viewing them as a natural class, in which the connection with either main land or the water shall appear as a subordinate feature.

Again the class of Insects, which is so thoroughly aërial throughout almost all its types, at least in their perfect state of development, circumscribed as it is within natural limits upon anatomical evidence, will appear to us as a type which shall bear no relation in our mind to the class of Birds, although their movement through the atmosphere be apparently so similar.

But, although we remove in this manner almost completely the circumstance of animals dwelling either in water or upon main land as influencing in any way our general classification of the animal kingdom, it were a great mistake to lose sight entirely of this most intimate relation among the natural secondary groups of animals under their different types.

The value of these considerations has become more apparent, since the outlines of the leading divisions in the animal kingdom have been made in detail by allowing the results of embryology to have their due share of influence upon our classification; and the object of these remarks is chiefly to show that there is a universal relation throughout the animal kingdom between their structure and gradation and the elements in which they live; that, in all the four great types of the animal kingdom, the aquatic groups stand, in natural classification, lower than the terrestrial, and that this connection is so intimate as to extend even to the subdivisions, and so much so, that I have arrived at the conviction that in an otherwise well defined natural division, the aquatic tribes should be placed below the terrestrial ones; that even in narrowly circumscribed families the aquatic genera rank below the terrestrial, and that even in natural genera the aquatic species are inferior to the terrestrial ones. But before considering those minor divisions let us take a general glance at the four great types of the animal kingdom beginning with the Radiata.

If we consider the type of Radiata as it is still circumscribed in some of our most recent works upon the animal kingdom in general, we may fail to discover this intimate connection between their natural types and the media in which they live. But if we reduce the type of Radiata to those classes which I consider as alone truly representing that type, we shall be at once struck with the remarkable result, that all these animals are aquatic, nay, that, with one single exception, they are all marine. But before this can be acknowledged, it must be shown that the type of Radiata should be reduced to the three classes of Polypi, Jelly-fishes and Echinoderms; and that, among Polypi, there are large numbers of animals now united which do not all belong to that class. The most extensive range acknowledged by some zoologists in the type of Radiata includes Infusoria with the Rotifera and also intestinal worms. Without entering for the present into a full discussion of the natural character of all the animals which have been included in the class of Infusoria, I may limit my remarks to a few critical points, in order to show that the Polygastrica, and even the Rotifera cannot be ranked among Radiata.

In the first place Rotifera constitute a particular group among Infusoria as Ehrenberg himself has acknowledged. They differ so completely from the Polygastrica as to forbid entirely their union in a natural classification. The only question is whether they can remain among Radiata, and, if not, where they should be placed. There is so little analogy between the structure of Rotifera and the structure of true Radiata, that ever since the beautiful illustration of their forms and structure as given by Ehrenberg, most naturalists and anatomists have felt inclined to remove them to another type of the animal kingdom. Their resemblance to Articulata has appeared to some so striking as to warrant, in their opinion, their removal to the class of Crustacea, among Entomostraca, while others have considered them as more closely allied to worms. But I may say that all, or almost all, naturalists at present understand the necessity of removing them from among Radiata into the great type of Articulata.

This point is no longer in question; the only remaining doubt respecting them is whether they should rank among the lower Crustacea, or among the worms in the wider sense. As for the Polygastrica, we meet with greater difficulties in attempting to classify them; for this group, as understood by Ehrenberg, consists still of most heterogeneous beings which do not even all belong to the animal kingdom. Recent investigations upon the so-called Anentera, including the families of Baccillaria and Volvocine Infusoria, have satisfactorily shown, in my opinion, and in that of most competent observers, that this type of Ehrenberg's Polygastrica without gastric cavities, and without an alimentary tube, are really plants belonging to the order of Algæ in the widest extension of this group; while most of the Monas tribe are merely movable germs of various kinds of other Algæ. As for the other Polygastrica which Ehrenberg combines in this division of Enterodela, I am satisfied that they also constitute still a heterogeneous group belonging to different types of the animal kingdom; and that most of them, far from being perfect animals, are only germs in an early state of development. The family of Vorticellæ exhibits so close a relation with the Bryozoa, and especially with the genus Pedicellina, that I have no doubt that wherever Bryozoa should be placed, Vorticella should follow, and be ranked in the same division with them.

The last group of Infusoria, Bursaria, Paramecium and the like, are, as I have satisfied myself by direct investigation, germs of fresh water worms, some of which I have seen hatched from eggs of Planaria laid under my eyes. This being the case, we see that, without exception, the whole class of so-called Infusoria must be dissolved into its various elements and divided partly among the Articulata, and partly among Mollusca in the widest extension of those groups, (if it can be shown that Bryozoa belongs also to the type of Mollusca,) that large numbers of them belong to the vegetable kingdom, and others are simply germs of other types, and that no single one of them belongs to the type of Radiata.

If we next consider the Polypi we find them constituting another main group and most natural class, to which indeed some heterogeneous types have been annexed; upon the removal of these however that class constitutes a very natural division of the type of Radiata among which they form the lowest class. The natural groups which require to be removed from Polypi are, —first, the so-called Hydroid Polypi, which, though truly radiated animals, do not belong to this class, but are, as I have shown from their structure, and as might long ago have been inferred from their development, true members of the class of Medusæ, among which they constitute a type of stalk animals, as crinoids among star-fishes.*

The Bryozoa also are not constructed upon the plan of Radiata, as has long been shown by Milne Edwards and others. Their true position is among Mollusca, and embryonic investigations upon Ascidia have satisfied me that Bryozoa, compound, and simple Ascidia, form a natural series of well connected types leading to the true Acephala among ordinary Mollusca, among which Bryozoa will form a natural group of compound animals, bearing the same relation to the ordinary bivalve shells, that common corals bear to the simple Actiniæ and Fungiæ. Though the doubts entertained about the Foraminifera among Bryozoa, would not affect at all the points under discussion, I may as well state at once, that I have arrived at the conclusion that Foraminifera constitute the lowest type of Gasteropoda, and exemplify under permanent forms the state of division of their germs in their embryonic development. Thus circumscribed, the class of Polypi constitutes a very natural group containing only animals of an identical radiated structure, the organization of which is at present very satisfactorily known.

The class of Medusæ has been from the beginning so well characterized, and circumscribed within so natural limits, that it has undergone since its establishment only slight modifications by the removal of some few genera: and after the position of the so-called Hydroid Polypi among them shall have been generally acknowledged, I believe it will undergo scarcely any new changes in its extension, though we may still expect extensive improvements, which are indeed very much needed, in the characteristics and internal arrangement of their natural families. Considering their structure, the Medusæ rank immediately above Polypi.

The Intestinal Worms have long been placed among Radiata, and considered as a natural class in this great type of the animal

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* See my paper upon the homologies of radiated animals with reference to the classification of the so-called hydroid polypi, read before the American Association for the Advancement of Science, held in Cambridge, August, 1849; also my lectures upon comparative embryology, delivered before the Lowell Institute, Dec., 1848, and Jan., 1849.

kingdom, notwithstanding so many striking differences in the plan of their structure. This position was assigned to them upon the ground of the radiated arrangement of parts around the head, and the vascular form of some of their genera, and also upon the supposed want of a nervous system in all of them. But since the discovery of nerves in all of their types, and since the most intimate relations have been discovered between them and so many other external worms, their complete separation from Annelides as a distinct class is hardly recognized now by any modern investigator. And the necessity of combining the intestinal parasitic worms into one great natural group with the other external free worms is becoming daily more evident to all, so that whatever position be assigned to Annelides in the great type of Articulata, Helminths have to follow them, and must therefore be removed from the type of Radiata. This point is undisputed now, though there may be a difference of opinion as to the propriety of admitting, to one great class, all Worms, or of subdividing them into minor natural groups.

The third class among Radiata is that of Echinoderms, which has been circumscribed within most natural limits since the reunion of Holothuriæ and Crinoids, with the common star-fishes and true Echini. Whoever is familiar with the embryonic development of Echinoderms, which has been extensively investigated of late, will acknowledge an intimate relation between them and the other two classes of Radiata, and not be willing to assent to the proposed separation of Echinoderms as one great type in the animal kingdom, placed upon an equal footing with Mollusca, and will consider their separation from Polypi and Medusæ, as proposed by Dr. Leuckardt, rather as a retrograde step, than as an improvement upon the general classification of animals. To me the type of Radiata, embracing the three classes of Echinoderms, Medusæ and Polypi, constitutes, in its circumscription illustrated above, a most natural group of the animal kingdom, all the members of which are intimately connected by a close uniformity in the plan of their structure, but present a remarkable gradation of their types in the manner in which this structure is developed in each of their classes. And the circumstance that even in the higher ones, which contain chiefly free movable animals, we have some few representatives attached permanently to the soil upon a Polyp-like stalk bearing the radiated animal crown, shows further the intimate connection which exists between them all. Radiata consist therefore of three classes only, which in their natural gradation rank as follows: Polypi, lowest, next, Medusæ, and highest, Echinoderms.

As soon as we have removed in this way all the classes or families which do not strictly belong to the type of Radiata, we cannot fail to perceive at once that all the remaining animals which must be considered as truly radiate are not only all aquatic, but, with a single exception of the genus Hydra, all strictly marine; from which we are allowed to infer that, in the plan of the creation, the radiated structure is incompatible with a terrestrial mode of life. We see that the lowest degree of development of the whole animal kingdom is entirely marine; and that it has been so throughout all ages in the history of our globe, is shown by the large numbers of Radiata found from the earliest periods through all geological epochs up to the most recent, and the entire absence of radiated animals in any of the fresh water deposits. The circumstance that no single genus among Radiata contains fresh water animals, further shows that this type in its main features is not better adapted for a fluviatile existence; or, we may say in other words, that the plan involved in the structure of radiated animals is chiefly adapted to the sea. We might perhaps even say, if, in this stage of the investigation, it would not seem premature to go so far, that the lower types of animals are not only entirely aquatic, but exclusively marine. The fact of so large a number of aquatic animals as Radiata being so exclusively marine, undoubtedly shows that the connection of organic structure with the ocean, involves peculiar circumstances, which fresh waters by no means afford to a similar extent. Whether this is especially connected with the greater density of the medium or not, I am not fully prepared to say, though I am inclined to believe that it is so, from the circumstance that Radiata are so constantly killed by the contact of fresh water, as I have ascertained by direct experiment upon Polypi, Medusæ and Echinoderms, some of which are struck with almost instantaneous death, when brought into fresh water, and decompose with astonishing rapidity. I have seen on dropping an Ophiura into fresh water, all the articulations dismembered and entirely separated within a few minutes.

No one of the three other great types of the animal kingdom is either so exclusively marine, or even so exclusively aquatic as that of Radiata. For among Mollusca we have quite a number of terrestrial genera, and even a large number of fresh water genera and families.

Among Articulata we notice also large numbers of fresh water species, and a still larger number of terrestrial forms. Finally, among Vertebrata we find the most promiscuous occurrence of marine, fresh water and terrestrial forms. It is now important to ascertain whether we may trace, beyond Radiata, a direct relation between structure and the element in which animals live, and whether the gradation of this structure has any reference to the surrounding media as it unquestionably has among Radiata.

Let us first consider Mollusca, and perhaps revise their classes in a zoological point of view before undertaking the investigation of their relations to the media in which they dwell, allowing in this revision, a due influence to embryology as far as it can influence this question at present.

The number of classes which should be admitted among Mollusca, is the first point of importance we have to consider. Since the Barnacles or Cirripedia which Cuvier still considered as a class among Mollusca, are now known to belong to the type of Articulata, and to be most conveniently combined with Crustacea, we have five classes of Mollusca left, if we follow Cuvier's arrangement of these animals, as he distinguishes Cephalopoda, Pteropoda, Gasteropoda, Acephala and Brachiopoda, as so many distinct classes of the type of Mollusca in the order of gradation just mentioned. It will hardly be necessary at present to insist upon the close relation which exists between Brachiopoda and the other bivalve shells. Indeed, anatomical investigations of these animals have shown that they are not only constructed upon the same plan, but that the differences between Brachiopoda and ordinary Acephala, are scarcely as great as the differences which exist between Ascidia and Lamellibranchiate Acephala, which Cuvier nevertheless placed in one and the same class. We shall therefore consider Tunicata, Brachiopoda and Diphyra, as one great natural class under the name of Acephala, to which we also refer, as mentioned above, the type of Bryozoa, which has been so long combined with Polypi. As to Pteropoda and Gasteropoda, though they are still generally considered as two classes, we shall, for reasons explained elsewhere,* and from embryological evidence, place Pteropoda below Gasteropoda proper, not as an intermediate type between Gasteropoda and Cephalopoda; for, Pteropoda are rather an embryonic type exemplifying, in a permanent form, that stage of development of common Gasteropoda, when they are provided with large vibracula, and a thin symmetrical shell deciduous in so many of them; bearing to that state of development of the common Gasteropoda the same relation which Foraminifera bear to a still earlier period of their embryonic growth, when the yolk is undergoing its process of gradual successive division, which seems to me to be exemplified in a permanent form in the numerous cells into which the body of Polythalamia or Foraminifera is naturally divided. If this view be correct, the class of Gasteropoda would therefore consist of the three types of Foraminifera, Pteropoda and true Gasteropoda, among which we would place the Heteropoda, lowest, and the Pulmonata highest, both on account of their structure, and on the ground of the peculiar mode of development of Pulmonata.

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* See a paper upon the homologies of Gasteropoda and Acephala with reference to the systematic position of Pteropoda, Foraminifera, Brachiopoda and Bryozoa, read before the American Association, &c.

The third class is that of Cephalopoda, which has always been circumscribed within natural limits, since Foraminifera have been removed from it. The position which I ascribe here to Foraminifera will appear very natural to those who are equally conversant with the succession of fossil types in geological periods, and with embryology, and who know, as we have seen it to be the case also among Radiata, that the higher classes reproduce in their lower forms, types analogous to the lower ones. For the great number of fossil chambered shells, existing in earlier geological periods, is very striking when we compare those old representatives of the class of Cephalopoda with their condition in the present period of the creation, and the natural gradation and analogy between Bryozoa as the lowest type of Acephala, with the Foraminifera as the lowest type of Gasteropoda, and the chambered shells of old ages as lower types of Cephalopoda will remind us of similar relations between Polypi as the lowest type of the animal kingdom, the so-called Hydroid Polypi as the lowest type of Acalephæ, and Crinoids as the lowest type of Echinoderms, which are strictly parallel cases in two of the great types of the animal kingdom.

If we now start from these modifications in the classification of Mollusca which rest entirely upon anatomical and embryological considerations, to appreciate the relations between the three classes of this type, and the media in which they naturally live, we cannot fail to be struck with the circumstance, that all Acephala, with one single exception, are aquatic, as are also Cephalopoda; and that we have only terrestrial representatives among Gasteropoda. Next it must be obvious, that among Acephala we have fewer fresh water representatives, than among Gasteropoda, as the fresh water types of Acephala belong truly to two groups one of which has very few fresh water families, whilst among Gasteropoda we have quite a variety of fluviatile and terrestrial types.

The first thing which must strike us in this type, when contrasting it with the Radiata, is the circumstance of a far larger proportion of fresh water forms and of the introduction of a number of terrestrial ones. This simple fact in itself would go to sustain the hint thrown out above, that a higher organization in the animal kingdom is better adapted to the fluviatile and terrestrial life, than a lower structure; as among Radiata we have not one single terrestrial type, and only a single fluviatile one; whilst the Mollusca, the structure of which is formed upon a plan decidedly higher than that of Radiata, present already a large increase of fluviatile types, with the addition of very many terrestrial ones. But this view will at once be sustained to a most unexpected extent if we consider which of the Mollusca are aquatic, and marine, which are fluviatile, and which are terrestrial. Beginning with the Acephala, we have then, in the first place, all the

Polyp-like Bryozoa, and Tunicata, and the compound Tunicata, entirely marine, with the exception of a few genera of fresh water Bryozoa. And it is very interesting to notice that fresh water animals among Mollusca are of the lowest type of their class, as also was the first and only fresh-water Radiate,—showing thus that the types to which they belong are not adapted to rise into any of their higher developments into the forms best fitted for other elements.

Next we notice the Brachiopoda which are all, without exception, marine. Next Lamellibranchiata, mostly marine, though some of their types are fluviatile. So the entire class of Acephala is aquatic and chiefly marine, and its fluviatile types belong to its lowest group, and to its highest. This circumstance has raised the question with me, what is the proper position to assign to the Naiades among the Lamellibranchiata, and upon due consideration of their peculiar characters, and especially of the circumstance that their mantle is entirely open, that they have no prolonged syphons whilst there are such even among Ascidia, I am inclined to suppose that they rank highest among Lamellibranchiata and that Monomyarians should rank between Brachiopoda and Dimyarians. The reason for assigning to Naiades this higher rank rests upon the homology traced between the foot of Gasteropoda and that of Acephala, and between the reduction of the mantle upon the sides of the foot which it no longer encloses in Gasteropoda, and also the higher position of the gills under the margins of the mantle, all peculiarities in which Naiades bear closer resemblance to common Gasteropoda, than any other of the Acephala. Thus this class of Acephala, though chiefly marine, with a few representatives of its lowest types in fresh water, would reach its highest degree of development in one family, which is entirely fluviatile.

Among Gasteropoda we have again Foraminifera as the lowest type entirely and without exception marine; Pteropoda, which rank next, entirely and without exception marine; Heteropoda which follow, equally marine; and among true Gasteropoda, which in their class are decidedly the highest, we find first, fluviatile and then terrestrial families. And now the question is, among these, what is the respective position of the marine families, of the fluviatile families, and of the terrestrial families. There are among them such structural peculiarities as will decidedly settle the question. If we set aside for a moment the few branchiate fresh water Gasteropoda, we have a large number left which are pulmonate, and which live in fresh water and upon land, and which as a whole we may contrast with the branchiate true Gasteropoda, which are almost all marine, with the few exceptions of Valvata and Paludina and Ampullaria. Now which of these two types rank highest will not be a matter of doubt as soon as it is remembered that Phlebenterata are among branchiate Gasteropoda, and by their general structure, rank below the others. So that we shall have the marine branchiate Gasteropoda follow immediately the Heteropoda to which they are more or less closely allied through the Phlebenterata, and, above all, the Pulmonata. But here arises a new question. This family of Gasteropoda is partly fluviatile and partly terrestrial, and we may further ask, which should rank higher? No one familiar with the forms of these animals will hesitate in answering this question. We need only compare the development of their tentacles, their forms and position, and the development of their organs of sense, to be satisfied that Helices and Limax rank above Planorbis and Limnæa. So that the natural gradation established by their structure among the upper groups in the class of Gasteropoda, agrees with their natural connection with the elements in which they live in the order which I have assigned to these, the types of Gasteropoda which are lowest being exclusively marine; the highest, equally fluviatile and terrestrial; and among these the fluviatile ranking immediately above the marine, and the terrestrial ranking highest, and the proportion of the fluviatile in the whole class being still larger than in the class of Acephala, inasmuch as the structure of Gasteropoda is also a higher degree of development of Mollusca than that of Acephala, and the first terrestrial type in the animal kingdom in the gradation of its structure making its appearance in the class of Gasteropoda.

The Cephalopoda are highest among Mollusca as a class. They rank so high as to rival in the complication and development of their structure even some of the Vertebrata, and strange to say, we have among them only marine types, not a single fluviatile representative, nor a single terrestrial one. This fact would at first seem to be in direct contradiction with the statements made before, if it were not for the circumstance that this class in itself as represented in our days does not seem altogether reduced in comparison with the other two, if we could not be satisfied that its perfect period of development were the former geological ages when its numbers were far greater than at present, a circumstance which places the whole class in peculiar relations to its type, which must be rather appreciated under the point of view of the conditions which prevailed in former ages, when the ocean covered more extensively the whole surface of the globe than at present; so that the type with its high organization must be considered more with reference to its development in former ages, than to what it is now, as at present the class is proportionally reduced, and it is well known, and it will be further mentioned with reference to other types, that in earlier periods however high animals might have ranked by their structure, they were all marine, as we know fishes to have been the only representatives of Vertebrata in earlier periods.

At this stage of the investigation, a comparison between Mollusca and Radiata shows that, though the former advance farther in their fluviatile development, and even reach with some few of their types a terrestrial mode of existence, there is not yet a single family among them which is entirely terrestrial, nor a single class which is either entirely fluviatile or terrestrial, this connection with the higher conditions of existence being only introduced among some few of their representatives, which we are allowed from other data to consider as the highest in their respective groups.

If we now pass to the great group of Articulata and begin as before by revising their zoological arrangements as based upon anatomical and embryonic data, we shall have at the outset to settle the limits of their classes, and their relative positions.

The first point which we have here to investigate is the question whether Articulata in the widest extension of this group constitute one single natural type, or whether they should be subdivided into two equivalent groups, as has been proposed by those who would restore the division of worms, in its widest sense, as a great division equal in zoological importance to the type of Mollusca, and unite the Arthropoda, Crustacea, and Insects to form another group of equal value.

The great diversity among worms, seems at first to warrant in some degree, such an arrangement. But as soon as we consider the metamorphosis which insects undergo, and compare their earliest stages of growth with the structure and forms of worms, we cannot fail to perceive, that notwithstanding the many peculiarities which characterize worms, they are, after all, only one of the permanent modifications of the same type as Crustacea and insects, among which last the characters and forms of a large number of worms are reproduced as transient states of growth; so that upon the most natural view, and especially if we allow embryology to have its due weight in fixing our opinion, we must consider worms with all their diversified forms, Crustacea in all their diversity, and Lepades, Arachnidæ and Insects, to constitute one single undivided natural type in the animal kingdom. Assuming upon the foundation alluded to, and without entering into a detailed argument upon this question, that this is the right view of this subject, the next question is about the number of classes into which these Articulata should be subdivided. Taking here again anatomical and embryological evidence as our guide, and remembering what was said above of intestinal worms we shall find that the most natural combination of the different groups of Articulata will bring them all into three classes, one containing those in which the body is either more or less distinctly articulated, or in which indications of transverse wrinkles in the skin are scarcely marked, or wholly wanting, but in which, however developed these joints may be, they never combine in such a manner as to divide the body into distinct ridges, in which the form is always elongated and vermiform, never provided with articulated rings, however numerous and diversified the locomotive appendages may be, and in which the foremost joints hardly ever assume a peculiar structure with the appearance of a head. This class for which the name of Worms is best retained, will contain the Helminths and Annelides exclusive however of the vermiform parasitic Crustacea, which embryology has taught us to refer unhesitatingly, to the class of Crustacea. The extraordinary diversity which exists among these animals renders it rather difficult to subdivide them into natural groups, and to assign to these groups a natural succession agreeing with the gradation of their structure, as there are so many the development of which is as yet very imperfectly known, and others which undergo so complicated metamorphoses as to leave great doubt respecting their natural relations to each other. However, there can be no doubt that Helminths rank lower than Annelides, for their structure indicates plainly their inferiority, and their mode of existence within other animals shows that they do not even reach that degree of independence which might allow them a free existence.

Among Annelides again there will arise similar difficulties respecting the relative position of the branchiate types of that group which are provided with external appendages performing simultaneously the functions of respiratory and locomotive organs, and those families which are deprived of external appendages, or which have stiff bristles upon their joints, independent of their aërial respiratory organs. Indeed at present the position of earth worms and leeches among Annelides, has not been the subject of any direct investigation as regards their relative position and rank. But if I were allowed to be guided by the impressions I have received from the study and comparison of the larvæ of insects, I should be inclined to consider the annelides with external gills as inferior to those which have no such appendages, and place the lumbricine Annelides highest in the class. So that Helminths should be placed lowest in the class of worms; next the Branchiate Annelides with external branchiæ; next those having internal branchiæ, and highest those with aërial respiratory sacks.

The second class in the type of Articulata is that of Crustacea, the natural circumscription of which can hardly be in any degree a matter of doubt, for these animals, with their distinct articulations, and aquatic mode of respiration, external appendages and particular mode of combination of the rings of their body, whereever they are combined to subdivide the body into distinct regions, are so peculiar as to determine well the natural limits of this class, to which we refer also the Cirripeda notwithstanding their transformations, also the Lernæan parasites, though they may assume in their parasitic mode of existence so extravagant forms, and an appearance so entirely different from that of common crustacea. In this class, again, the parasitic vermiform types rank lowest; next follow the Entomostraca, and highest the Malacostraca, in most of which the anterior rings are combined into a distinct region, assuming a peculiar appearance differing widely from the posterior free movable rings. The circumstance that among Crustacea the organization reaches a point where the anterior part of the body assumes so peculiar an appearance, leaves no doubt as to the relative position of Crustacea among Articulata; they rank higher than worms; though they must be placed below the insects notwithstanding their perfect circulation and their otherwise highly developed structure; for, in every respect, insects considered as a whole class, are more highly organized, their higher types assuming a division of the body into three distinct regions;—undergoing also far more extensive metamorphosis, and assuming finally an aërial mode of respiration, to which the Crustacea do not reach. For these reasons, which I have illustrated more fully on another occasion, I have no hesitation in placing the class of insects highest among Articulata, and in comprising in one class the true insects with Arachnida and Myriopoda, which are only lower degrees of development of the more special types of true insects; the Myriopoda representing in a permanent state of development, and with the structure of true insects, the form of their caterpillars; the spiders with their cephalic and thoracic rings united into a cephalo-thorax representing their chrysalis in a permanent state of development; and the true insects with their three distinct regions, the so-called head, thorax and abdomen, ranking highest among them, as well for their more extensive metamorphosis as for the characteristic division of the body, the reduction of their locomotive appendages to a peculiar region, the complication of their chewing apparatus, and the development of their wings. The true arrangement of the different members of this class however is readily indicated by the remarks already made upon this class, and we shall not hesitate to consider Myriopoda as their lowest type, and to place Arachnida next above them, and then true Insects, among which the sucking tribes rank highest.

If we now consider the connection of these three classes with the elements in which they are developed, and in which they permanently live, we cannot fail to be struck with the fact that two of their classes are either parasites or entirely aquatic, for even the terrestrial worms live in moist ground or on the bark where moisture is constantly accumulating; and these two classes we have seen to be the lowest of the type, while the class of insects, which, in their perfect development, are all terrestrial or aërial, constitute the highest type.

Reviewing the secondary groups of all these classes also in the same connection, we find that the lowest of all not only live in a fluid medium, but require the existence of other animals in whose cavities they find shelter and means of subsistence; and among those which have an independent mode of life we find that the marine worms are probably lower than the fluviatile, and terrestrial,—at least, if the view expressed above respecting the relative position of Lumbrici and branchiate Annelides be correct.

In the class of Crustacea we have exclusively aquatic animals, and we find that among them those which live as parasites upon other animals rank lowest. The distinction however between fluviatile and marine types in this class does not seem to be in strict accordance with their gradation, for we have fluviatile Decapods which cannot be considered as higher than the crabs, unless it were shown that the shortened body of the Brachyural Decapods is the result of a retrograde metamorphosis, which I am however not inclined to suppose, as we have some crabs which are in the habit of leaving the water to dwell upon the main land. The occurrence of parasitic Crustacea upon fresh-water fishes, again, seems to indicate that here the parasitism prevails over the influence of the surrounding media; and we should not wonder at this circumstance, as a parasitic mode of development dependent upon the prior existence of organized beings, is not only a prominent feature in the mode of existence of so many Worms and Crustacea, but also even of many of the Insects, especially of the tribe of Arachnida and Diptera, at least in some earlier periods of their existence. In this connection it is an interesting fact to notice that the American fresh water Crustacea, the craw fishes, have fewer pairs of gills than the other representatives of the class.

Again, it may be, that to appreciate truly natural relations of this type of animals, it will be necessary to consider separately each of their minor divisions rather than the whole class as a unit; as we shall have to do also among the reptiles where the peculiarities of the primary divisions overrule the influence of the media in which they are developed.

However obscure these relations may be among Crustacea owing to the parasitism of some of their types, or the peculiar metamorphosis of others, if we now consider the insects proper we shall find here again a strict accordance with the results we have already derived from the investigation of the lower classes. Having acknowledged the superiority of the sucking insects over the chewing tribes, we cannot fail to perceive that Neuroptera, which must be considered as the lowest, inasmuch as their body still preserves the elongated form of worms, are aquatic in their larval condition and have even external gills, as their respiratory organs during that period. Next, Coleoptera among which also we find aquatic larvæ, and a number of terrestrial types, and highest the Orthoptera which undergo a less extensive, but entirely terrestrial, development, whilst Hymenoptera have a more diversified metamorphosis, and assume even in their larval condition in some of their types, the higher forms which characterize the larves of Lepidoptera.

Among the sucking insects we begin again with various aquatic types, or aquatic larval forms,—next rise to Diptera with other aquatic larval conditions but a constant aërial mode of life in the perfect state, and finally to the type Lepidoptera in which all larvæ are terrestrial, and even highly organized in their earliest state in the higher groups; so that the class as a whole does not only rank above Crustacea for its structure, but consists chiefly of aërial types in their perfect state of development, a large number of which are aquatic but fluviatile in their larval condition, and comparatively exceedingly few marine. So that if we compare the whole type of Articulata, with either Mollusca or Radiata, we see that in accordance with the higher development of its structure it has not only proportionally a larger number of terrestrial and aërial types, but an entire class is throughout aërial in its perfect state of development, and, though aquatic in the stages of growth, these larvæ are chiefly fluviatile and not marine, so that we may conclude from zoological evidence that the more intimate connection with the main land and aërial mode of existence indicate a higher degree of development than an aquatic mode of life; and between the animals living in water, that fluviatile types must rank higher than the marine.

These views are fully sustained by the order of succession of these great types of the animal kingdom throughout the earlier geological periods; for as it is already ascertained from zoological comparisons, that the earlier types in each class rank lower than their present living representatives, we have further evidence from the circumstances under which they live that they were all aquatic and marine in the earliest periods, and that fluviatile and terrestrial types have followed only at later periods. Without alluding to those classes in which the gradation of fossil types is less distinctly shown, let me only recall the Crinoids among Echinoderms, which for so long time prevailed to the almost entire exclusion of all other families among Acephala; the great prevalence of Brachiopoda in the oldest deposits and the first appearance of Naiades in tertiary beds; the large number of branchiate Gasteropoda up to the time of the tertiary period, when Limnææ and Helices made their first appearance; the earlier development of Crustacea with more uniform joints, and the appearance of insects of the tribe of Scorpions anterior to that of the winged families, among which the Neuroptera seem to be the first to increase in number, and the late occurrence of the sucking tribes in tertiary beds, and there will be no doubt left that the gradation of structure is intimately connected with the extension of continental lands, and that the present connection of animals with the surrounding media in which they live agrees also with their natural gradation. If we would study the natural relations between animals and the media in which they live, we could not begin with better prospect of success than by investigating minutely the different families of Vertebrata separately, rather than the whole classes of this great type. For though it is at once apparent that the class of Fishes as a whole is entirely aquatic, and stands at the same time lowest among Vertebrata, as soon as we pass to the investigation of the Reptiles we find aquatic and even marine types among Turtles, which rank much higher than the whole order of Batrachians, which are almost entirely fluviatile; and we find again marine and fluviatile types among Birds and Mammalia, the highest of all Vertebrata. These facts show most conclusively that an organization as high as that of the Vertebrata —introducing a mode of existence so independent of the changes of the seasons throughout the year, so durable as to last for numbers of years, (whilst among Invertebrata, and especially among Insects, but also among many other animals of lower type, there exists the most intimate connection between their development and the course of the seasons); we say these facts show that with such animals which are placed so far above the influence of physical conditions, their connection with the circumstances under which they live is much weaker, so much so that internal structure overrules greatly the foundation of those connections which are so intimate in lower animals, and reduces their limits to subordinate connections between members of the minor groups; while in the class of Fishes—the lowest—the whole type is organized in such a manner as to make it uniformly dependent upon one of the natural elements in which animals live, the three other classes present most diversified combinations, there being marine, fluviatile, and terrestrial or aërial types in these classes, under the development of as many structural types, differing almost in the same degree when contrasted with each other and so much that the aquatic Mammalia even in their marine types, or the marine Turtles, differ as much from each other or from Birds as they agree with their respective fresh water or terrestrial types. These discrepancies between the great types may be owing to other motives in the plan of creation than those to which they are here ascribed. The apparent anomalies between some of the articulated types may also be the results of combinations different from those with which they are connected above. But whether these views are correct or not, I have no doubt that the study of the phenomena which I am now contrasting, cannot fail to lead finally to a more correct appreciation of the natural relations which exist between animals and the media in which they live, than the vague views which have prevailed lately from want of investigation of the subject rather than from an especial view taken of it; I am far from supposing that in every instance I have hit at the outset the true view. I shall be satisfied to have called forth direct investigation upon this question, and led the way in a field which promises so ample reward.

Before entering into a special investigation of the natural relations of Vertebrata and the surrounding media, it may not be out of place to call attention to some collateral facts which will appear particularly prominent in the type of Vertebrata, but which have already their value in the study of the lower types. I allude to the relative bulk of animals of the same type living in different media. We can derive no impression upon this point from the investigation of Radiata, as they are all aquatic, and almost entirely marine. But the difference is already marked between Mollusca if we contrast their marine and their fluviatile and terrestrial types within the limits of their natural secondary groups. Among Acephala, if we consider the Lamellibranchiata, we can not fail to observe that the marine representatives are as a whole and taking into consideration the proportional number of their genera and species, of larger size and greater weight than the fluviatile. We have nowhere such gigantic, bulky and heavy fresh water Bivalves, as are many of the marine shells, and we need only compare the large Chamas or Tridacnas and Hippopus, the gigantic Pinna, even with the largest of Anadonts; and again the numerous species of Cyclas, &c., with the smaller marine Bivalves, among which we find but few species of so minute types. Again, among Gasteropoda how much larger are most of the Univalve marine shells, such as Dolium, Strombus, Voluta, and others, than even the largest fresh water Ampullariæ and the whole lot of fresh water and terrestrial Pulmonata, among which latter we have absolutely the smallest of all Mollusca in the innumerable varieties of Pupa, and other genera. We reckon in this type of Gasteropoda, the minute species by hundreds, while there are exceedingly few of really small size among the marine ones, and the greater number are even universally above the medium size of the larger fluviatile and terrestrial types.

Among Articulata the same rule obtains, and here we may compare classes with classes, even in their different stages of growth. Are not the Worms, taken as a whole, larger animals than the Caterpillars? Do we not find among marine Worms by far the largest types? We need only remember the gigantic Eunice, or even the parasitic Tape Worms to be satisfied of the fact. Are not the Crustacea as a class composed of types exceeding far the largest of Insects even with their wings spread? Are not the marine Lobsters many times larger than the fresh water Craw

Fishes? A minute investigation of the details of this numerous class might lead to very interesting comparisons which however would be out of the way in this general sketch.

I shall mention only a few facts to show that these comparisons might even be traced between the different stages of growth of these animals. It must be, for instance, a matter of surprise to see that the body of so many Insects is smaller in their perfect state of development than as a pupa; and that again this is smaller than that of the larva, though the larva be after all only the younger state of the pupa, and the pupa the younger state of the perfect Insect. But in the same ratio as we find so frequently throughout the animal kingdom that the lower condition of structure and development of a type is manifested in a more bulky body, so we find among Insects, that their earlier state of metamorphosis which is developed under inferior circumstances, reaches its final growth in a more bulky body than that of following periods during which their successive moultings and the transformations of the substance of the body takes place; the greatest size which the larva acquires is first reduced in its transition into a chrysalis, and this again is reduced in its transition into a perfect Insect,—the development of wings only leaving them seemingly of greater size when their surface is extended, though the bulk as a whole be reduced. Weighing these animals in these different states of development will satisfy the most incredulous of the reality of what is here stated, should the appearance have deceived him before. A Silk Worm when it begins to spin is much heavier than the chrysalis, and this heavier than the perfect Moth. Without directly weighing these animals, we might be satisfied about this fact if we should consider the amount of silk which is thrown out by the latter, and the amount of fluid which is discharged by the Moth even before it rids itself of its load of eggs and sperm to enjoy the last moments of its complete maturity.

If we now allude to the Vertebrata we shall find very similar facts, and perhaps in the animals to be mentioned, inducements for the discovery of curious unnoticed connections. And here again we should be cautious for reasons alluded to already above, not to take the classes as such, but rather to consider their different types separately; for the class of Fishes as a whole cannot be said to contain the largest Vertebrates, nor even to afford any support to the view that aquatic animals in general are larger than terrestrial, for we find proportionably a much greater number of large species among Mammalia than among Fishes; we find a greater number of large terrestrial Reptiles than of aquatic ones. But if we review the classes separately, and consider their secondary groups by themselves, we find that the rule holds good, but bears, at the same time, most interesting reference to the order of succession in geological times, as the respective types of any given group are the larger in the present period, whether terrestrial or aquatic, for being representatives of families which had numerous representatives in older periods. Among Fishes, we find the largest in the family of Sharks and Skates, Sturgeons and Garpikes, the first of which are exclusively marine, the second marine and fluviatile, the third entirely fluviatile; but the three types are either exclusively representatives of families largely developed in former geological periods, or so connected with extinct types as to show that this connection has influenced their development.

Among Reptiles we find the largest in the family of Turtles among their marine representatives; among the Lizard-like, in the fluviatile Crocodiles; among Batrachians, in their aquatic families.

In Birds, the aquatic families, Pelicans, Geese, Ducks, &c., bear a much larger proportion of heavy bulky forms than any terrestrial families; and if the Ostrich should at once occur as a striking exception, let us not forget that the giants of this family are known in a fossil state, exceeding far their living representatives.

Among Mammalia, we have the Whales as the largest class, and if we should be reminded of the great size of terrestrial Pachyderms, let us not forget that Pachyderms were the prominent type of Mammalia during the tertiary period. In connection with these facts it might be shown that natural families throughout the animal kingdom, are constructed within limits of size, which do not admit of great differences. A comparison of Cetaceans with Rodents, of Ruminants with Bats, of Passerine with Gallinaceous Birds, of Sharks with Herrings, of Cod-fishes with Blennoids, of Cuttle-fishes with Pteropods, of Crabs with Entomostraca, &c., might easily satisfy the most skeptical, that there are natural limits assigned to certain combinations of structure and the material bulk of the animals in which they are manifested.

After this digression let us return to our consideration of the natural connection of the secondary groups of Vertebrata, with the elements in which they live.

Though the class of Fishes is entirely aquatic, we have among these animals a greater number of marine types, and some which are partly marine and partly fluviatile, or, at periods, marine, or, at periods, fluviatile; and others which are entirely fluviatile or almost so. And though, at present, it is not plain that fluviatile types on the whole are superior to the marine types, we should not lose sight of the circumstance that the only living Sauroids, which have so many characters by which they may be connected with the class of Reptiles, and considered as the highest among Fishes, are entirely fluviatile; both Lepidosteus and Palypterus occur only in fresh waters; some of the Lepidostei only are known to reach the mouths of rivers emptying into the sea. And though the families of Sharks and Skates are chiefly marine, numbers of them, especially of those types of Skates which have numerous fossil representatives during the tertiary period, such as Myliobatis, are known to ascend freely the rivers in tropical regions. Among Cyclostomes, the lowest type Branchiostoma is marine, Petrostoma proper being both marine and fluviatile, the higher type of Ammocœtes (for we must consider Ammocœtes as higher, inasmuch as the division of the lips indicates a tendency towards a formation of a distinct upper and lower jaw), is exclusively fluviatile. The Goniodonts which from their affinities to Sturgeons rank higher than the Siluridæ, are exclusively fluviatile, whilst there are some marine types among the latter. Among Percoids we find in fresh water a larger number of those in which the two dorsals are distinct, a character making them eminently superior to the forms with undivided fins. For the same reason we should consider the Sparoids inferior to the Percoids, their dorsals being not only generally undivided, but even covered with scales. Among the Eels, those destitute of all fins are exclusively marine, those without pectorals also exclusively marine, and we may fairly consider the fresh water Eels as the higher type of the family on this ground. If there is any natural connection, as I have attempted elsewhere to show that there is, between Scombroids and Scomberesoces, and Esoces proper, it becomes plain at once that the latter are the higher from the abdominal position of their ventrals, and they are a fluviatile family. Even taking the Cycloids as a whole, we find among them the lower families of Thoracici and Jugulares, as the families of Cod and Scombrides, chiefly marine, whilst the family of Salmonidæ, and Cyprinidæ are chiefly fluviatile. Among the Gadoids we have those with many vertical fins, as the true Cod, marine, while those in which the dorsals and anals are reduced such as the genus Lota are fluviatile. Even among the Salmonidæ in the widest extension which this family had formerly, we find the Scopelidæ with the inferior structure of their jaws chiefly marine, while the Coracini and true Salmonidæ are chiefly fluviatile. Everywhere, in fact, in each minor group, the fluviatile representatives show characters indicating their superiority over their marine representatives. Whatever exceptions might be found to this law, which in the outset appears so general, I have no doubt will lead at some future time to the discovery of some other principle as yet unknown.

The class of Reptiles is one of the most interesting in the point of view under consideration, and each of their types exemplifies in itself the law of the intimate connection between animal types and the media in which they live in the most striking manner, inasmuch as here the gradation, which might be inferred from structural and embryological evidence, agrees most fully with the gradation of the elements in which they live. Among Batrachians we have chiefly fluviatile and terrestrial families. The Ichthyodes, or Batrachians with permanent branchiæ, are all aquatic, and acknowledged the lowest in the class. Some of their lowest representatives occur even in brackish swamps, and, as soon as attention is called to this subject, it cannot fail to be perceived that the Frogs with their more or less palmate fingers, and their more aquatic habits, rank lower than the Toads with their divided fingers and terrestrial mode of life. Among Ophidians we have chiefly terrestrial families, and only a few marine and aquatic ones; but who can fail to perceive that the marine serpents with their flattened tail, are inferior to the terrestrial genera, and that among these it is a well known fact there are some with rudimentary posterior extremities which assigns them a superior rank. Some objections might be drawn from the consideration of the Saurians, among which, the highest type, the Crocodiles, are chiefly fluviatile; but it has elsewhere been shown that Crocodiles are not truly Saurians of the same type with our Lizards, but modern representatives of a large family which was very numerous in former geological periods, when their first representatives were marine types provided with fins instead of distinct fingers; so that, far from being an exception, the Crocodiles of our days which are either fluviatile or terrestrial, must be considered as the highest representatives of that almost extinct type of Reptiles, the earliest forms of which were marine, followed by fresh water. Finally, among Chelonians the gradation in connection with the natural elements in which they live is most striking, for the inferiority of marine Turtles is as plain as it can be, not only in the form of their organs of locomotion, but even in the peculiarity of many of their internal organs especially of their ovaries, which contain eggs almost as numerous as those of Fishes. Next we place the fresh water Turtles with palmate fingers, and highest, terrestrial Testudines with their short undivided fingers. So that we have in this class with its various marine and fresh water and terrestrial types, not only a full illustration of these laws, but so intimate a connection between gradation of structure and mode of living in various elements, as to lead to the conviction that the mere mode of living might in many instances be almost as safe a guide to ascertain the natural gradation of types, as the study of their internal structure.

Ever since the class of Birds has been the object of regular investigation, their aquatic types have been considered as inferior to the terrestrial ones, and among the former, those which live entirely an aquatic life are decidedly the lowest. They are so, not only on account of the more imperfect development of their legs, which preserve throughout their embryonic form, but also in the less extensive development of their wings, in the more scale-like form of their feathers, and the greater number of eggs they lay, and the less care they take of their young, which are hatched in a state of development in which they are already prepared to provide for their own food. The same is the case with the Gallinaceous and the Wading Birds, which, though more advanced in many respects, are still inferior to the climbing and Passerine Birds in this respect, having a heavier flight, if they fly at all, and living a more terrestrial, and even aquatic life; the Wading Birds coming nearer in this respect, to those with palmate fingers, and the Gallinaceous Birds, as well as the Ostriches having a more terrestrial mode of life, whilst the Passerine Birds rank higher in all these respects, feed their young, and take care of them for a longer time, and live almost exclusively an aërial life, few of them having aquatic habits, and those being in their respective families by their form as well as by their mode of life, decidedly inferior to their loftier relations.

The classification of Birds as a whole is still so imperfect, though their minor groups are well understood, that many important relations in these respects must necessarily be more or less concealed as long as their primary divisions are not better known; so that we may expect many interesting hints from further investigations in this view.

The class of Mammalia is not only the most diversified in the forms of its members, but also in the diversity of their mode of life; nevertheless this diversity is connected by the most intimate relations of structure. The Whales are as much Mammalian by their internal organization as the most exclusively terrestrial quadrupeds. True Cetaceans constitute a natural family, all the members of which are exclusively marine, and no one of them even fluviatile—for the Sirenidæ must be considered as entirely distinct from true Cetaceans; and these Cetaceans, at the same time that they are so exclusively marine, are also the lowest type of Mammalia, not only from the imperfection of their extremities, of which there is only one anterior pair, and from the want of hind-legs, but also from the extraordinary development and bulk of their muscular tail, and the development of a caudal fin, and sometimes even a fin-like fold of the skin upon the back. If it can be shown that the Sirenidæ are an aquatic type of a larger group embracing Pachyderms, the direct relation of their structure and mode of life will be at once obvious, since Sirenidæ are either marine or fluviatile, while true Pachyderms are terrestrial; and should we not be justified in considering the subaquatic Hippopotamus as inferior to its more terrestrial relatives of the genera Rhinoceros, Elephant, and Horse? Are we not to consider the Ornithorhynchus, with its palmate hind-legs and spur, as inferior to Echidna? Are not the palmate Rodentia inferior to the terrestrial and arboreal types? Are not the aquatic Shrews inferior to the arboreal Insectivora? All these secondary questions will receive, in future, due attention and will no doubt be satisfactorily settled. But there are families in which we can already see our way and arrive at precise conclusions. Among Carnivorous Mammalia we have three very distinct types, the Pinnipoda or Seals; the Plantigrada or Bears, and the Digitigrada, Dogs and Cats. Now even if objections were raised against the association of the Walrus with the common Seals, there can be no doubt of the inferiority of the latter when contrasted with Plantigrada and Digitigrada. Their short fin-like legs, their clumsy body in connection with their aquatic marine life, assign them a lower position, and the Plantigrada must be considered as intermediate between them and the Digitigrada. Now among Digitigrades, even if we take isolated genera, we are led to assign to the species with aquatic habits, an inferior position among their nearest relatives. The polar Bear comes decidedly nearer the Seals in all its habits, than any other species of that genus, and on that ground should be considered as inferior to the terrestrial species. Again, the others, with their palmate fingers, rank lower than their terrestrial relatives: and we may even find that such considerations will hold good among the varieties of one and the same species; for we have varieties among the Digitigrade Dogs in which the fingers are palmate, a character which is derived from the imperfect development of their legs, preserving throughout life their embryonic form; and these varieties among Dogs are the most playful and at the same time, most aquatic in their habits, preserving in their adult state characters of the young and habits of the lower types,—this playful disposition being universal even among the most ferocious of the Cat tribe. I shall abstain purposely from tracing these comparisons higher up among Monkeys, and in the human families, from fear of alluding to exciting topics; but leave it to the philosophic observer to consider how far the idea of an aquatic Monkey is compatible with the high position which these animals hold in the class of Mammalia; and how curious it is that in the human family there are races which differ so much in their natural dispositions, mode of life, habits and adaptation to higher civilization; and how closely these natural dispositions are connected with apparently insignificant peculiarities of structure.

Upon reviewing the facts mentioned above, and the inferences derived from the facts, no impartial observer can in future deny the importance of the study of the natural relations between animals and the media in which they live; and the close connection which exists between them and the gradation of their structure. But this being the case, it must be a matter of surprise that the views so long entertained of the importance of this connection, which led earlier naturalists, generally, to the classification of animals according to the media in which they live, should have been so completely abandoned, and even considered of no value at all in systematic classification. For my own part I have no doubt that this negative result has arisen from the circumstance that all aquatic animals were brought together, in these earlier attempts, without reference to their structure or organic development, while we have found that structure is the ruling principle, and that natural connection with the element, is the secondary motive by which these connections are influenced. Indeed, aquatic animals, though agreeing in many respects, and though provided with analogous apparatus to perform the same functions, have, in different types of the animal kingdom, a very different plan of structure, and very different organs to perform the same functions. I shall not enter into a detailed illustration of these differences, as I have alluded to these facts in other papers, but only recall here, the great difference which exists in these connections between the different types.

Among Radiata, which are all aquatic, we find even that the adaptation to the liquid element is introduced in a plan of structure which is widely different from the plan of structure prevailing in Mollusca, though they also are chiefly aquatic; and that even the terrestrial types of Mollusca present, for adaptation to an aërial mode of life, only a modification of their aquatic types. The same may be said of Insects, in which the structure is mainly that of the Crustacea and Worms, which are permanently aquatic types, presenting simply a transformation of those peculiarities of structure which enable the lower classes to live under water, such as will enable them to rise in their adult state into an aërial condition of existence. Among Vertebrata the case is very different. The type is constructed for a terrestrial and aërial mode of life; even their aquatic representatives have rudiments of the apparatus, which acquire the highest development in the complete terrestrial types, and most of their aquatic types are truly aërial animals living in water, just as Insects are aquatic types adapted to the air. Let us only contrast in this respect, Cetacea with common Articulata. They have a pulmonary mode of life as much as man; they have the same mode of reproduction; only their form enables them to dive under water and to dwell permanently in the Sea; but, for all their structure, they are truly aërial animals. And this is equally the case with Birds and Reptiles; and with the Fishes I am prepared to show that there is no difference in this respect. For, though in their perfect state, Fishes are exclusively aquatic, they are completely built upon the same plan with those aërial classes of Vertebrata. The difference here is only this that the branchial apparatus, which exists simultaneously in Reptiles, Birds, and Mammalia, in their imperfect condition, is developed to be a permanent organ of respiration, while it is reduced and disappears in the higher classes in proportion as the lungs acquire a greater development. In Fishes, on the contrary, the homologue of the lung remains functionally and organically in a rudimentary state, as an air bladder. But all classes have both apparatuses in an inverse state of development, and thus Fishes are as fully constructed on the plan of the higher Vertebrata as the aërial Invertebrata are on the plan of their aquatic types. But the circumstances that Fishes have the double type of respiratory organs, and that the pulmonary one which by no means exists in any Invertebrates as I have shown elsewhere, but throughout the Vertebrata including Fishes, show that the whole type of the Fishes, have to be viewed in the same light as Reptiles, Birds and Mammalia, and must therefore be only considered as a lower condition of these aërial types, and not the latter as a higher degree of the former. For tracheæ of Insects, and lungs of Spiders, are only modified branchiæ of the type of Articulata, just as much as lungs of Pulmonata are modified branchiæ of the type of Mollusca, while gills and lungs in Vertebrata are parallel systems both coëxisting in all of them and only acquiring respectively a different degree of development in each of their classes. These facts which I have traced in other papers through a special comparison of all the homologies of the different types of respiratory organs in Vertebrata, Articulata, Mollusca, and Radiata, show plainly, that the aquatic, marine, or fluviatile, and terrestrial mode of life are introduced throughout the animal kingdom by special adaptations of peculiar different systems of organs performing analogous functions; and that the failure of introducing the consideration of the adaptation of animals to the media in which they live, in the plan of their classification, must be ascribed to the fact that these analogous structures were in the beginning considered as identical features in the organization. But taking in future into consideration all these peculiarities, we shall rapidly proceed towards the full understanding of all the relations between the gradation of animals, and the media in which they live, as far as they are not yet fully understood.

An extensive review of the Vertebrata might long ago have led to such conclusions, but before they could be considered as a general law ruling the whole animal kingdom, it was necessary that they should be treated in a special manner through the innumerable types of Invertebrated animals; and we have seen that this agreement is as close and as complete throughout the types of Radiata, Mollusca and Articulata, as it is plain among Vertebrata, and the slight difficulties to which we have alluded, must probably be referred to the present state of our knowledge respecting some of them, rather than to a departure from this law in any of their types.

ART. XXXVIII.—*On a new Analogy in the Periods of Rotation of the Primary Planets, discovered by Daniel Kirkwood*, of Pottsville, Pennsylvania.

(From the Proceedings of the American Association for the Advancement of Science, 2nd meeting, held at Cambridge, 1849. p. 207.)

Mr. SEARS C. WALKER addressed the Association on the subject of a new analogy in the periods of rotation of the primary planets, discovered by Daniel Kirkwood, Esq., of Pottsville, Pennsylvania.

The subject of my present communication is contained in a letter of Mr. Daniel Kirkwood, of Pottsville, Pennsylvania, dated July 4th, of this year.

The Secretary then read Mr. Kirkwood's letter, as follows:—

Pottsville, Pa., July 4th, 1849.

SEARS C. WALKER, Esq.,

Dear Sir,—Knowing the great interest you feel in astronomical inquiries, I take the liberty of submitting the following paper to your consideration, and respectfully soliciting your opinion as to the problem which I have been attempting to solve. Is it, or is it not, deserving of further investigation? Whatever may be your decision, as I have the fullest confidence in your judgment, I shall at once aquiesce. Wishing to be as brief as possible, I will not trouble you at present with any statement of the considerations which suggested my hypothesis.

While we have, in the law of Kepler, a bond of mutual relationship between the planets, as regards their revolutions round the sun, it is remarkable that no law regulating their rotations on their axes has ever been discovered. For several years, I have had little doubt of the existence of such a law in nature, and have been engaged, as circumstances would permit, in attempting its development. I have arrived at results, which, if they do not justify me in announcing the solution of this important and interesting problem, must at least be regarded as astonishing coincidences.

Let P be the point of equal attraction between any planet and the one next interior, the two being in conjunction: P', that between the same and the one next exterior.

Let also $D =$ the sum of the distances of the points P, P', from the orbit of the planet; which I shall call the diameter of the sphere of the planet's attraction;

$D' =$ the diameter of any other planet's sphere of attraction found in like manner;

$n =$ the number of sidereal rotations performed by the former during one sidereal revolution round the sun;

n'=the number performed by the latter; then it will be found that $$n^2 : n'^2 :: D^3 : D'^3;\ \text{or}\ n=n'\left(\frac{D}{D'}\right)^{\frac{3}{2}}.$$

For the sake of convenient reference, I subjoin the following tables. The masses of Venus, the Earth, Mars, Jupiter, and Saturn, are taken from your edition (1845) of Sir John Herschel's Treatise on Astronomy. Those of Mercury and Uranus correspond with my hypothesis, and are nearly identical with the most recent and reliable determinations of astronomers. In other words, the mass of Mercury is very nearly a medium between the two estimates of Encke,* while that of Uranus is more than $\frac{17}{18}$ths of Struve's mass, $\frac{1}{26860}$ found by observations on the satellites.† The mean distances not being given in miles in Herschel's Treatise, I have used the table of distances in the Astronomy of Professor Norton. For Mars's period of rotation (24^{h} 37^{m} 20^{s}. 6.) I have adopted the recent determination of Prof. O. M. Mitchel, (*Sid. Mess.*, vol. i, p. 52).

TABLE I.

Planet's name.	Mean Distance from the Sun in miles.	Mass.	Square root of Mass.	No. rotations in one Sid. Period.	Log.
Mercury,	36,814,000	277,000	526·3	87·63	1·942653
Venus,	68,787,000	2,463,836	1569·6	230·9	2·363424
Earth,	95,103,000	2,817,409	1678·5	366·25	2·563777
Mars,	144,908,000	392,735	626·7	669·6	2·825815
Jupiter,	494,797,000	953,570,222	30879·8	10471·	4·019988
Saturn,	907,162,000	284,738,000	16874·1	24620·	4·391288
Uranus,	1,824,290,000	35,186,000	5931·5		

The points of equal attraction between the planets severally (when in conjunction) are situated as follows:—

TABLE II.

		Miles from the former.	Miles from the latter.
Between	Mercury and Venus,	8,029,600	23,943,400
"	Venus and Earth,	12,716,600	13,599,400
"	Earth and Mars,	36,264,600	13,540,400
"	Jupiter and Saturn,	266,655,000	145,710,000
"	Saturn and Uranus,	678,590,000	238,538,000

It will be seen from above, that the diameter of the earth's sphere of attraction is 49,864,000 miles. Hence the diameters of the respective spheres of attraction of the other planets, according to my empirical law, will be found to be as follows:—

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* See Prof. Encke's letter to Mr. Airy, dated Dec. 20, 1841.

‡ Edinburgh Phil. Journal, for July, 1848.

	Diam. of Sphere of Attr.	Log.
Mercury, ...	19,238,000	1·283704
Venus, ...	36,660,000	1·564218
Mars, ...	74,560,000	1·872479
Jupiter, ...	466,200,000	2·668594
Saturn, ...	824,300,000	2·916127

Remarks.—The volumes of the sphere of attraction of Venus, Mars, and Saturn, in this table, correspond with those obtained from Table II; that of Mars extending sixty-one million miles beyond his orbit, or to the distance of two hundred and six million miles from the sun. This is about two or three million miles less than the mean distance of Flora, the nearest discovered asteroid. That of Mercury extends about eleven million miles within the orbit; consequently, if there be an undiscovered planet interior to Mercury, its distance from the sun, according to my hypothesis, must be less than twenty-six million miles. Jupiter's sphere of attraction extends only about two hundred million miles within its orbit, leaving eighty-nine million miles for the asteroids. It is only in the most distant portion of this space, where small bodies would be less likely to be detected, that none have yet been discovered.*

The foregoing is submitted to your inspection with much diffidence. An author, you know, can hardly be expected to form a proper estimate of his own performance. When it is considered, however, that my formula involves the distances, masses, annual revolutions, and axial rotations, of all the primary planets in the system, I must confess, I find it difficult to resist the conclusion that the law is founded in nature.

Very respectfully, your obedient servant,

DANIEL KIRKWOOD.

[The reading of Mr. Kirkwood's letter was followed by remarks by Mr. Walker who pronounced the analogy the most important which has been brought forward since the time of Kepler. Mr. Walker also read a paper prepared at the instance of Mr. Kirkwood, containing a mathematical examination of the law, in its application to the whole Solar System, using the most recent values for the elements of the planets. Another paper on the same subject was read by Prof. B. A. Gould. These we defer to our next number.]

We annex the following Letter, dated Pottsville, January 23, 1850, from Mr. Kirkwood containing a brief history of his very important discovery.—EDS.

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* It may be proper to remark that *one planet* between Mars and Jupiter, with a mass and mean distance of about double those of the former, would perfectly satisfy the conditions of my theory.

The following is a very brief history of the astronomical discovery communicated to the American Association for the Advancement of Science, at its session in Cambridge, Mass., in August, 1849, by Sears C. Walker, Esq.

My first notions in regard to the existence of an unknown law regulating the revolutions of the planets on their axes, date some time previous to the commencement of 1839. No investigation of the subject, however, was undertaken until the spring or summer of that year, when, in reading Young's Mechanics, I was struck by the remarks at the 204th page in support of the conjecture that both the progressive and rotary motions of the heavenly bodies were originally communicated by the same impulse. While reflecting upon the subject it occurred to my mind that an examination of this theory, in case it were founded in truth, might possibly develop that harmony, of which I had for some time entertained a vague conception. Having determined to give the subject my earnest attention, I commenced by calculating the distance from the centre of each planet to the point at which, according to the known laws of dynamics, the projectile force must have been impressed.* These distances I compared with each other in a great variety of ways. Failing thus, however, to detect any relationship between the different members of the system, I abandoned this hypothesis as hopeless.

After this, my leisure hours were spent for several years, with no better success, in comparing the masses, volumes, densities, distances, &c. At length, as the only remaining source of hope, I took up the nebular hypothesis of Laplace. This was in 1846. Here I soon found that a proper discussion of the questions which presented themselves required an analysis beyond my reach, and that consequently there was little prospect of attaining my object by any direct process of mathematical reasoning. Still, however, I could not persuade myself utterly to abandon my laborious though hitherto unavailing pursuit.

I had not been long engaged in my researches on the nebular hypothesis when the diameter of the sphere of attraction presented itself to my mind as a probable element of the law sought. Further consideration of the subject led to the conjecture that the ratio of the angular velocity of translation to that of rotation, or, which is the same thing, the number of a planet's days in its year, might be another element. Finally, on the 12th of August, 1848, I obtained the simple analogy announced a few months since in my letter to Mr. S. C. Walker. My delight as I applied it to the different planets in succession and found its wonderful agreement with the known elements of the system, may well be imagined.

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* In these calculations I was, of course, under the necessity of making certain assumptions in regard to the variation of density from centre to surface.

Some time previous to the date of my discovery, I learned that the nebular hypothesis had been abandoned by some of its most distinguished advocates in consequence of the revelations of Lord Rosse's telescope. This fact, together with several other considerations, prevented me from at once making the result of my investigations public. Having, however, again and again revised my calculations, and having found that according to the theory of probabilities there are many millions of chances to one against the accidental coincidence of so many independent variable quantities, I ventured to submit the subject to the inspection of astronomers. The interest it appears to have excited, and the favor with which it has been received, have exceeded my most enthusiastic anticipations. If it be indeed the expression of a physical law and not a mere harmony, it undoubtedly opens to men of science a vast field for cultivation.

ART. XXXIX.—*On the so-called Biogen Liquid;* by CHARLES GIRARD, Member of the Boston Natural History Society.

THE following pages are devoted to an examination of a letter published in the *American Journal of Science and Arts*,* also of a communication read before the *Boston Natural History Society* in December, 1848.†

The letter consisted of an exposé of three facts and one theory, viz.:

First fact. The formation of the egg in the ovary, as observed in a soft-shelled mollusk (*Ascidia*) and in a worm (*Sigalion*).

Second fact. The germinative vesicle does not always and necessarily disappear before the division of the yolk.

Third fact. There exists in the centre of the germinative spot, a transparent vesicle.

Theory. What embryologists have called albumen in the egg of invertebrated animals, has nothing in common with the albumen of the egg of Vertebrata. This liquid is the *mother liquid* of the yolk, that is to say, of the elements from which a new individual originates; therefore it is called *Biogen.*

These facts which have been added to science were not first made known by Mr. Desor. The theory is really his own. We shall presently see on what it rests.

In the communication read before the Boston Natural History Society, besides a brief account of the letter just mentioned, we find introduced some comparisons between certain pretended phenomena which are said to take place in the earlier age of the egg and the merely conjectural phenomena of the nebular hypothesis.

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* Second Series, vol. vi, No. 21, (May, 1849,) p. 395.

† See Journal of that Society, vol. iii, p. 85.

Without further prefatory remarks, I proceed directly to take up one by one the facts, the theory, and the speculations.

I. The primitive egg has been made the subject of much research by Prof. Agassiz, especially in the department of Mollusca. Ascending even beyond the first existence of the egg, he has shown us the ovary itself in the process of development. This is composed of sacks or pouches varying in form and size, in which the eggs are formed. The sacks are filled with an homogeneous and transparent liquid. Soon this liquid becomes granular, that is, consists of cells, and the cells becoming more and more numerous, give birth to a little opaque sphere, which is the vitellus. The germinative vesicle and the germinative spot have appeared during the formation of the yolk, and sometimes even prior to this period; but at the moment when the phase of division commences, both the spot and the vesicle generally disappear, and in the interior of each of the spheres produced by the division, is seen a clear space.

A Résumé of these observations has been published.* Since then, Mr. Desor has observed analogous phases in other animals. He published them, as he had a right to do, but he should have at least declared at the outset, that he was doing nothing more than repeating the observations which another had made before him.

II. When an egg has reached that point of its history which is called its maturity, it is distinguished by the following characters:—a spherical mass, more or less opaque, which is the yolk; in the center of this is found a much smaller sphere, the germinative vesicle, containing another substance, usually transparent; then in the interior of this last, a sphere or spheres still smaller, the germinative spot or spots.

The epoch of the appearance of the germinative spot varies as it would seem within very considerable limits. This is not the place to discuss this question. Let it be observed, however, that they exist in every egg when it is mature, and that they disappear from every egg when it enters upon the period of division.

But among the Nemertes a curious phenomenon is observed. Generally as we have just said, the vesicle and spot disappear before the division of the yolk, or, at least, at the moment when it divides in halves. The secondary spheres resulting from the subdivisions of the vitelline mass, have then, each one in its interior, a clear space. The question has been raised, what part the germinative vesicle plays in the history of the eggs? Is the division the consequence of its disappearance? in other words, is its content necessary to effect the division. The germinative vesicle has been considered as containing the primitive elements of the

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* Lectures on Comparative Embryology, by Louis Agassiz. Boston. January, 1849.

new being, or an element indispensable to its formation. Now here, among the Nemertes we meet with a case where the yolk is already divided into four parts, while the germinative vesicle still exists. The division of the yolk, then, can take place without the previous bursting of the germinative vesicle.

This fact is set forth and illustrated fully in the Lectures on Comprehensive Embryology,* and what appears strange to us, is, that Mr. D. now takes for his own, an observation to which he strongly objected when it was first communicated to him. Having made his observations upon a species different from that in which the fact was originally observed, there was, it seems to me, sufficient merit in pointing it out in another species, without claiming for himself the absolute priority.

III. In 1840, Mr. Martin Barry and Prof. Valentin, simultaneously observed, the one in England in the egg of the Rabbit; the other upon the shores of the Mediterranean, in the egg of a sea Urchin, (*Echinus lividus*,) that the germinative spot is not so simple as had been previously supposed. The observations of Mr. Barry were published during the same year;† those of Prof. Valentin, written in 1840, did not appear till 1842, and at this time he was still unacquainted with those of the English micrographer, for he would not have failed to mention observations so curious and a coincidence so remarkable. Prof. Valentin merely says that a round opaque body is often discerned in the center of the germinative spot.‡ In 1841, Van Beneden§ observed a granule in the germinative spot of the *Hydractinia rosea*, and in 1844,‖ when reconsidering the same species, he detected an opaque corpuscle within the germinative spot. This fact I have verified in 1848, in the case of the common sea Urchin (or sea egg) of Massachusetts Bay.

More recently Mr. D. says, that he has observed in a worm (*Sigalion*), and a sea anemone (*Actinia*), that the germinative spot contains a clear transparent vesicle. Comparing then this clear vesicle with the opaque nucleus observed by Prof. Valentin, he calls it *Vesicula Valentini*.

We honor the homage rendered to Prof. Valentin:—but Mr. D. has failed to explain how it happens that a transparent vesicle in the worms and sea anemone, is the same thing with the opaque nucleus of the sea Urchins; and moreover he ought not to have overlooked two points of its history, those which belong to Mr.

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* Pages 70, 71.

† Researches in Embryology: Third Series.

‡ Anatomie du genre Echinus, p. 105, Pl. viii, fig. 167.

§ Bulletin de l'Académie de Bruxelles.

‖ Recherches sur l'embryogénie des Tubulaires.—Mém. Acad. Brux., vol. xvii, p. 62, Pl. vi, fig. 6.

Barry and Van Beneden. By examining more closely, and studying more intimately the contents of the germinative vesicle and of the germinative spot, he might have satisfied himself that the presence of a clear vesicle, or of an opaque nucleus, indicates only two states of one and the same phenomenon, since they are observed alternately in the same species. This is the case with the eggs of Ascidiæ, of Medusæ, of Echini, and probably the eggs of many others.

By merely reading the paper of Mr. Barry, he might have been convinced that this observer had seen much deeper than any of his predecessors. Mr. Barry has pointed out a cellular content in the germinative vesicle, a thing then new to science; he believes this substance to be produced by changes which take place in the germinative spot. I do not enter into more full details upon the researches of Mr. Barry, for in that case I should be obliged to make some objections of secondary importance, which is not here my object. I had only to point out a fact, to correct an oversight. I now return to my subject.

IV. The researches of Mr. D. upon the development of the eggs of Ascidiæ, have led him to imagine a theory. This theory rests upon a false fact. According to this theory, the primitive state of the egg is a little sphere containing a transparent homogeneous liquid, in the midst of which sphere, may be already seen the outline of the germinative vesicle and spot. By degrees this liquid becomes *turbid*, and the germinative vesicle appears surrounded *by a slight cloud* which increases in extent until it fills the sphere of the egg. Then finally there is a retreat of the matter from the circumference towards the centre of the egg where it is condensed and forms the yolk. A free space remains between this last and the external membrane. This space is filled by a liquid; this liquid is the Biogen.

Having examined during many weeks and continuously each day the eggs of the same Ascidia which was the subject of his observation, I have never witnessed this phenomenon. And yet I examined them in individuals of very different sizes, and in most diverse conditions, taking care always that the egg should remain in its natural state; never, I repeat it, did I see this phenomenon of gradual condensation and of the retreat of the vitellus. Having tried all the good methods of which we can avail ourselves in the use of the microscope, the idea occurred to me to compress strongly a fragment of ovary. What was my surprise, at seeing living copies of the figures published upon this subject. It could even have been easy to make a more complete series of them. The eggs were no longer in their natural state; they were pressed down or crushed, their natural state destroyed, and this was the foundation upon which was built the theory of Biogen liquid, which was to apply to the whole animal kingdom.[*]

What then is the liquid, and what part does it play in the history of the egg? This liquid is albumen, the albumen which is formed in the ovary, and to judge rightly of the part which it takes in the formation of the egg, some general considerations upon the primitive state of eggs are here necessary.

Prof. Agassiz[†] has already reminded us that the point of departure of the egg is the same as that of the cells of the organic tissues. There is a period when the ovule is only a minute cell. More recent observations confirm these first results. To know the origin of the egg, we must then ascend to the origin of cells.

There are *primordial cells*, and *derived cells*. The experiments of Dr. Ascherson,[‡] have taught us that primordial cells are formed of two substances; of an oily substance and of albumen. Cells perfectly like primordial organic cells can be made artificially by bringing an oily liquid into contact with albumen, although the albumen and the oil or oily matter show a perfect continuity of substance when we examine them separately. But bring them in contact, and cells are formed immediately. Every physiologist can repeat these experiments, and ought to do it.

Primordial cells once formed in the manner above indicated, another phenomenon presents itself. They become nucleated, and these nuclei enlarging, give birth to derived cells.

Thus derived cells are multiplied by the growth of the nuclei, according to the researches of Mr. Martin Barry,[§] of Prof. Agassiz and my own, and whenever the third generation appears, the parent cell bursts and allows its contents to escape; it is in this way that they increase in number.

Now the only difference there is between the cells of the tissues and eggs, is that in these last the parent cell never bursts,[‖] the primordial cell preserves within itself all the subsequent generations of derived cells; which by their accumulation, form the substance out of which the new individual is produced.

Applying now this knowledge in a more special manner to the development of eggs, we can reply to the question asked above, viz., what part does the albumen play?

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[*] If the Biogen is so general, I would ask why it was not shown in the Sigalion and the Sabella of which Mr. Desor also speaks?

[†] Lectures on Comparative Embryology, 1849, p. 81.

[‡] Ueber den physiologischen Nützen der Fettstoffe und über eine neue auf deren mitwirkung begründete und durch mehrere neue Thatsachen unterstützte Theorie der Zellenbildung.—In Müller's Archiv. fur Anatomie Physiologie, &c. 1840, p. 44. —Comptes Rendus de l'Institut, vol. vii, 1838, p. 837. (*Sur l'usage physiologique des corps gras.*)

[§] Researches in Embryology: Third Series.

[‖] I mean, at least, as long as the new individual is not ready to escape out of the egg.

At a determinate epoch, for each species, the ovarian sacks are filled with primordial cells. It would be premature to raise the question whether they are formed in the ovary itself, or are brought there already formed. Let us take them, as they exist in the ovary. There under the influence of the organism, they pass through that course of development which we have pointed out as proper to cells destined to become eggs. They contain at first oil. By endosmosis albumen passes through the envelop or membrane, and coming in contact with the oil, cells are formed, the constituent cells of the vitellus (the granules of the yolk). When the oil is exhausted, no more cells are formed. The mass of the vitellus then increases, after the ordinary method of multiplication by the growth of nuclei. The albumen itself continues to penetrate through the membrane of the cell, which has now become an egg. It remains under the form of albumen, and surrounds the vitelline globe with a concentric zone more or less thick which increases as the egg grows larger. The intermediate space between the yolk and the external envelop (*chorion*) being increased, one would be tempted to acknowledge a withdrawing of the vitellus from the circumference towards the centre, if it were not known that all parts of the egg enlarge in the same proportions. Besides, a yolk which retreats, which is condensed, ought to occupy a less space, while the contrary is the fact, even as shown by the drawings made by Mr. Desor himself.

The conclusion is doubtless, already anticipated, that the pretended biogen liquid is found to be nothing more than an accumulation of albumen, the albumen formed in the ovary. An embryologist would have known that the yolk of the egg of all animals is composed of albumen and of an oily substance, and that no one has ever supposed the first of these two substances to be formed in the oviduct. When the albumen deposited in the oviduct is spoken of, it is the white which surrounds the yolk of the egg of certain animals that is referred to, and it is altogether gratuitous to attribute to embryologists doubts on this subject. I think Mr. Desor is the only person who has ever confounded the albumen of the vitellus, with the albumen which *surrounds* the essential parts of the eggs common to all animals.

When mature eggs are to be referred to a uniform type, it is necessary to distinguish between the *essential* parts (the vitellus or yolk, the germinative vesicle and the germinative spot), and the *accessory and protective* parts (the external albumen or white, the shell-membrane and the shell itself). The former are identical throughout the animal kingdom, they are never wanting; they are therefore necessary. The latter are not absolutely necessary, and as a proof of this, they are modified according to circumstances, and, in an infinite number of cases, are entirely wanting.

Starting now from the structure of the egg and knowing it to be identical in its constituent elements throughout the whole animal kingdom, the doctrine of its crystallization from a *mother-liquid* refutes itself. The idea that the vitellus is precipitated, or is crystallized, is indeed very strange. Is not this the distinction which we make between the inorganic kingdom and the organic kingdom, that the former is *crystallized*, while the latter is *organized.*

And then as to the physical characters of this biogen liquid, and the method of distinguishing it from albumen, not a word is said. All that has been done is the substitution of a name, the thing newly named is hidden from the eyes of physiologists. To explain the formation of eggs in the animal kingdom, Mr. D. thus finds himself obliged to procure the intervention of a liquid of which he knows nothing,—a liquid which would make the function of the ovary of secondary importance,—a liquid which would substitute itself for the vital action of the organism, an action which physiology explains,—in fine, an occult liquid, which sound philosophy disowns.

To oppose such a liquid to the vital action of the organism in the procreation of the substance, from which new individuals arise, is to go out of the domain of science. Mr. D. moreover has found that his biogen liquid runs through various modifications. This liquid then has no permanent character, it is under the influence of something beyond it, which produces it in its turn.

Anatomy and physiology are our guides in our embryological researches;—one confirms the other. Remaining within these limits, it was not necessary to go beyond the bounds of sound philosophy, and to fancy a theory which rests upon nothing, which teaches nothing new, which explains nothing, and which stands apart, isolated from physiology.

Thus the theory of biogen, applied to the egg of Ascidia, is not even probable; applied to the animal kingdom it is absurd.

V. § 1. Prepossessed by the false notion that the vitellus is formed by condensation, Mr. D. compares the formation of eggs to that of the celestial bodies, according to the nebular hypothesis.

But in order that a comparison of one phenomenon with some other phenomenon may be established, it is necessary that the one with which the comparison is made, should be perfectly demonstrated,—it must be a law or a principle.

Now the author forgets that the question of the condensation of the heavenly bodies according to the nebular hypothesis, is one of the most controverted questions. The fact is that we know nothing positively respecting the origin of the stars. Has the matter of which they are composed, been diffused throughout space under the form of what has been called nebulæ, and has it been gradually condensed around a nucleus to acquire its sphericity under the power of universal attraction, and to assume then a given movement and a determined direction?

There is no astronomer who can answer this question in the affirmative. From the study of our globe we arrive at the idea that it has had a beginning, and that it was originally in a fluid state. Beyond this, all is conjecture. Reasoning from the earth to the stars, we acknowledge, for all, a beginning of which we are ignorant.

It is then a false generalization to compare the phenomena of ovulation with the theory of the condensation of the sidereal bodies.

But let it be for a moment granted that the stars have been formed by the condensation of matter at first diffused. Where is the analogy between what ought then to take place, and what we witness in the formation of the egg?

The point of departure of organized beings is a sphere—the sphere is the figure of the celestial bodies; this is the whole of the analogy! In that sphere which constitutes the egg, two liquids are brought in contact and having an affinity for each other, they combine and form the vitellus which, from the first, is distributed equally throughout the whole sphere, less dense, it is true, at the beginning; but never showing the least tendency to centripetal motion, the least disposition to be precipitated around the germinative vesicle. There is never any retreat of the vitellus from the periphery towards the centre; there is no gravitation; there is a molecular attraction in the interior of a sphere, there are two liquids which are associated together, and not one liquid creating another out of itself.

Thus then should the theory of the condensation of the heavenly bodies be true, that of the eggs arising from *biogen* would not even be its analogue. Where is the biogen of the stars? No astronomer has had the hardihood to imagine a mother liquid, a gas, or any substance whatever preëxisting in space to create matter, and to disappear after having undergone various modifications.

§ 2. But Mr. D. stops not here. After having found *the great law of attraction at the bottom of the formation of organic bodies*, he comes to the question of movement. "As soon," he says, "as the egg enters upon its organic life, it begins to revolve." There are, indeed, a few invertebrated animals in which the embryo is subjected to a rotatory movement within the envelop of the egg. When one witnesses this for the first time, his thoughts naturally revert to the rotatory movement of the celestial bodies. But on looking deeper into the subject, he soon perceives the difference. I have described the movements which take place in the embryo of a marine Planaria.* I have shown that there is

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* Proc. of the Amer. Assoc. for the Adv. of Sciences. Second meeting, held at Cambridge, August, 1849. Cambridge, 1850. 8vo, p. 400.

nothing regular about them, no subjection to law. The young animal itself regulates and controls them. There are vibratory ciliæ, that is to say, organs of locomotion, and where these do not exist, vibratory cells. There is not an external force under the dominion of which it is caused to move.

The egg possesses organic life from the moment when it appears under any form whatever, therefore it cannot be said to acquire it when it begins to move. Besides eggs, as eggs, move not; when they move they are no longer eggs; they are *embryos.* For when movement occurs it does not take place till after the division of the yolk; and after that division, the embryo exists. So that in this view also, the comparison is false.

ART. XL.—*Note on Heteronomic Isomorphism;* by J. D. DANA.

IN the table on page 241, of this volume, the mineral Petalite is placed with the triclinic feldspars. The cleavages appear to correspond more correctly to a monoclinic form, although as far as now understood, not wholly analogous to the ordinary feldspars in direction. In the C atomic volume, as determined, it is identical with the monoclinic feldspars. The atomic volumes of the feldspars will then stand as follows:

	A.	B.	C.
I. MONOCLINIC.			
Orthoclase,	1388	231·3	60·4
Ryacolite,	867	216·7	57·8
Loxoclase,	1063	212·6	56·0
Baulite,	2178·1	217·81	55·85
Petalite,	6071·8	224·96	57·3
II. TRICLINIC.			
Albite,	1280·4	213·4	55·67
Labradorite,	795·5	198·9	53·03
Oligoclase,	1038·3	207·66	54·647
Andesine,	2912·4	208	55·0
Anorthite,	1959	195·9	52·94
Vosgite,	2266·5	197	52·84

Topaz and Andalusite approximately isomorphous.—The angle of the vertical prism of Andalusite is 91° 20′, and in Topaz there is the corresponding angle 93° 7′ (form $\propto\breve{P}2$, as usually taken). In the former, P: *a*, (a brachydiagonal prism,) =144° 50′ Teschemacher, 140° Phillips, while topaz has the corresponding angle 138° 3′. Rammelsberg has recently suggested that in topaz the fluorine replaces oxygen, and that the formula is essentially $\dddot{\bar{A}}l^3\,\dddot{S}i^2$, with one-seventh of the oxygen replaced by fluorine, or as written out in full,

$$6[3Al^2O^3+2SiO^3]+[3Al^2F^3+2SiF^3].$$

As this, excluding the fluorine, is the formula of Andalusite, the isomorphism here pointed out may be a case of ordinary isomorphism.

Manganocalcite.—This species is a trimetric carbonate of manganese, illustrating the remark on page 239.

ART. XLI.—*On some Minerals recently investigated by M. Hermann;** by JAMES D. DANA.

1. GIBBSITE.

THE analyses of Gibbsite by Hermann, according to which Gibbsite is a phosphate instead of a hydrate of alumina,* are alluded to by Prof. Silliman, Jr., in his memoir, in volume vii, of this Journal, page 411, where this chemist, by several analyses, sustains the original view with regard to this species, his results giving much less than one per cent. of phosphoric acid. Hermann in a late memoir† publishes the following as his recent conclusions upon the Richmond mineral.

	1*a*.	1*b*.	2.	3.
Phosphoric acid, . . .	37·62	26·30	15·30	11·90
Alumina, ...	26·66	38·29	50·20	53·92
Water, ...	35·72	35·41	34·50	34·18

Nos. 1*a* and 1*b* were two specimens somewhat foliated on limonite; G.=2·21. No. 2 was a stalactitic mass; G.=2·44. No. 3 was porous with an earthy fracture; G.=2·20. The phosphoric acid is here made a very varying constituent.

This species, from Richmond, has recently been analyzed by Mr. Crossley in the Laboratory of Dr. C. T. Jackson, with direct reference to the occurrence of phosphoric acid (as in Prof. Silliman's investigations), and he has found that his specimens *contained no phosphoric acid, and were a true hydrate.* The mineral is therefore identical with Rose's hydrargillite and includes that species, as has been before suggested.

2. WILLEMITE, OR ANHYDROUS SILICATE OF ZINC.

The anhydrous silicate of zinc was first recognized as a species by Vanuxem and Keating, who published a full and accurate description both physical and chemical, in 1824, in the Journal of the Academy of Natural Sciences of Philadelphia, volume iv, page 8. They describe the form of the crystals, as occurring at Stirling, New Jersey, and give the angle R : R, 118°, which was offered as only an approximation, the faces being irregular and rough.

Subsequently, Dr. Thomson of Glasgow received specimens. He described the mineral physically nearly as done by Vanuxem and Keating,‡ mentioning the hexagonally prismatic form with trihedral summits, though giving the angle 124° instead of 118°, observing however that it was "impossible to measure the angles," as the planes were so very uneven. He states that the

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* Jour. für Prakt. Chem., xl, 32. † Ibid, xlvii, 1.

‡ Ann. Lyceum Nat. Hist., N. Y., iii, 1828, and Mineralogy, 1836, i, 519.

above-mentioned authors had made it out a *silicate of zinc.* His investigations transformed it into a silicate of manganese with the composition

$\dddot{\mathrm{Si}}$ 30·650 $\dot{\mathrm{Mn}}$ 46·215 $\dddot{\overline{\mathrm{Fe}}}$ 15·450 moisture and carbonic acid 7·300=99·615.

Dr. Thomson's reputation at that time served to put the blunder on Vanuxem and Keating. The mineral was named Troostite, and Thomson's analysis assumed as the correct one. Recently the so-called Troostite has been examined by Hermann,* who has confirmed the original analyses, both results giving the formula $\dot{\mathrm{Zn}}^3\,\dddot{\mathrm{Si}}$ = Silica 72·47, oxyd of zinc 27·53, or the constitution of Willemite. The analyses hitherto made of the American and foreign Willemite are as follows:—

1, 2, Vanuxem and Keating (loc. cit.); 3, Hermann (loc. cit.); 4, Thomson (Min. i, 545); 5, Levy (Ann. des Mines, [4], iv, 515); 6, Rosengarten (Rammelsberg's 3d Supplement to his Handwörterbuch, 65); 7, 8, Monheim (Verh. Nat. Vereins. Rheinl., 1848, and Rammelsberg's 4th Supplement, 114); 9, 10, Delesse (Ann. des Mines, [4], x, 211).

	$\dddot{\mathrm{Si}}$	$\dot{\mathrm{Zn}}$	
1, Stirling,	25·44	68·06	$\dddot{\overline{\mathrm{Fe}}}$, $\dddot{\overline{\mathrm{Mn}}}$ 6·50 = 100·00, Vanuxem and Keating.
2, "	25·00	71·33	$\dddot{\overline{\mathrm{Fe}}}$ 0·67, $\dddot{\overline{\mathrm{Mn}}}$ 2·66 = 99·66 " "
3, "	26·80	60·07	$\dot{\mathrm{Mn}}$ 9·22, $\dot{\mathrm{Mg}}$ 2·91, $\dot{\mathrm{Fe}}$ *trace*, loss by ignition 1·0=100 Herm.
4, Moresnet,	26·97	68·77	$\dddot{\overline{\mathrm{Fe}}}$ 1·48, $\dddot{\overline{\mathrm{Al}}}$ 0·66, ib. & trace $\dot{\mathrm{Zn}}$, $\dddot{\overline{\mathrm{Fe}}}$ 0·78, $\dot{\mathrm{H}}$ 1·25=99·91, Thom.
5, "	27·05	68·40	$\dddot{\overline{\mathrm{Fe}}}$ 0·75, loss by ignition 0·30 = 96·50, Levy.
6, Silesia,	27·34	70·82	$\dot{\mathrm{Fe}}$ 1·81 = 99·97, Rosengarten.
7, Stolberg,	26·90	72·91	$\dddot{\overline{\mathrm{Fe}}}$ 0·35 = 100·16, Monheim.
8, "	26·53	69·06	4·36, $\dot{\mathrm{Ca}}$ 0·41, $\dot{\mathrm{Mg}}$ 0·13, $\ddot{\mathrm{C}}$ 0·04 = 100·53, Monheim.
9, "	27·28	72·37	$\dot{\mathrm{Fe}}$ 0·35 = 100, Delesse.
10, Stirling,	27·40	68·83	0·87, $\dot{\mathrm{Mn}}$ 2·90 = 100, Delesse.

Hermann gives the specific gravity of the Stirling ore 4·02; Vanuxem and Keating 3·89–4; Thomson for the Willemite 3·935, and Levy 4·16–4·18. No. 7 (from Stolberg near Aix la Chapelle) was crystallized; G. = 4·18. No. 8 massive; G. = 4·02–4·16. No. 10, the Stirling mineral, according to Delesse, has G. = 4·154.

The crystals of Troostite have besides the primary rhombohedron (115°) another truncating its terminal edges, $(-\frac{1}{2}\,R)$ with $R:R = 142°\ 52'$. The crystals of Willemite are quite small, being but 2 or 3 millimeters long and 1 thick. They are hexagonal prisms, but the prism is intermediate to that of Troostite; and the trihedral summit has according to Levy the angle of 128° 30′ nearly, the planes not admitting of very accurate measurement,—corresponding possibly to the rhombohedron $\frac{4}{5}R$, which has this angle 127° 33′.

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* Jour. für prakt. Chem. of Erdmann and Marchand, xlvii, 11.

3. RHODONITE, OR MANGANESE SPAR.

Rhodonite was long since shown to be a manganese augite, and the Fowlerite of Shepard is recognized by Hermann as giving the angle of augite; M : M=87° 6′. Hermann has analyzed the Stirling, N. J., mineral with the following result,

	$\dddot{Si}$	$\dot{Fe}$	$\dot{Mn}$	$\dot{Zn}$	$\dot{Ca}$	$\dot{Mg}$	
	46·48	7·23	31·52	5·85	4·50	3·09	loss by ignition, 1·00=99·67
Oxygen,	24·13	1·60	7·06	1·15	1·28	1·22	

giving for the oxygen ratio for protoxyds and silica 12·31 : 24·13, or very nearly 1:2, as in the received formula $\dot{Mn}^3\dddot{Si}^2$. He obtained the specific gravity 3·63.

Hermann has also analysed the manganese spar of Cummington, Massachusetts, and has concluded that the mineral instead of being a manganese augite is a manganese hornblende, that is, has the oxygen ratio 4 : 9 and formula $\dot{Mn}^4\dddot{Si}^3$.

His analysis gave

	$\dddot{Si}$	$\dot{Mn}$, *trace* of $\dot{Fe}$	$\dot{Ca}$	$\dot{Mg}$
	48·91	46·74	2·00	2·35=100·00
Oxygen,	25·38	10·37	0·57	0·91

The result affords the oxygen ratio for protoxyds and silica 11·85 : 25·38 or very closely 4 : 8½, which is as near augite as the hornblende ratio. He unites with his *mangan-amphibol*, Thomson's sesquisilicate of manganese from Stirling, which according to Thomson has the angle 123°30′, which is nearly that of hornblende. But Thomson's analysis proves the crystallographic measurement of little value, since it makes the species a *mangan-augite*—it giving

$\dddot{Si}$ 42·40 $\dot{Mn}$ 50·72 $\dot{Fe}$ 6·76

or even less silica than required for an augite, instead of the excess which would make it a hornblende.

The mineral of Cummington often contains disseminated through it visible points or grains of silica, and if in visible grains, there will be also invisible silica, and enough to account probably for the hornblende composition. M. Adolph Schlieper, now of Lowell, Mass., has examined and analyzed the Cummington mineral, from specimens placed in his hands by the writer, and he attributes the excess of silica to this source. His analysis gives the oxygen proportion 11·36 to 26·6, or quite closely 4 : 9. He found the mineral to be partly soluble in acids and by this means separated it into an *insoluble* portion 90·15 per cent., a *soluble* 9·85.

The insoluble part afforded

	$\dddot{Si}$	$\dot{Mn}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{Fe}$
	51·21	42·65	2·93	*trace*	4·34=101·13
Oxygen,	26.6	9·56	0·84		0·96

The soluble part consisted of carbonates as follows,

$\dot{Mn}\ddot{C}$	$\dot{Fe}\ddot{C}$	$\dot{Ca}\ddot{C}$	$\dot{Mg}\ddot{C}$	$\dot{H}$ and loss.
50·52	8·60	37·17	2·44	1·27=100

The presence of carbonic acid in this mineral was long since announced by Hitchcock, who found ten per cent. in one specimen. If the uncombined silica bears any proportion to the invisible carbonates, the excess of this ingredient is sufficiently explained. We believe therefore with M. Schlieper, the mineral to be essentially identical with the mangan-augite.

4. LEPOLITE AND LINDSAYITE.

The Lepolite of Hermann* is a feldspathic mineral from Finland, identical in chemical formula with anorthite, but differing in having its crystals oblique or inclined to the *left*, (when the edge T : T′ is in front) instead of to the *right*. He gives for T : T′ 120°30′, P : M 93°, which is the angle between two cleavage planes. H=6. G=2·75–2·77. Vitreous and transparent; colorless, grayish, greenish, often brownish externally. Crystals often large, and sometimes two inches long. Composition $\dot{R}^3\dddot{Si}+3\bar{\dddot{Al}}\dddot{Si}$.

	$\dddot{Si}$	$\bar{\dddot{Al}}$	$\bar{\dddot{Fe}}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{Na}$	loss by ignition.
1. From Lojo,	42·80	35·12	1·50	14·14	2·27	1·50	1·56=99·69
2. From Orrijervi,	42·50	33·11	4·00	4·00	5·87	1·69	1·50=99·54

It fuses with difficulty on the edges before the blowpipe, and is decomposed by concentrated acids.

Hermann has also published a description of a new feldspar which he calls *Lindsayite*† in the same memoir with the Lepolite. The following are its characters:

Monoclinic or triclinic, T : T′=120°, P on the axis 65°. Crystals often of large size. H. = 4. G. = 2·83. Color, black externally, internally gray, bluish-gray, dull reddish. Subtranslucent. In a matrass yields water. Before the blowpipe fuses with difficulty on the edges. With the fluxes, the reaction of iron and silica. Analysis afforded,

	$\dddot{Si}$	$\bar{\dddot{Al}}$	$\bar{\dddot{Fe}}$	$\dot{Fe}$	$\dot{Mg}$	$\dot{K}$	$\dot{Na}$	$\dot{H}$	
	42·22	27·55	6·98	2·00	8·85	3·00	2·53	7·00	$\overset{\cdot\cdot\cdot\cdot\cdot}{\bar{P}}$ *trace* =100·13
Oxygen ratio	21·90	12·84	2·09	0·44	3·49	0·50	0·64	6·22	

whence he deduces for the oxygen of the water, protoxyds, peroxyds and silica, the ratio 1 : 1 : 3 : 4, and the formula‡

$$\dot{R}^3\dddot{Si}+3\bar{\dddot{Al}}\dddot{Si}+3\dot{H},$$

which, excluding the water, represents the composition of anorthite and also Hermann's lepolite.

Breithaupt, in volume xlvii, p. 236, of the Journal für praktische Chemie, stated that the Lindsayite was properly a pseudomorph, after lepolite. To this view Hermann objects in volume xlviii, 254, (Nov. 1849,) mentioning that lepolite contains 10 to 15 per cent. of lime and lindsayite none.

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[*] Jour. f. prakt. Chem., xlvi, 387.

[†] Jour. f. prakt. Chem., xlvi, 396.

[‡] This is only an approximation; for the oxygen of the peroxyds and silica has more nearly the ratio 2 : 3 than 3 : 4.

The constitution of the mineral, so different from all known feldspars—its 8 per cent. of magnesia, 7 per cent. of oxyd of iron, and 7 per cent. of water—entirely favor the opinion that the crystals are actually pseudomorphs of some feldspar mineral as Breithaupt suggested. Changes through pseudomorphism of the extent this would imply, and even far greater, are abundantly exemplified.

ART. XLII.—*On the Interpretation of Mariotte's Law;* by Lieut. E. B. HUNT, U. S. Corps of Engineers.

IT is readily demonstrated that in any entirely *homogeneous* medium, the component parts of which act on each other by forces varying as any function of the distance, Mariotte's law must prevail. Both elastic tension and cohesive force will necessarily vary as the density, in a medium assumed as homogeneous, quite irrespective of the law of force, the variation being expressed in terms of distance between the component parts of the medium. Whether the force be attractive or repulsive, varying inversely with the first or hundredth power of the distance, the result is the same; that *entire homogeneousness makes Mariotte's law necessary.*

To prove this: assume a perfectly homogeneous medium whose parts exert forces varying as any function of the distance. Assume in this an origin of coördinates, three coördinate axes, X, Y and Z, and three constant elementary distances, dx, dy, dz. Conceive each axis graduated by laying off its element successively from the origin outward. Through each point of graduation on either axis pass a plane parallel to the other axes: do this for each axis. The space around the origin is thus divided into elementary parallelopipeds, each of which contains a like portion of the homogeneous medium.

The force of elastic tension or of cohesion is measured by the resultant action on a unit of surface of the plane X, Y, by all the forces acting in the positive direction of the axis Z, between the parts on opposite sides of the plane X, Y. This resultant is balanced by an equal one acting in the negative direction of the axis Z. To make up this resultant, a certain number of the elementary portions of the medium conspire. It may therefore be equated with a series, each term of which expresses the positive component along the axis Z, of the force exerted between two elementary portions of the medium on opposite sides of the plane X, Y.

If now the density of the medium be varied, each term of this series will vary in the same ratio, since the quantity of matter in each elementary volume varies as the density. The density thus governs each term of the series, by fixing the quantity of matter in each elementary volume. If we call the ratio of the varying density to a standard density N, each term of the series contains N as a simple factor: or the whole series varies as N. Hence the resultant or entire elastic tension or cohesion varies as N, or as the density. This result is entirely independent of any particular law of relation between the forces and distances: and will always be true so long as the elementary volumes can be assumed as homogeneous. As dx, dy, dz, can always be taken indefinitely less than the radius of sensible activity of any assumed force, the demonstration can only fail by the parts failing to be homogeneous.

It will be seen by the above that any inference of the law of repulsive force between ultimate atoms or molecules, cannot be correctly drawn from Mariotte's law, for this leaves the primary forces involved, wholly indeterminate. We are by no means authorized to conclude that in elastic fluids where the pressure varies as the density, the molecules repel each other directly as the distance.

The demonstration now given, has a singular bearing on the atomic theory of material constitution. We know experimentally that Mariotte's law does not prevail uniformly in elastic media, while in liquids and solids it has no show of application. Hence we are bound to infer *non-homogeneousness*. Now how can homogeneousness be interrupted, except through something like an atomic constitution of media? A laminated, filamental, or molecular structure alone can produce heterogeneousness. The two first would confer special properties in certain directions, which are not found in fact. Hence a molecular constitution of matter seems entailed as an inference, from the bare fact that Mariotte's law is not universal. According to the view now presented, the elasticity of gases varies as the density, because the quantity of matter within the sphere of sensible activity varies in that ratio. As they approach the point of liquefaction, other considerations derived from the special atomic constitutions of the media must be introduced. The entire absence of a limit to the division of parts would produce that homogeneousness from which Mariotte's law becomes an inevitable inference. Such an inference, as applied to media in general, being contrary to the fact, a limit to actual division of parts must be admitted. *Any other theory than one of ultimate molecules, separated by spaces, seems to impose inferences conflicting with facts, throwing us back irresistibly into the theory of true molecular structure.*

Boston, April, 1850.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Deportment of Crystalline Bodies between the poles of a Magnet;* by JOHN TYNDALL and HERMANN KNOBLAUCH; (Phil. Mag., xxxvi, 178, March, 1850.)—The results obtained by Professor Plücker of Bonn, in his investigations upon crystals, induced us early in the month of November last to commence a series of researches in connection with this subject. Our inquiries, so far as they at present reach, form the subject of this paper.

After a long series of trials, not necessary to be recapitulated here, we arrived at the persuasion that no safe inference could be drawn from experiments made with full crystals. It appeared necessary to examine the forces attributed to crystalline bodies in detail, one at a time, removing as far as possible all influences likely to interfere with the simple action of this one.

To attain this object we experimented with cubes: we had one cut from tourmaline, in such a manner that the optical axis of the crystal ran parallel to four sides of the cube; on suspending it between the poles and closing the circuit, the optical axis set itself strongly equatorial; thus corroborating the law of Plücker, which affirms that the optical axes of negative crystals are repelled. When, however, the same cube was hung with the optical axis vertical, the influence of that axis being thus destroyed, a preference was shown to one of the diagonals of the horizontal face of the cube, not to be explained by the law mentioned: this preference was more strikingly exhibited in the case of the following two crystals.

A cube of beryl, cut similarly to the tourmaline, being hung with its optical axis vertical, one diagonal of its horizontal face set itself axial; only one diagonal could maintain this position, the other was repelled. In dichroite this phenomenon was strikingly exhibited; when hung with the middle line of the optical axes vertical, one diagonal assumed the axial position; if, however, the circuit was closed when the other diagonal chanced to lie from pole to pole, the latter seemed to experience a repulsive shock, sufficient to make the cube spin several times round upon its axis.

We do not see any possibility of referring this election of a particular diagonal to the influence exerted by the optical axis, at least in the case of beryl.

To ascertain the exact nature of this influence, we had recourse to discs, cut so that the optical axis of the crystal lay as a diameter in the plane of each. In this way the influence of mere form was totally annulled, and the pure action of the optical axis, if such existed, might be observed.

Our first discs, five in number, were taken from a semi-transparent crystal of Iceland spar, and lay at various angles to the sides thereof. In all these cases the law of Plücker was strictly verified, the optical axis being always repelled.

Four discs and one square were next taken from two transparent crystals of the spar, and suspended successively between the poles. We were by no means prepared for the reply given to these experiments; *in each of the five cases the optical axis set itself distinctly axial.*

The balance sheet of our inquiries up to the present time is this; out of eleven crystals of Iceland spar examined as above, five have obeyed the law of Plücker, while six have contradicted that law.

In determining whether the optical axis will be repelled or not, it is not necessary to cut the crystals in the manner described. A thin rhomb cloven from the crystal and ground into the shape of a disc, will decide the question. If it belong to the class whose optical axis is repelled, the line bisecting the acute angles of the rhomb will set itself axial; if to the other class, the same line will set itself equatorial.

Discs thus prepared form undoubtedly the purest means of investigating this question. The rhomb itself, however, without being ground into a disc, affords us sufficient intelligence as to the class of the crystal to which it belongs. Is its optical axis repelled, then the long diagonal of the rhomb will incline to the axial position; is the optical axis attracted, the long diagonal will stand nearly equatorial.

The same adherence of the diagonal to the axial or equatorial position continues after a thin bar containing the diagonal has been severed from the rhomb. For example, a bar containing the short diagonal of that class whose optical axis is attracted, will stand nearly axial. This fact is perhaps worthy of notice: if Iceland spar be diamagnetic, as Prof. Plücker asserts, and if the optical axis be repelled, what is it that overcomes the united action of both in the case of this diagonal? The projection of the optical axis lies in the same direction as the bar; both therefore work together, and both strive, in virtue of the two properties mentioned, to attain the equatorial position; they do not attain it, however; the bar stands almost axial.

The question, "Is the substance magnetic or diamagnetic?" necessarily lay at the threshold of all attempts to explain these phenomena. To answer this question by experimenting with the full crystal was impossible, as a diamagnetic crystal, it is well known, can set itself axially. This being evidently owing to some hidden property of the crystalline structure, we thought it might be destroyed by reducing the mass to powder. Portions of crystals of each class were finely pounded in an agate mortar; by the addition of a little distilled water the powder was made into a paste, from which small bars were constructed and carefully dried. On being hung between the excited poles, those whose optical axes were repelled stood equatorial, the others axial.

Adopting the plan already followed by Faraday, we next brought the two classes of crystals to the test of a single pole. At first, little bits of crystal were attached to the cocoon thread by means of a soft sticky kind of wax; the presence of this, however, was found to interfere with the purity of the experiment, and it was therefore abandoned; fine silver wire was next tried and also found ineligible; we next hung a straw horizontally, into each end of which a bit of crystal was thrust; but the straw was diamagnetic, and permitted no safe conclusion. Common white taper-wax was at length found exactly suited to our purpose;

it must, however, be handled with clean fingers, and even thus very little ; after two or three suspensions it invariably showed signs of magnetism. We chose long thin bars of crystal and hung them vertically thus bringing the wax so far above the poles, that, on examination, it showed not the slightest trace of magnetism or diamagnetism. A former remark explains why this vertical hanging is to be preferred to horizontal ; in the latter case, a rotation towards the pole, easily mistaken for an attraction, and difficult to distinguish from it, might occur with a diamagnetic body ; hung vertically, however, it could be distinctly seen whether the *mass* of the crystal was attracted or repelled. The results here delivered were in harmony with those already mentioned : those whose optical axes were attracted, were attracted ; those whose optical axes were repelled, were repelled.

Anxious to investigate this difference of action to the bottom, we chose two perfectly pure and transparent crystals from each class, and submitted them to chemical analysis. An experienced mineralogist was unable to detect the slightest visible difference between these crystals ; the analysis, however, showed that those whose optical axes were attracted contained protoxyd of iron in considerable quantity, while those whose optical axes were repelled contained no trace of this metal.

Here, then, we have two crystals perfectly alike in optical respects, but chemically different ; the change in the position of the optical axis between the poles being doubtless due to this difference. This seems to reduce that position to a mere function, so to speak, of the chemical nature of the substance. Could a salt of iron be introduced as an isomorphic substitute for some other constituent in the whole class of diamagnetic crystals, it is exceedingly probable that the position of the optical axis between the poles would in most of these cases be reversed, and this without in the slightest degree interfering with the optical properties of the crystal. It is even likely that Nature, as in the case before us, furnishes many examples of this isomorphic substitution. If this be true, then the position of the optical axis between the poles is a mere accident, and the introduction of it can only serve to render this already difficult subject unnecessarily complex.

On bringing a circular disc of gutta percha, which, in its manufacture, appeared to have a fibrous structure imparted to it, between the excited poles, the direction of these fibres set itself strongly axial. This action was so decided, that a parallelogram, three-quarters of an inch long and half as wide, with the fibres crossing it transversely, set itself stiffly equatorial. This can by no means be referred to the distance of the parallelogram from the poles, or to any other of those circumstances by which diamagnetic action is said to be exhibited ; our voltaic power varied from one to twenty cells of Bunsen's battery, but the result remained specifically constant ; further, on being hung edgeways, the parallelogram stood strongly magnetic ; and when one pole was removed, the whole mass was attracted by the other.

Whence, then, this apparent diamagnetism of the gutta percha ? The answer to this question will perhaps throw a light upon the complicated phenomena exhibited by crystals generally. The equatorial position of the gutta percha is manifestly due to the comparative facility with which the magnetic force can act in the direction of the fibre. Let us suppose the parallelogram suspended, and the circuit closed; every point of its substance is now affected, but not with equal force in all directions; in the direction of the fibre the action is strongest, and may be represented by the longer diameter of an egg, in the centre of which the point may be imagined. All lines drawn from the centre to the shell will represent the amount of the magnetic force in their various directions. On this assumption the equatorial position is readily explained; and the necessity of the parallelogram, when hung edgeways, to set itself axial, is also manifest.

As may be expected, when the parallelogram is made very long in comparison to its width, the long diameter of our hypothetical egg, is overpowered by the united action of a number of short ones, and the oblong stands axial.

We have succeeded in obtaining analogous results with ivory, which, though diamagnetic, can be so cut that it stands almost axial. The anomaly is explained by reference to the structure of the tooth, which modifies, in certain directions, the diamagnetic power. By attending to these circumstances, we have been able, with these two substances, gutta percha and ivory, to imitate almost all the experiments which we have made with both classes of crystals.

If we suppose the shorter diameter of an ellipse to coincide with the straight line formed by the intersection of any two surfaces of cleavage, and the ellipse to rotate around this diameter, an oblate spheroid will be the result. Conceive lines drawn through the centre of this figure and terminated by the surface, to represent the amount of magnetic or diamagnetic force in the direction of these lines, and we have an hypothesis of magnetic or diamagnetic action within the crystal, sufficient, not only to account for every fact noticed in this paper, but for numerous others, the discussion of which we refer to a future occasion.

Extending this principle to the intersections of the three surfaces of cleavage, we obtain a resultant which falls in the direction of the principal axis of the crystal, or of the optical axis. The position of that resultant between the poles will depend solely upon the magnetism or diamagnetism of the crystal, and in nowise upon the fact of its being negative or positive, as asserted by Professor Plücker.

It is highly improbable that our representative spheroid will be of a constant shape in all crystals: in the case of gutta percha we assumed it formed by the rotation of a semi-ellipse round its longer axis, or what is commonly called prolate; in the case of Iceland spar it is oblate; in common iron it would be a sphere, as here the magnetic force appears to act equally in all directions. Every crystal will doubtless modify it in a manner peculiar to its own substance and structure. Future experiments will perhaps enable us, in many cases, to determine the numerical values of the long and short diameters of these spheroids.

From these considerations it would follow, that M. Plücker, in attempting to refer the facts observed by Mr. Faraday* to the optical axis, inverts the right course of proceeding; the attraction or repulsion of this axis being a secondary result, depending first of all upon the mag-

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* Phil. Mag., Jan., 1849, p. 75.

netism or diamagnetism of the substance, and secondly upon the manner in which either force is modified by the peculiar structure of the crystal.

The conducting power, so to speak, of Iceland spar for both magnetism and diamagnetism appears to be in directions perpendicular to the lines of cleavage. If these views be correct, the optical axis can no longer be regarded as the prime agent in the production of the phenomena which we have been considering; we shall no longer seek the explanation of new facts in the hypotheses of new forces, but rather in modifications of the old.

Marburg, January, 1850.

2. *Arsenic in the deposit from Mineral Waters;* by M. J. L. Lassaigne, (Journ. de Chem. Med., Sept., 1849; Phil. Mag., Dec., 1849.)—The large quantities of arsenic recently discovered in certain chalybeate waters, have made it a matter of much interest to determine the state in which the arsenic exists, and its effects upon the animal economy.

The deposit from the waters of Wattvillier (Haut Rhine) yielded 4·42 per cent. of arsenic acid, equivalent to 2·8 per cent. metallic arsenic. Forty grammes (about 600 grains) of this deposit were administered to a dog in two doses, the animal showed not the slightest uneasiness, ate as usual, and, in short, was uninjured by a dose equivalent to 26·52 grains arsenic acid or 16·8 grains metallic arsenic.

From this and another experiment of similar character, the author infers, that the poisonous property of the arsenic is destroyed in these deposits by the combination with peroxyd of iron—confirming the value of peroxyd of iron as an antidote to arsenious and arsenic acids.

[It is worthy of remark, however, that the recent deposit from chalybeate water is not without serious effect upon the human system, as is shown by the following case which was brought to our notice. Two gentlemen while drinking the water of a celebrated chalybeate spring thought to add to its strength by mixing with it several teaspoons full of the fresh deposit. In a very short time such alarming symptoms manifested themselves as to require medical aid. These symptoms were violent headache, throbbing in the temples, &c., and were evidently due to an over dose of iron. The parties soon recovered, but in the more plethoric of the two the effects were sensible for several days.

The same quantity of *dry* peroxyd of iron—such as is erroneously called carbonate of iron, might have been taken with impunity. No more striking instance of the difference in effect between the moist freshly precipitated oxyd and the dry could be given.]

G. C. Schaeffer.

3. *On the reduction of Chlorid of Silver;* by M. Wittstein, (Buch. Rep., vol. ii, in Chem. Gaz., Sept., 1849.)—The author prefers the reduction by charcoal. Two parts of chlorid of silver are well mixed with one part moist charcoal powder and poured into a black lead or other crucible with a smooth surface. The crucible is loosely covered and ignited until a quarter or half hour after the muriatic acid has ceased to appear. The outside of the crucible being cleaned it is to be inverted over a sheet of paper, and if any of the contents adhere they may be removed with a feather. The carbonaceous mass is then gradually added to 3 parts nitric acid, sp. gr. 1·20, in a convenient flask, and the solution is completed by a gentle heat.

As it is not easy to extract the whole of the silver, the mass need not be washed very long and the residuum may again be employed in another process to avoid loss. The impurities derived from the charcoal are trifling in amount; lampblack of course answers still better.

The author considers that the reduction is effected in reality by hydrogen, as only muriatic acid and no chlorine is given off.

G. C. S.

4. *On the Chemical Composition of the Fluid in the Ascidia of Nepenthes;* by Dr. A. VOELCKER, (Phil. Mag., Sept., 1849.)—The fluid of this, and similar secretions as in Sarracenia, &c., is commonly said to be pure water. Dr. Turner found on evaporating, a minute quantity of crystals supposed to be binoxalate of potash, while the odor of boiled apples given out indicated the presence of organic matter. The author examined eight different samples from various gardens and in most cases from unopened pitcher plants. In all the cases litmus paper gave an acid reaction. The same odor as that mentioned by Dr. Turner was observed during evaporation. The quantity of solid matter, as might be expected, varied considerably—from ·27 to 1 per cent. No volatile acids were present and no oxalic acid.

The dry residue from several samples united, contained about 38 per cent. of malic and a little citric acid, 50 p. c. chlorid of potassium; the remainder consisted of soda, lime and magnesia.

These experiments show this to be, as botanists have already demonstrated, a true secretion, containing *some* of the inorganic materials of the plant; but it is remarkable that not a trace of sulphuric acid could be detected, and yet it is hardly possible that sulphates are entirely wanting in the plant. G. C. S.

5. *Chlorine and Oxygen from Chlorate of Potash;* by Dr. VOGEL, (Buch. Rep., vol. iii, in Chem. Gaz.)—The author states that chlorate of potash repeatedly crystallized furnishes a pure gas, and ascribes the impurity to the presence of some perchlorate (hyperchlorite?).

[It is generally understood that oxygen from the mixture of peroxyd of manganese and chlorate of potash, is always contaminated with more or less chlorine, in which case the above precaution would be of no use.

The supposed easy preparation of pure chlorate is at the foundation of numerous determinations of chemical equivalents, and in particular that of chlorine.] G. C. S.

6. *Action of Potash upon Caffeine;* by A. WURTZ, (Comptes Rendus, Jan., 1850.)—A boiling concentrated solution of potash dissolves caffeine and disengages a considerable quantity of methylamine.

This confirms the supposition made in the last No. of this Journal, p. 282, that the base formed by Rochleder in the decomposition of caffeine by chlorine was methylamine. M. Wurtz also notices that the composition of the platinum salt is identical with that of the corresponding platinum salt of methylamine. G. C. S.

7. *Separation of Butyric, Valerianic and Acetic Acids;* by J. LIEBIG, (Liebig's Annalen, Sept., 1849; Chem. Gaz., Jan., 1850.)—The simultaneous occurrence of these acids renders an easy and economical process for their separation exceedingly desirable. This desideratum is fully answered by the plan proposed by Prof. Liebig. A part of the mixture of acids is saturated with potash and soda, or the re-

mainder added to it and distilled. If butyric and valerianic acids only are present, a portion of one or the other is at once obtained pure. If the alkali added is not sufficient to neutralize the whole of the valerianic acid, the distillate is a mixture, and the residue is a pure valerianate. If the alkali is more than sufficient to neutralize the valerianic acid, the residue is a mixture of valerianic and butyrate, but the distillate is pure butyric acid.

The mixtures remaining may be treated in the same way, and a new portion obtained pure.

Acetic acid, although more volatile than the other two, is not expelled by them from a partially saturated solution, owing to the formation of an acid acetate. Either valerianic or butyric acid may be distilled from this salt without intermixture with acetic acid. Where all these acids are present, the partially saturated mixture is to be distilled, and if any acetic acid is found in the distillate the process is to be repeated. Acetic acid is thus removed and the other two may be separated as above.

G. C. S.

8. *On the Production of Organic bases from Vegetable substances containing Nitrogen;* by Dr. J. Stenhouse, (Liebig's Ann., May, 1849; Chem. Gaz., Oct. and Nov., 1849.)—Reasoning upon the fact that fossil coal has yielded four bases besides ammonia—the author proposed to examine the products of the dry distillation of nitrogenous vegetable matter, and as these substances could not easily be obtained pure in large quantity, he operated directly upon seeds, &c., which are known to contain most of the nitrogen of plants. A large quantity of common beans was distilled in an iron retort. The product resembled that from animal matters, containing acetone, acetic acid, &c., with tarry matter and a large quantity of ammonia and oily bases. These latter were, with some difficulty, obtained in a state of purity, but the result was an evident mixture, the boiling point rising from 226° F. to 428°. The larger portion passing over between 302° and 311°, a tolerable quantity of an oil of constant boiling point was obtained.

Notwithstanding the difference in the bases indicated above—their properties are otherwise quite similar. They are colorless and transparent, of high refractive power, with pungent aromatic taste and odor. The more volatile are also more soluble in water, but all of them dissolve readily in alcohol and ether. The alkaline reaction upon test paper is very strong, and a rod moistened with hydrochloric acid held over them produces white fumes. The salts are generally crystalline; the double platinum, gold and mercury chlorids are readily obtained; not a trace of aniline could be detected.

The analysis of the oil boiling between 302° and 311°, gave the formula $C_{10}H_6N$, but this must be considered only as an approximation. The formula is nearest to that of nicotine; but the properties are rather those of picoline, discovered by Dr. Anderson.

An examination of oils boiling at very different temperatures, gave almost the same per-centage of carbon and hydrogen. May not some of these be merely polymeric modifications of the less volatile bases?

Oil cake required a higher heat for its distillation than the bean, and a smaller quantity of bases was obtained; wheat furnished a still smaller quantity, but the product was more volatile. Peat gave a larger quantity, but the products of the distillation of solid wood furnished hardly any.

To avoid the high heat necessary in distillation, by which the bases are decomposed, and the quantity of ammonia increased—experiments were made by boiling the substances with alkaline solutions; the products were nearly the same but more free from impurity. Flesh and guano were also tried, and the action of sulphuric acid upon beans, with like results.

The author proposes putrefaction as a still more eligible process for the alkaloids, as the action is less energetic. The fact that beans and bones do not yield the same products by distillation, is adduced as evidence that the vegetable and animal substances having the same composition are yet not identical. G. C. S.

9. *Preparation of Hydrobromic and Hydriodic Acids;* by E. H. Mène, (Comptes Rendus, April, 1849; Chem. Gaz., July, 1849).—The process now proposed for these two acids is free from objection, being neither costly, difficult nor dangerous, as are the usual modes.

In this process, crystallized hypophosphite of lime, obtained in preparing phosphuretted hydrogen from phosphuret of calcium, may be used, but from its being more readily obtained, sulphite of soda is to be preferred. The crystallized sulphite is to be first dipped in water and the iodine or bromine added to it in a suitable vessel. The reaction is aided by heat, and the gases are obtained pure, if a cotton or asbestus plug is placed in the neck of the vessel to intercept vapors of bromine or iodine.

The sulphite aids the decomposition of water by the iodine or bromine, the latter taking the hydrogen, the former the oxygen.

The proportions for the above process are 1 water, 3 iodine or bromine, 6 crystallized sulphite of soda. G. C. S.

10. *Passage of Hydrogen Gas through solid bodies;* by M. Louyet, (Ann. de Chim. et de Phys., Sept., 1849.)—M. Louyet, finds that a horizontal current of hydrogen from a capillary jet under a pressure of 40 to 45 inches of water, will pass through a sheet of paper, continuing as a current on the other side, inflaming or igniting spongy platinum, as if no obstacle existed.

Gold, tin and silver leaf, even when double, exhibit the same property, as also a thin film of gutta percha; but the thinnest glass which could be blown was found impermeable. G. C. S.

11. *On the presence of Silver, Lead and Copper in Sea-water, and in Plants and Animals;* by MM. Malaguti, Durocher and Sarseau, (Comptes Rendus, Dec., 1849; Phil. Mag., Feb., 1850.)—MM. Malaguti and Durocher having proved the wide diffusion of silver in metallic minerals, particularly in the sulphurets, which are converted by salt water into chlorids, the present research was undertaken with a view to ascertain the extent of the distribution.

Sea-water taken at a distance of some leagues from St. Malo, was found to contain ·000,000,001 of silver; the ash of Fucus serratus and ceramoides contained ·000,001. Rock salt of Lorraine was found to contain silver, indicating its presence in the ancient ocean.

This wide distribution of the metal induced a search for it in the ashes of terrestrial plants and in animals, the blood of them being saturated for the experiment. In both cases silver was found. Its presence could not be distinctly proved in the ashes of coal.

Lead and copper could not be detected in sea-water, but the ashes of several species of Fucus contained ·000,018. G. C. S.

12. *Ruthenium.*—The atomic volume of Ruthenium has been found by Claus to be identical, or nearly so, with that of Rhodium, or 651·96, see table, page 220.

II. Mineralogy and Geology.

1. *Description of the Vermiculite of Milbury, Mass.;* by Dr. C. T. Jackson, with an analysis by Mr. Richard Crossley, (communicated by Dr. Jackson.)—This mineral was first noticed in Milbury by Dr. Thomas H. Webb of Providence, R. I., and was described by him in the American Journal of Science in 1824, vol. vii, p. 55. Dr. Webb gave it the name it bears, which is very descriptive of its remarkable action under the influence of heat. It occurs in small scales resembling green talc disseminated throughout a mealy magnesian mineral of an ash grey color, and resembling a decomposed talcose rock. The vermiculite occurs in small scales, rarely more than one-sixth of an inch in diameter, and having no well defined lateral crystalline edges; but still they are obviously imperfect crystals and probably hexagonal prisms. They split readily into thin laminæ, like talc, and are flexible, but not elastic. Hardness 1·; sp. gr. according to Mr. R. Crossley, 2·756, the mineral having been rendered dry previous to being weighed. Color dark olive green by reflected light, with a pearly and greasy lustre; by transmitted light, color apple green. Translucent, and sub-transparent in thin scales. Before the blowpipe a thin scale of the mineral suddenly exfoliates and swells into a cylinder or prism nearly *one hundred times its original length!* This exfoliation takes place at a temperature between 500° and 600° F., and not at a temperature of 300° F., hence it is not wholly due to interposition of water between the laminæ of the crystals.

In a glass tube closed at one end, on heating until exfoliation takes place, a certain portion of water is given off, but on raising the heat to redness a still larger quantity is obtained. This water restores the blue color to litmus paper, that had been reddened by acids, and is therefore slightly alkaline. The expansion of vermiculite by heat is so sudden and powerful as to burst a glass tube filled with it, producing an audible explosion and scattering the glass to a distance.

In the platina forceps a scale of the vermiculite melts readily into a yellowish green glass. With carbonate of soda it fuses to an opaque brown bead. With borax it dissolves readily, giving a yellow glass while hot, which becomes colorless when cold.

With salt of phosphorus, it dissolves giving a transparent glass, which is yellow while hot, and colorless when cold, and becomes somewhat milky white. It is decomposed by chlorohydric and sulphuric acids. Mr. Crossley used a mixture of these two acids in decomposing the mineral for separation of its ingredients; having previously ascertained that its decomposition by acids was complete.

Clean scales of the mineral were selected with great care by Mr. Crossley, who obtained the following results—

Silica, . . .	35·74	containing oxygen =	18·56	ratios = 6·
Alumina, . .	16·42		7·66	2·
Protoxyd of iron, .	10·02		2·28	4·
Magnesia, . .	27·44		10·62	
Water, . . .	10·30		9·15	3·
	99·92			

Which gives approximately the following formula,*

$$2\ddot{\mathrm{Al}}\,\dddot{\mathrm{Si}}+4\dot{\mathrm{Mg}}^{3}\,\dddot{\mathrm{Si}}+9\dot{\mathrm{H}}$$

which is the formula given by von Kobell for *Pyrosclerite.*

Vermiculite therefore does not approach Pyrophyllite, which, according to the analysis of Hermann, gives the formula,

$$\dot{\mathrm{Mg}}^{3}\,\dddot{\mathrm{Si}}^{2}+9\ddot{\mathrm{Al}}\,\dddot{\mathrm{Si}}^{2}+9\dot{\mathrm{H}}$$

Mr. Crossley has devoted much time and attention to this analysis, and I am satisfied that it has been correctly made. The only subject for farther research is the cause of the very remarkable exfoliation of this mineral when exposed to heat. I ascertained the temperature at which the exfoliation takes place by heating the mineral on paper and on lead. It fully exfoliates below the fusing point of sheet lead, but not on a paper card, until it takes fire.

2. *On the Blowpipe characters of the Mineral from the Azores identified with Pyrrhite by J. E. Teschemacher;* by A. A. Hayes, (communicated.)—I received enough of the Pyrrhite from Mr. Teschemacher for the following trials. It proves to be a (columbate) niobate of zirconia, colored apparently by oxyds of iron, uranium and manganese. The following are its characters in the blowpipe flame. On the first impulse of heat, the assay becomes darker colored, its fine red color returning as the mineral cools; and this character may be observed, even after it has been highly heated for a long time. At the melting point of cast iron in the reducing flame, it becomes permanently darker and brown; on platinum wire, the assay dissolves in six bulks of fused borax and affords a clear colorless glass, which barely retains its transparency on cooling; becoming instantly opaline, or opaque by flaming. The oxydating flame causes opacity in a hot clear globule removed from the reducing flame. Phosphoric salt in the reducing flame affords a clear glass with one sixth its bulk, and when reduced, the glass is green. The oxydating flame colors the glass yellow. With one-fourth its bulk the fused salt dissolves the assay slowly, and the glass remains clear. In the reducing flame with twelve times its bulk of soda, the assay dissolves; some clear portions are seen while the globule is hot, but on cooling, opacity precedes the crystallization of the globule. When by continued reduction, the soda is partly evaporated, a gray brown slag remains, which cooled from the oxydating flame gives the green color, indicating oxyd of manganese.

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* Considering $\ddot{\mathrm{Al}}$ and $\dddot{\mathrm{Si}}$ as replacing one another, the analysis gives very exactly the formula $4\dot{\mathrm{Mg}}^{3}(\dddot{\mathrm{Si}}, \ddot{\mathrm{Al}})^{2}+9\dot{\mathrm{H}}$.—J. D. D.

Decomposed by much soda and the resulting mass treated with nitric acid, a heavy white insoluble powder remains. Boiling water causes the heavy powder to take a flocculent form, which is retained. This powder exhibits with tests, all the characters of (columbic) niobic acid. The acid solution when mixed with carbonate of ammonia remains clear; heated, some iron oxyd falls, while a light yellow tint is retained by the fluid; oxalic acid causes the separation of a white earth, which, heated with sulphuric acid to destroy oxalic acid, dissolves, giving a fluid, forming with potash before complete neutralization, a white double salt, which has the characters of that from zirconia, but may contain oxyd of cerium also. The oxalate as first formed does not afford, when heated, the cinnamon brown color, characteristic of deutoxyd of cerium.

The extremely small portion of the mineral operated on forbids the expression of certainty respecting the bases, and although inclining to the opinion of the existence of cerium from the red color of the crystals, I am not in possession of any facts proving this point.

3. *On the Red Zinc Ore of New Jersey;* by A. A. HAYES, (communicated to one of the Editors.)—Some recent trials on the red oxyd of zinc, confirm my earlier statement that the manganese is in a protoxyd state, *mixed* with the oxyd of zinc. The object was however to separate the peroxyd of iron, so as to show that its power of coloring confers on the oxyd of zinc the blood red color seen in fine specimens. In the trials, that variety of scaly peroxyd of iron, *which is produced when chlorid of iron is decomposed by vapor of water*, was obtained, and this oxyd, *being transparent and blood-red*, gives, by being interleaved with the crusts of zinc sublimate, the red color: the evidence was conclusive.

4. *On the existing Mineral Localities of Lewis, Jefferson, and St. Lawrence counties, New York;* by Dr. F. B. HOUGH.—From the great number and variety of mineral species, which were discovered during the course of the State Geological Survey, in the northern part of New York, in addition to those that were known before, and have been discovered since, the mineral localities of that section have attained a merited notoriety, among amateur collectors, and scientific mineralogists.

Many of the localities have become exhausted, and others have been discovered, while there are yet others which have been attributed to these counties through mistake. A concise account of existing localities seems to be especially desirable.

LEWIS COUNTY.—*Magnetic iron ore*, associated with sulphuret of iron, occurs in Greig; *bog iron ore*, in Watson, Diana, and New Bremen; *specular iron ore* in Diana, and *iron sand* on the sandy margins of most of the streams and lakes, throughout the primary regions in the county. *Calcareous tufa*, abounds in many of the springs that issue from the limestone formation; particularly in Lowville. *Tremolite* occurs frequently in *boulders* but not *in situ*, in the county. A mass weighing about a ton occurs a mile southeast of the village of Collinsville, in West Turin.

Wad occurs in the southwestern part of the town of Martinsburg, in nodules disseminated through the soil of a swamp. The masses are from one to three inches in diameter; pulverulent externally, but exhibiting a glossy fracture when broken. It soon crumbles on exposure.

In the town of Diana, the following minerals occur abundantly. *Tabular spar*, with *green coccolite*, *nuttallite*, *variegated serpentine*, *rensselaerite*, *black pyroxene*, *feldspar*, in crystals variously modified, and a singular mixture, apparently of graphite, chlorite, and specular iron ore, which has been strangely considered an "ore of silver." Associated with the foregoing, but in less quantities, are *sphene*, crystals of *sulphuret of iron*, and very rarely *zircon.*

The vicinity also affords surfaces spangled with minute crystals of *quartz,* upon a coarse variety of *agate*, and *calcedony:* and a *crystalline limestone* of a crumbling texture, and a sky-blue color.

Opake crystals of *quartz*, of large size, are frequent near the serpentine locality. Most of the localities in Diana, occur along the line of transition between the primary, and the sedimentary formations, and within two miles of the little village of Natural Bridge.*

The following localities attributed to Lewis county are exhausted, or the mining operations which produced them have been discontinued, so that specimens can be no longer procured. None of these mines will ever in any probability be reöpened.

Galena, occurred in the lead mines three-fourths of a mile N.W. of Martinsburgh village. It exhibited various forms, intermediate between the cube and octahedron. It occurred also arborescent, pseudomorphous, fibrous and massive. With it were associated *carbonate of lead*, *blende*, *sulphuret of iron*, *calcareous spar*, in the forms represented in the Mineralogical Report of the Geological Survey of New York, figures 60, 62, 71, 73, 74, 75, and 76, in which last form the sides of the prism were nearly obliterated by the approximation of the terminal planes;—also very rarely small cubes of *fluor spar*.

Near Lowville village, there formerly occurred *galena*, in minute crystals, associated with *sulphuret of iron*, *calcareous spar*, often beautifully crystallized, and magnificent specimens of *green fluor spar*, crystallized in small cubes of nearly uniform size, which were never modified by replacements upon their edges or solid angles.

Unfortunately this mineral was usually so penetrated by sulphuret of iron, as to be rapidly destroyed by the efflorescence of the latter. It may be possible to procure more of this mineral, but the expense would be great, and success very uncertain.

With the exception of an occasional boulder, containing *epidote*, *colophonite*, *tourmaline*, *garnet*, &c., the foregoing is a complete list of the minerals found in Lewis county. For a more particular account of the geological relations of these minerals, reference may be made to the "Am. Jour. of Agriculture and Science," Nos. xiii and xiv, pp. 267–314.

JEFFERSON COUNTY.—*Agaric mineral* abounds in the caverns of Watertown, and Pamelia.

Cacoxenite. Sterling iron mine, Antwerp.

Calcareous spar appears in numerous and peculiar forms of crystallization in the town of Antwerp, particularly in the vicinity of Oxbow village, and on the shores of Vroman and other lakes.

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* Near the Natural Bridge, a few years ago, was opened a mine of *copper pyrites*, which occurred thinly disseminated through gneiss. It was unpromising, and after some outlay, operations were suspended. In one of the excavations were found traces of *coal*, much resembling anthracite.—S. W. J.

Saccharine limestone forms immense ledges in Antwerp, &c.

Theresa affords several localities of calcareous spar.

Calcareous tufa. Pamelia, Adams, &c., along the range of transition limestones.

Carbonate of iron crystallized at the Sterling iron mine, Antwerp.

Feldspar. In Alexandria, in great abundance. Antwerp, &c.

Fluor spar. Theresa, in several localities. The celebrated locality at Muscolongue lake, in this town, is nearly or quite exhausted. In Adams, associated with sulphate of barytes. It occurs here in delicate shades of pink and green.

Hornblende. Theresa. Alexandria.

Idocrase, in minute crystals, on the banks of Vroman's lake, in Antwerp near the village of Oxbow. It occurs in an impure limestone, with sphene, &c.

Iron, (*bog ore.*) Wilna, Antwerp, &c. In the latter town, it occurs in a deposit in which an immense variety of organic substances are mineralized by it. It is near the village of Oxbow.

Iron, (*specular ore.*) Theresa, Antwerp, and Philadelphia. It fnrnishes a vast amount of iron annually.

Mica, in Antwerp, near Vroman's lake crystallized in hexagonal prisms, often six inches in length.

Most "mineralogists" refer to Henderson, in this county, as a fine locality. After many inquiries I am forced to believe that none occurs in the town. This town as well as most of the adjoining ones, *is underlaid by transition limestone*, and no primary rock can occur in it, larger than *common bowlders.*

Pargasite. Antwerp, near Muscolongue lake.

Pyroxene, of a light color, near Vroman's lake, in Antwerp, associated with crystals of mica, and sphene.

Quartz. Antwerp and Theresa, associated with specular iron. Near Vroman, and other lakes, in the northern part of the county.

Scapolite. Rarely in slender crystals in Antwerp, on the farm of David Eggleson.

Serpentine. Theresa, Antwerp, of various shade of white and black. (Rensselaerite ?)

The *brecciated* or *porphyritic* variety, is a constant associate of specular iron, in Antwerp, Theresa, &c.

Sphene. In Antwerp near Vroman's lake.

Sulphate of barytes. Pillar Point, in Brownville, near Sackett's Harbor, near North Adams, in a vein which has been traced nearly a mile. A porous coralloid variety, occurs in Antwerp near the village of Oxbow. It is filled with vermicular cavities, and stained with iron.

Sulphate of strontia. Theresa, or Alexandria, in beautiful crystalline masses; of a snow-white color.

Sulphuret of copper and iron. In Antwerp, on banks of Vroman's lake.

Sulphuret of iron. Antwerp, associated with specular ores of iron.

Sulphuret of nickel. Sterling mine, Antwerp, in brilliant capillary crystals.

Tourmaline. In large crystals. Alexandria.

Tourmaline, (yellow.) Antwerp, in limited quantites.

Terenite, has been attributed to this county, (Antwerp,) but its locality is lost.

Tremolite, occurs in minute quantities, occasionally in cavities of Black river and Trenton limestone.

In addition to the foregoing the usual variety of minerals, occur scattered in detached bowlders, over the country.

ST. LAWRENCE COUNTY.—The uncommon splendor and variety of minerals brought to light by the mania for mining speculations, which prevailed throughout the county about ten or twelve years since, has rendered St. Lawrence county proverbial for its mineral localities.

Most of these enterprises having proved unprofitable, and often ruinous, to those engaged in them, have been abandoned, and the iron mines are the only ones that are now wrought. No probability exists of any of them being ever resumed, and consequently many minerals formerly found here can be no longer procured at their localities. This applies especially to the *lead mines* of Rossie, which were discontinued about ten years since.

A vein of spar was often the only inducement to engaging in a mining operation, and many elegant specimens were obtained in these enterprises, which can no longer be procured. The following minerals occur at present in the county, being all of them more or less accessible, and abundant, with the exceptions specified.

Agaric mineral, in a calcareous spring, Governeur.

Apatite. Rossie, Hammond, &c. Good specimens readily procured with little labor and expense. A new locality was accidentally discovered in Rossie, about two miles from the village of Oxbow, in the fall of 1849.

Albite. Governeur, Fowler, &c., in granite.

Agate. A coarse variety in Fowler.

Arragonite. Iron mines, near Somerville.

Automolite has been attributed to Rossie. Its existence there is very doubtful. Locality unknown.

Babingtonite. Locality unknown. Said to occur in Governeur. After much search in the spot where it was said to occur, I am inclined to believe that if it was ever found there, it has become exhausted.

Blende. Morristown, DeKalb, Fowler, Macomb. Several of its localities are now inaccessible.

Calcareous spar. Governeur, Rossie, Russel, &c. The large limpid crystals from Rossie, are no longer procurable.

Calcareous tufa, frequently met with in calcareous springs.

Calcedony. Fowler.

Carbonate of iron. Iron mines, Rossie, magnificent specimens occasionally found; those of ordinary quality frequent.

Chondrodite. "Governeur near Somerville." This locality was a *boulder*, and has been carried off. Frequent in Rossie, near Yellow lake, in detached masses.

Dolomite. Hammond.

Feldspar. Rossie, Governeur, Hammond, &c.

Feldspar. *Labradorite* occurs near Ogdensburgh.

Fluor spar. Morristown, Governeur, associated with heavy spar.

Galena. No longer procurable at the localities without mining.

Graphite. Rossie, Governeur, Dekalb, &c.

Hematite. Iron mines, Rossie, Governeur, &c.

Hornblende. Dekalb, Rossie, Governeur, Potsdam, Pierrepont, &c.

Hyalite. Quartz, with the appearance of hyalite, is associated with apatite and zircon, in Hammond and Rossie.

Idocrase. Governeur.

Iron, (*bog ore.*) Hermon, Brasher, Fowler, Governeur, Canton, &c.

Iron, (*magnetic.*) Edwards, Russel, Pierrepont.

Iron, (*specular.*) Hermon, Rossie, Governeur, Edwards, Canton, Pierrepont and Fowler. Often beautifully crystallized and associated with interesting minerals. It is the most important iron ore in the county.

Mica. Governeur, near Somerville, in serpentine. Edwards, Macomb, Potsdam, Rossie, &c.

Pargasite. Rossie, Hammond, Russel, Hermon, &c.

Pearl spar. Banks of Oswegatchie in Rossie.

Pyroxene. Governeur, Rossie, Hermon, DeKalb, &c.

Quartz. Usually associated with specular iron ore. Rossie, Russel, Governeur; in Governeur the smoky variety occurs. In Russel the dodecahedron with triangular faces. Spongy quartz occurs in DeKalb.

Rutile, attributed to Governeur. No locality known in that town, or in the county.

Scapolite. Governeur, in great abundance, in primary limestone, associated with quartz, pargasite, and *formerly* with apatite. The latter mineral has become exhausted.

Satin spar. Rossie, Fowler, Pitcairn. In each of its localities it is associated with serpentine.

Serpentine. Governeur, near the tremolite locality. Edwards, Pitcairn, Rossie, DeKalb, Hermon, Fowler, Russel, Canton, Fine, Colton. In most of the above towns, serpentine occurs in ledges, and is associated with primitive limestone.

Rensselaerite, occurs in nearly all the above mentioned towns, it is of every shade of white, black, green, &c., and occurs crystallized, radiated, fibrous, laminated, and cleavable. The *brecciated* variety, is a constant associate of the specular iron ore, and in some localities, as at Kearney mine, near Somerville, it is beautifully variegated. The texture of this variety is so fragile, as to fall to pieces upon receiving a slight blow from a hammer. Varieties which have received the name of *soapstone*, and have been wrought into various ornamental articles, occur in Fowler, Edwards and Russel. It is often of a snowy whiteness, and passes by insensible gradations into talc, and tremolite.

Sphene. Rossie, in pale red and brown crystals, with apatite, pargasite and crystallized feldspar. Governeur, in black crystals, in granite.

Spinelle. Associated with mica, in serpentine, in the town of Governeur, near the village of Somerville. Crystals of a large size, (one and two inches on a side,) have been found here, but they are rare. Small brilliant crystals are common. The small crystals are very perfect, but the larger ones are much blended with the matrix. Color pink and reddish brown.

Sulphate of barytes. Governeur, in highly crystalline and fibrous varieties. Fowler, Rossie, DeKalb.

Sulphate of strontia formerly found in lead mines, Rossie. Locality inaccessible.

Sulphuret of iron. Rossie and Governeur, in iron mines. Fowler, Canton, &c.

Sulphuret of copper and iron. Canton, Fowler, Macomb, &c.

Tourmaline. Rossie, Governeur, Hermon, &c. Often of a brown and yellow color.

Tremolite. Governeur, in splendid crystalline and fibrous masses, associated with primary limestone, DeKalb. In Fowler, a purple variety occurs. Rossie, Hermon, Edwards, &c.

Zircon. Hammond and Rossie. Coarse opake specimens may be obtained with facility. Beautifully crystallized and very perfect specimens often procured. It occurs in primary limestone, associated with apatite, feldspar, loxoclase (?) hyalite, graphite, &c. The principal locality is on the farm of Mr. Hardy. It has been improperly attributed to the farm of Mr. Robinson.

5. *Isomorphism of Miargyrite and Augite.*—Miargyrite crystallizes in monoclinic forms, and the angles as given by Haidinger are M : M = 86° 4′, P : M = 101° 6′. Augite has M : M = 87° 6′, P : M = 100° 25′. The augite group of isomorphs with this addition includes, augite, pyroxene, glauber salt, acmite, hornblende and miargyrite.* Calculating the atomic volume of miargyrite we have

$$A = 3762{\cdot}8 \div 5{\cdot}234 \text{ (sp. gr.)} = 718{\cdot}9 \qquad C = 718{\cdot}9 \div 6 = 119{\cdot}8$$

The result 119·8 divided by $2\frac{1}{2}$, gives 47·92, which is very near the atomic volume of the augite series. If antimony is taken as a double atom, it gives 718·9 ÷ 7 = 102·7, which is a little more than double the number for the augite series. Moreover, the whole number 718·9 is not much above the number for Hudsonite. We repeat the numbers here for comparison.

		A.	B.	C.
Pyroxene,	1st var., $(\dot{Ca}, \dot{Mg})^3 \dddot{Si}^2$	637·	127·4	45·5
	2nd var., $(\dot{Ca}, \dot{Mg}, \dot{Fe})^3 \dddot{Si}^2$	645·2	129·	46·1
	3d var., Hedenbergite,	673·4	134·7	48·1
	4th var., $\dot{Fe}^3 \dddot{Si}^2$	674·7	135·	48·2
	5th var., $\dot{Mn}^3 \dddot{Si}^2$	684·8	136·9	48·9
	6th var., Hudsonite,	706·0	141·2	48·9
Miargyrite,		718·9		119·8 (or 102·7)
Acmite,		918·5	183·7	48·34
Hornblende,	1st var.	971·6	138·8	48·58
	2nd var., aluminous,		155·95	47·25
	3d var. "		138·4	48·43
	4th var.		144·0	48·24
Borax,		1391·6	107·0	46·38
Glauber salt,		1290·5	107·54	49·6

J. D. D.

6. *Analysis of the Schorlomite of Shepard*; by C. RAMMELSBERG, (Poggendorf's Annalen, lxxvii, 123, 1849).—Rammelsberg finds this mineral from Arkansas to consist of

	Silica.	Titanic acid.	Lime.	Protoxyd of iron.	Magnesia.
1.	26·09	17·36	31·12	22·83	1·55 = 98·45
2.	27·85	15·32	32·01	23·75	1·52 = 100·45

The results give the formula

$$2\dot{R}^3 \dddot{Si}^2 + 3\dot{R}^2 \ddot{Ti}$$

In the 2nd analysis some titanic acid still remained with the silica.

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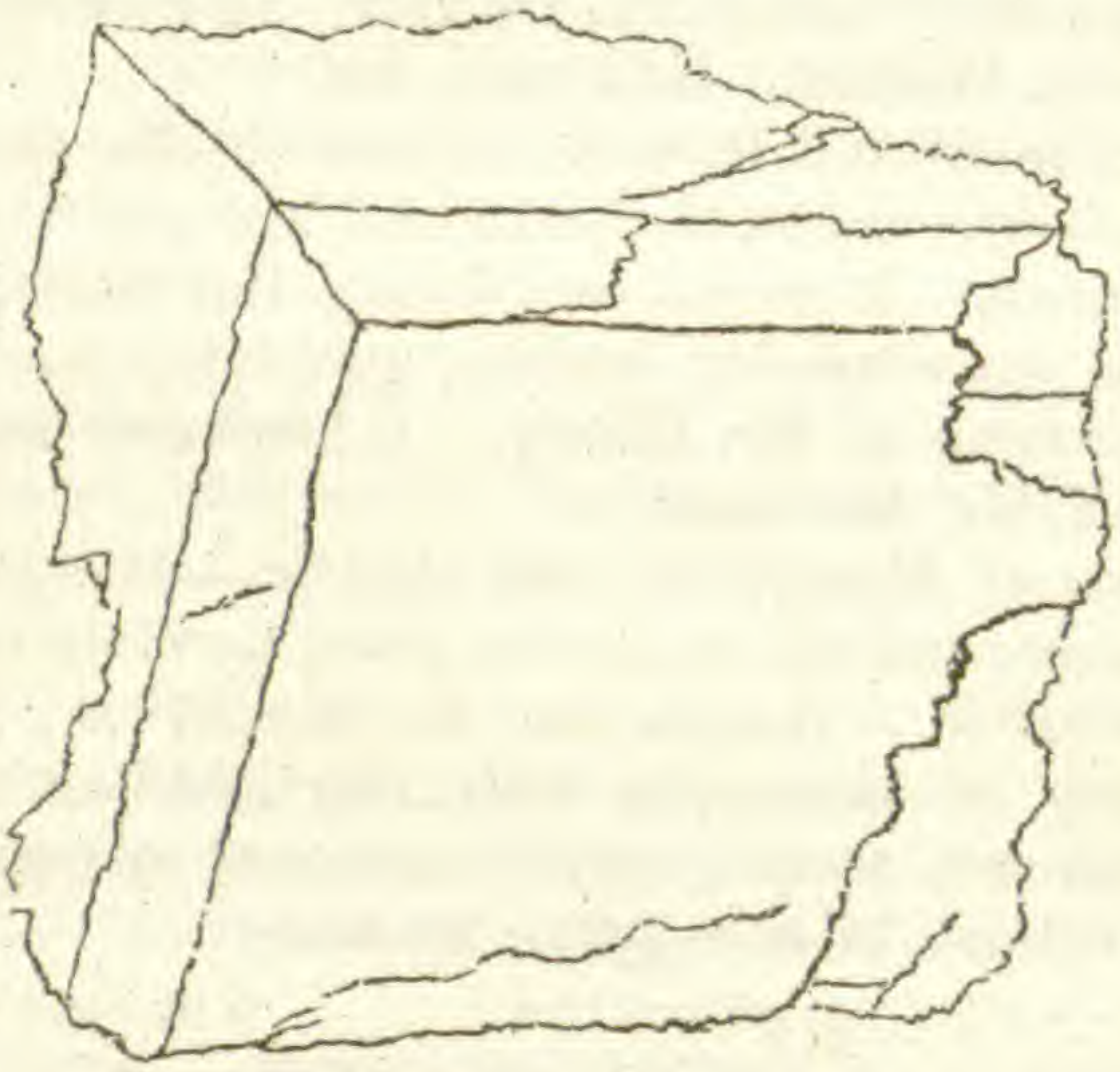
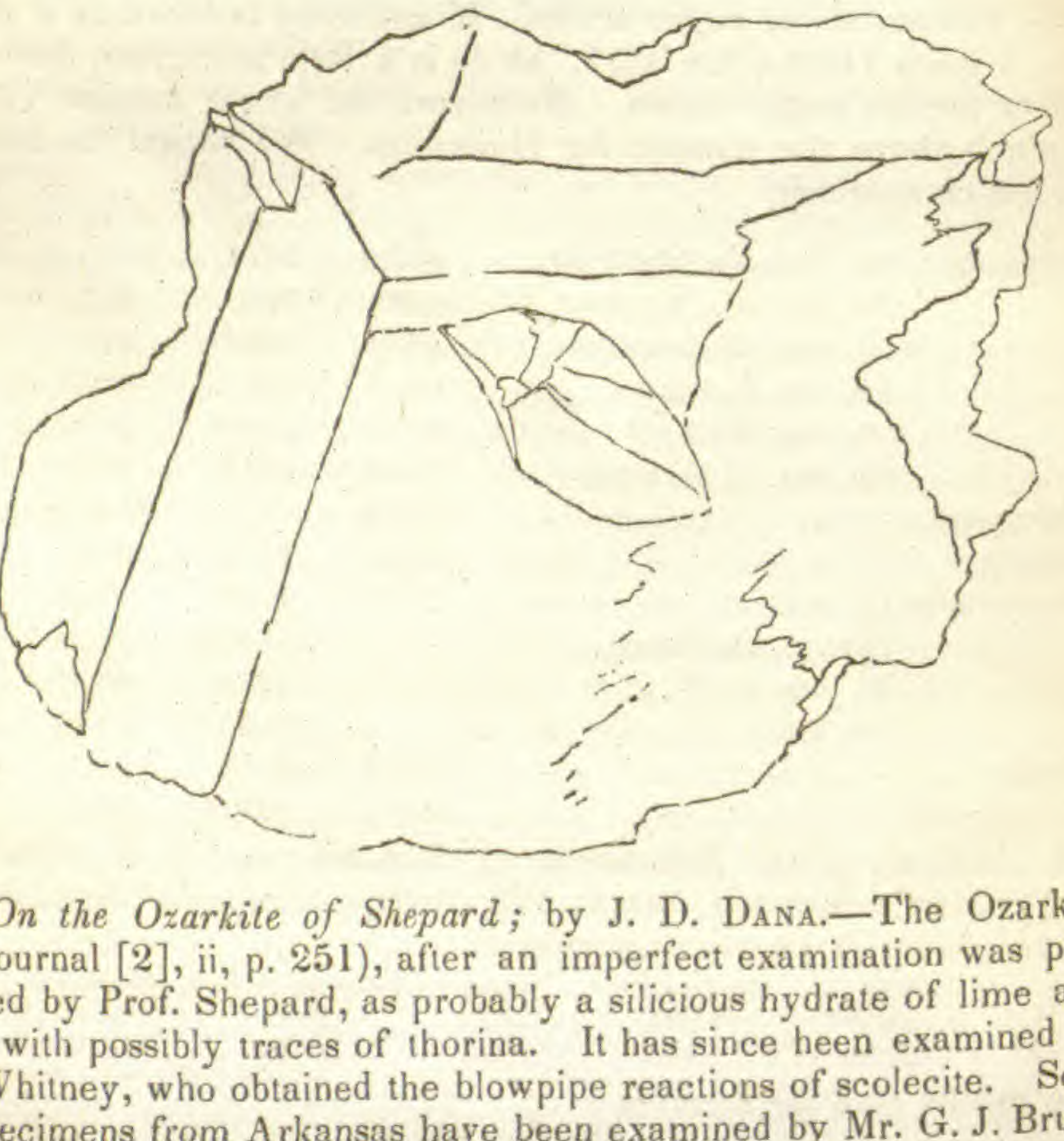
* See pages 223, 228, 230, of this volume.

7. *Large crystals of Sphene.*—The accompanying figures of sphene are by Wm. S. Vaux of Philadelphia, from specimens in his cabinet, obtained at Diana, near Natural Bridge, Lewis Co., N. Y. The color is dark brown. The form is that of the so-called Lederite, which comes from the same locality; the narrow plane is the plane *n*, and the large one below to the right *y*.





8. *On the Ozarkite of Shepard;* by J. D. Dana.—The Ozarkite (this Journal [2], ii, p. 251), after an imperfect examination was pronounced by Prof. Shepard, as probably a silicious hydrate of lime and yttria, with possibly traces of thorina. It has since been examined by J. D. Whitney, who obtained the blowpipe reactions of scolecite. Several specimens from Arkansas have been examined by Mr. G. J. Brush in the Yale Laboratory, New Haven, and found to consist largely of phosphate of lime. They have often the radiated appearance of a zeolite

with acicular crystallizations; but after Mr. Brush's discovery of phosphoric acid, the writer found by means of a glass that the acicular prisms were in fact hexagonal prisms of apatite. Other large prisms were also found in some specimens. The acicular mesotype-like mineral is associated with another of a mealy character and in part sub-lamellar, which may be a zeolite as observed by Whitney.

9. *The Lagoons of Tuscany*, (Bull. Soc. Geol. de France, Dec., 1848, 147.)—The Tuscan Lagoons are, properly speaking, natural depressions of the soil ordinarily filled with water from which hot vapors are ejected. They are situated within a space of ten or twelve miles, lying between 28° 27′ and 28° 40′ of longitude, and between 43° 10′ and 43° 15′ of latitude. The principal lagoons are those of Monte Cerboli, of Castel Nuovo in the valley of Cecina, those of Sasso, of Monte Rotondo, of the Lago del Edifizio, of Lustignano and of Serrazzano in the valley of Cornia. The ancients were acquainted with the Tuscan lagoons, and the name of Mount Cerberus accords well with the poetical and mythological ideas of the early people of Italy.

Even as late as the 18th century the lagoons were regarded only as a supernatural wonder which excited astonishment rather than courted investigation. Under the Grand Duke Leopold 1st, the chemist Hœfer discovered by analysis, that they contained boracic acid. This discovery, followed by farther explorations, has bestowed upon the lagoons an unrivalled industrial importance, and has brought into the countries possessing them an activity contrasting strikingly with the miserable state in which they before languished. It is a curious fact in their history that before the discovery of this acid, the fetid odor developed by the sulphuretted hydrogen gas,—the certain death which met the man who fell into the scalding baths,—the disruptions of the ground occasioned by the appearance of new *Soffioni*,—and above all the superstitious terror with regard to them, had made the people consider the lagoons as a scourge from which they sought deliverance by public prayers; but now if by any cause the *Fumacchi*, the source of common prosperity, should become extinguished, they would not fail to seek from heaven a restoration of this scourge, which in the skillful hands of M. Larderel, has become, to quote M. Bowring, a source perhaps of greater riches than the mines of Peru, or of Mexico, and certainly more reliable. After the discovery of Hœfer, Paul Mascagni, a noted chemist, had the first idea of procuring from the lagoons boracic acid like that of China, and of thus restoring to Europe the tribute that she had paid to Asia. But the attempt was not at first profitable, as the waters contain in solution at the moment of their escape from the earth, only an insignificant quantity of boracic acid. Another chemist having observed that a part of the acid was thrown beyond the lagoon, by the violence of the vapors, and that it was scattered on the margins of the craters, and moreover being confident that the waters were capable of dissolving a greater quantity of acid, endeavored to find means of saturating them by constructing upon the declivities of the country artificial lakes fed by the streams from the mountain. The vapors which issue from these lakes keep their waters constantly at a boiling temperature. After impregnation for twenty or thirty hours by the vapors of the highest lake, they draw off the waters into the second lake to submit them to a new impregnation. From thence they are drawn into a third, and so on till they reach the receptacle at the lowest point. In their passage across six or eight lakes, they are charged with half per cent. of boracic acid. They are then led into the reservoir from which they are conducted into lead reservoirs for evaporation, to produce concentration ; and to hasten that operation, the happy idea was proposed of substituting for the combustibles sometimes used, and which were enormously expensive, the direct application of the heat of the Soffioni. This improvement decided the success of the enterprise. It is surprising that it was introduced at so late a day, since this method was not new and had been long practiced at the solfatara of Pozzuoli in extracting alum from the earth that contains it. In the lagoons, the hot vapors for carrying on the evaporation are taken at their origin and carried across by lead pipes or by subterranean conduits below the boilers. Thus the fabrication is exceedingly simple, the locality itself furnishing the means of carrying it on. A single discharge of the vapors is sufficient to throw into ebullition, almost immediately, 20 or 30 cauldrons of a capacity of 20 barrels, which may be estimated at 84,000 pounds of liquid impregnated with boracic acid. Before allowing the vapors to escape, they direct them under the ovens in order to free the acid from its hygrometric moisture. Of late the somewhat complex system of boilers and coolers has been simplified by substituting rectangular tables of lead of 20 or 30 metres, divided at small intervals by transverse parallel divisions, but whose height is never raised above that of the edges. These tables have an inclination of two to three degrees. The water of the last lagoon is introduced upon the upper side, in small quantities. The hot vapors for evaporating are conducted in such a manner that they act upon the lower surface. The liquid after having filled the first compartment is diffused very gradually into the second, then into the third, and so successively to the last, where it reaches such a state of concentration that it deposits the crystallized acid ; the workmen remove it immediately by means of wooden scrapers. This mode of gradual concentration is very ingenious, and requires so few hands that it may almost be said that the acid is obtained without expense. From 1818 to 1845 the quantity of acid manufactured was 33,349,097 Tuscan pounds. From 1839 to 1845 the mean quantity has been two millions and a half of pounds.

Thus in estimating the product at 7,500 pounds per day ; the quantity of saturated water upon which they operate daily is 1,500,000 lbs. daily, and annually 547,500,000 lbs.

This labor brings to Tuscany 12 millions of pounds (10 millions of francs), and it is surprising that it should have remained unproductive during so many ages, and that it should have been reserved for the skill of M. Larderel, now Count of Monte Cerboli, and before 1818 a simple wandering merchant, entirely unacquainted with scientific researches, to discover the fugitive vapors and render them a source of inexhaustible wealth.

The violence with which the burning vapors escape gives rise to muddy explosions, when a lake has been drained by turning its waters into another lake. The mud is then thrown out, as solid matters are ejected from volcanos, and there forms in the bottom of the lake a crowd of those little cones of eruption whose activity and play recall exactly under another form the *hornitos* of Malpays. Their temperature varies from 120° to 145° centigrade, and the clouds which they form above the lagoons constitute true natural barometers, whose greater or less density rarely disappoints the predictions that they announce.

While in an industrial point of view, the lagoons occupy the first rank among the natural products of Tuscany, they place new resources at the disposition of science, permitting the investigation of various geological phenomena, even under the direction of the will of the experimenter. The metamorphic gypsum which we have seen produced at Pereta under the influence of sulphuretted hydrogen vapors, is formed at the lagoons which, like those of *Monte Cerboli* and of *Castel Nuovo*, are made to cross argillaceous limestone beds; and with such abundance that their formation may be fully tested. Action also takes place at the same time upon the walls of fractures and the fissures of the soil which open a passage to the subterranean vapors. Thence it extends gradually into the interior of the masses, and it ends by gypsifying whole circles whose radius is generally that of the lagoons themselves. Pure limestones are converted into a lamellar sulphate of lime, but of a loose texture and free of cellules. This structure is probably due to the expansion they undergo from the addition of new materials, and perhaps also by the passage of the gas at the moment of the crystallization of the salt. The calcareous formations below the argillaceous, preserve after their transformation their primitive position, and they present an alternation of gypseous beds, and of argillaceous beds which the acid has freed from the soluble bases. When this influence is exerted in the direction of the thickness of the strata, it is very common to see towards the limits where the metamorphic influence ceases, a mass of rock strikingly calcareous at one of its extremities, terminating at the other extremity in a gypsum which the inhabitants use for buildings. The resemblance to the gypsum beds, occurring in the midst of the secondary formations, is exhibited even in the reddish tint with which oxydation marks the associate clays of the alberèse. But a peculiarity which has given me the solution of a problem which had embarrassed me thus far, deserves mention; for we have reproduced here certain phenomena of which the enormous deposits of the Provençal Alps present many examples. I had noticed at Roquevaire and at Digne, irregular argillaceous incrustations in which are found entangled without order, angular fragments of sulphate of lime of various sizes. In admitting the transformation of the jurassic limestone of these countries posterior to its consolidation under the influence of the acid vapors, it was difficult to explain the mode of formation of these breccias and the manner in which these fragments were introduced. In all these cases, they seemed to indicate an overflow of waters, but the theory opposes the intervention of waters for the accomplishment of the facts relative to the conversion of the limestone, or it leaves in doubt the part which they must have acted. But, observe what is apparent at the lagoons of Monte Cerboli and of Castel Nuovo. At the same time that the limestone is changed into gypsum, by the contact of sulphurous agents, the fragments of alberèse which waters had brought down from heights above to the midst of the miry and boiling lakes, are thus changed into sulphate of lime and constitute, with the clays in which they sink, brecciated argillo-gypseous beds without stratification. That this fact should be equally apparent in the ancient beds under analogous circumstances, is at least what might be inferred from the examination of that which passes in the lagoons. We should also observe the analogous positions of the *boracite* of Luneburg, which is found in crystals disseminated in gypsum intercalated in the midst of a cretaceous bed, and the boracic acid and borates of the Tuscan lagoons.

These different facts well confirmed, establish in my view an intimate resemblance between the gypsum of the lagoons and the abnormal gypsum beds of secondary regions.

If the silicification of the Macigno which we have noticed in the neighborhood of the solfatara of Pereta should appear an exaggerated application of the theory brought forward, the verification of it may be traced in the lagoons of *Sasso* where the solution of the silex of the freestone and its redeposition are manifest in all places where circumstances allow of this double transformation. The Fumacchi of Sasso rise, to the south of the establishments, from beneath a vast mantle of fine grained freestone, over which passes the mountain road connecting the valley of the Cornia with the Province of Sienna. At intervals the road is interrupted by isolated boiling pools or shallow cavities, which exert a metamorphic action upon the region which they traverse. The first evidence of alteration is apparent in the color of the rock which from blackish gray becomes white. It is cracked in all directions. The vapors follow quickly these lines of separation, attack the silica of the macigno, dissolving it out, and immediately depositing it under a gelatinous form. The gelatinous mass becomes opaque in the air and assumes the resin-like appearance peculiar to hydrated silica. In connection with this we observe imbedded in a silicious cement, nuclei of a white micaceous sandstone unaltered at centre, causing a breccia appearance. This kind of breccia is finally, by the complete solution of the nuclei, converted into a grayish rock entirely silicious, which resounds under the hammer like clink-stone, and resembles exactly by its aspect and its roughness of touch, porcelain biscuit. Sometimes the solution is more rapid, and then the rock is formed of an agglutination of little grains analogous to those of an ancient quartz rock and possessing its tenacity and hardness. Examined with a glass, each grain is composed of an independent particle or driblet of hydrated silica, and they seem to have collected as viscous tears, such as would have adhered together in hardening. Breislak observed at the solfatara of Pozzuoli fragments of decomposed lava bound together by a silicious substance almost vitreous; but in the lagoon of Sasso the solution and permanent regeneration of silica effected at the expense of the macigno, are carried on upon a vast scale and over a space of great extent.

10. *On the Great Diamond in the possession of the Nizam;* by HENRY PIDDINGTON, Curator, Museum Economic Geology.—At the November meeting of the Asiatic Society, Captain Fitzgerald, B.A., presented for the inspection of the Society a model in lead of this remarkable stone, and gave a brief note of its history, which will be found in my report for that month. He has since favored me with a more detailed one, which is as follows:—

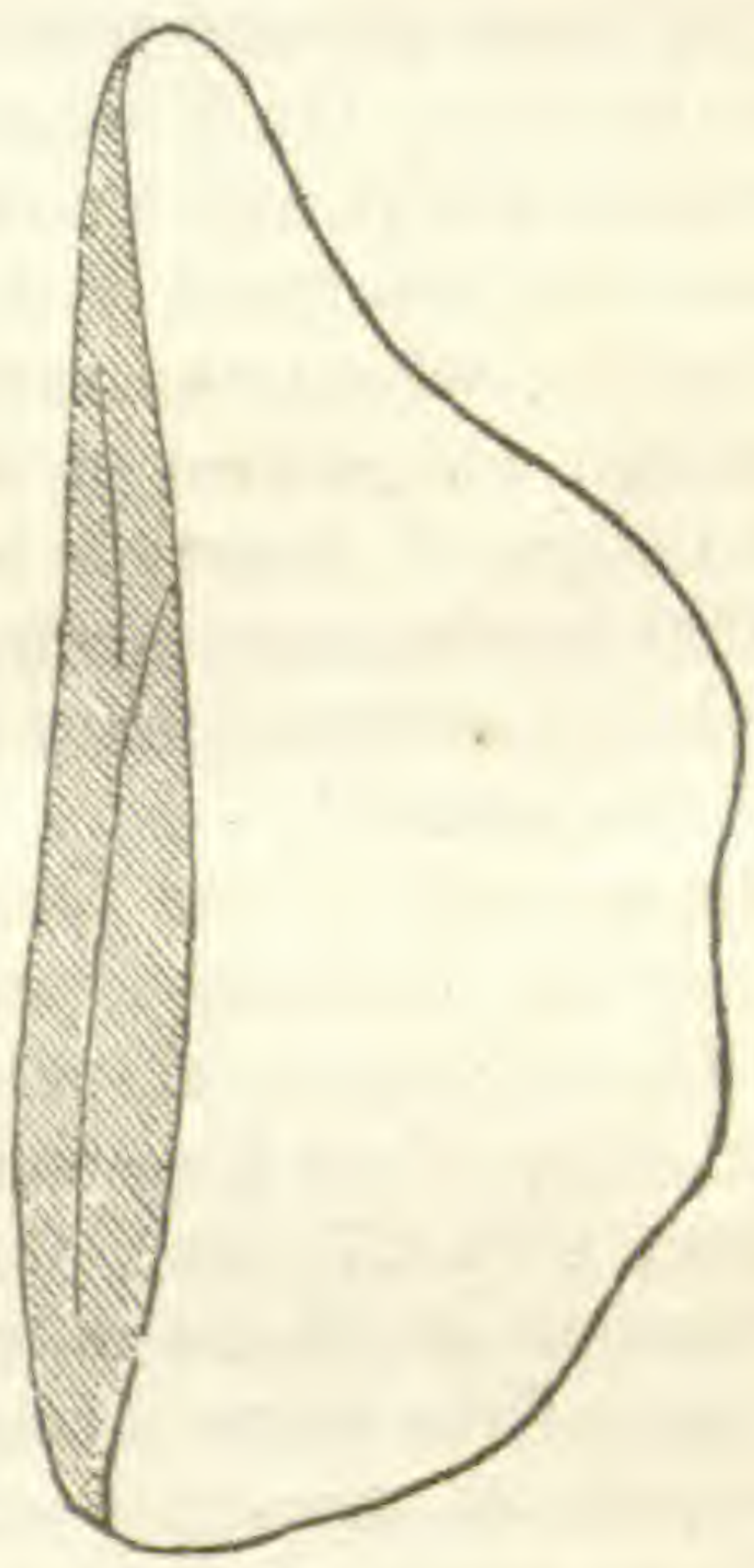
Note by Captain Fitzgerald, Bengal Artillery, attached to the Nizam's Service, on the Nizam's Diamond—1st December, 1847.—"About twelve or fourteen years ago a large diamond was found in the Nizam's country under circumstances of rather a curious nature. The model now shown is the model of a part only, a piece having been chipped off, which, after passing through many hands, was purchased by a native banker for 70,000 rupees.

The larger piece, as represented by the model, is in the possession of his highness the Nizam, and at the time of discovery was exhibited to many European gentlemen.

The manner in which this diamond was originally found, may be considered interesting. It was first seen in the hands of a native child, who was playing with it, of course ignorant of its value. On *eight* annas being offered for what the poor people considered as a mere stone, their suspicion was excited, which led ultimately to the discovery of the bright stone being a real diamond.

Its form and size is shown below. This stone, hitherto unknown, may now be classed among the larger description of diamonds which we read of, but seldom see.

Base.



Side view.

The size of the stone exactly taken by callipers, from the leaden model, is as follows:—

	Inches.
Length,	2·48
Greatest breadth,	1·35
Average thickness,	0·92

I have had now exact models cast in glass from the leaden one exhibited at the meeting, and I find that

	Grains.
Their absolute weight is,	1164·50
Their specific gravity,	3·70

Now according to various authorities we have for the specific gravity of the diamond,

Ure,	3·53
Brewster, colorless,	3·52
orange,	3·55
Jameson, twelve authorities, mean,	3·52
Mean,	3·52

And hence assuming our model to be exact, (and it is very nearly so,) we have by a simple proportion not quite **1108** grains for the actual weight of the Nizam's diamond.

This is equal to 277 carats of weight of the rough diamond, and as the rough stones are usually taken to give but one half of their weight when cut and polished, it would allow 138½ carats, or a weight between the Pitt (or Regent) diamond (136¾ carats), and that of the Grand Duke of Tuscany (139 carats), for it in its present condition; and if we take it that one-eighth of what it would be when polished was taken off with the splinter sold to the native, as related by Captain Fitzgerald, we shall then have 155¾ carats for the possible weight of it, if it had been cut and polished entire; which would then place it as to weight between the Tuscan and the great Russian diamond of 195 carats, which last is well known to be an Indian stone.

We are not informed if this stone is considered likely to be one of pure water, which can only be ascertained by polishing it, though we know that the natives of India, and particularly of the Deccan, are too good judges of diamonds to mistake a topaz for one, and it is stated that 70,000 rupees have been paid for the fragment. It therefore certainly adds one extraordinary fact more to the history of this most wonderful of the gems."

11. *An account of the Strata and Organic Remains exposed in the Cuttings of the Railway from the Great Western line near Corsham, through Trowbridge to Westbury in Wiltshire;* by REGINALD NEVILLE MANTELL, Esq., Civil Engineer, (Proceedings of the Geological Society of London, Feb. 27, Sir C. Lyell, President, in the Chair.)—This line in the distance of fifteen miles passes through the usual series of the subdivisions of the oolite formation of that part of England. Numerous displacements of the strata occur, and in some parts thick beds of alluvial drift are superimposed on the regular deposits, and contain water-worn fragments of rocks and fossils from various formations. Near Westbury an extensive accumulation of bones of elephants and other large herbivorous mammalia was cut through; the quantity of these remains being so great, that they were employed to form an embankment. The immense number of fossil shells exposed in some of the areas, laid bare by the works, was surprising; the whole surface being thickly spread with Ammonites and other Cephalopoda, and osselets of Belemnoteuthis and Belemnites, mixed with shells of Rostellaria, Murex, Terebratula, Turritella, &c., deep sea and littoral mollusca being promiscuously intermingled. Some of the finest examples of Belemnites and Belemnoteuthis hitherto known, were found in these deposits, and have been described by Dr. G. A. Mantell [the author's

father] in the Philosophical Transactions. With these remains, were found teeth and bones of fishes and of four or five genera of reptiles. In the strata of Oxford clay lignite occurs abundantly, and in some places very large trunks and branches of coniferous trees, the wood retaining its structure and tenacity. The whole deposit resembled a mud-bank of a deep sea to which trees and other terrestrial plants, and littoral shells, had been drifted and mixed up with the relics of the mollusca of the profound depths of the ocean; constituting an interesting example of what M. Constant Prevost has aptly termed a fluvio-oceanic formation. The paper was illustrated by drawings and sections, and a splendid series of the fossils collected and arranged by the author: a table of all the genera and species by John Morris, Esq., was appended.

12. *Notice of the Remains of the Dinornis and other Birds, and of Fossil and Rock specimens recently collected by Walter Mantell, Esq., from the Middle Island of New Zealand;* by G. A. MANTELL, Esq., LL.D., F.R.S., &c., (Ibid.)—This memoir consisted, 1st, of a descriptive account of the country explored by Mr. Walter Mantell as Government Commissioner for the settlement of native claims on the east coast of the Middle Island, extending from northwest of Bank's Peninsula to Otago, a distance of about two hundred and sixty miles. 2dly, a general notice of the rocks, minerals and fossils; and 3dly, a summary of the facts brought to light in the course of the survey: forming the most interesting sketch hitherto made of the geology of that part of the colony. The rock specimens consisted of between 200 and 300 examples; principally of plutonic, metamorphic, and igneous substances. The foundation rocks of the country appear to be metamorphic schists, these are traversed by dykes of basalt, amygdaloids, &c. Obsidian, vesicular lava, and volcanic grits, in many places flank the sides of the great mountain chains which reach above the line of perpetual snow; and along the base of the range and over the adjacent plains are thick deposits of conglomerates and rich alluvial loam. Along the coast towards the south unaltered sedimentary strata appear. These belong to three distinct groups. The most ancient is the Ototara limestone which abounds in Terebratula, Echini, shark's teeth, &c., like certain European cretaceous beds; and the chief mass is composed of microscopic foraminiferous shells precisely similar to the white chalk of England; even the soft parts of the bodies of these minute animals are in many instances preserved. The deposit next in age is a blue upper tertiary clay full of marine shells of species still existing in the South Pacific Ocean.

Lastly, a ferruginous sandy grit with shells of recent marine species superimposed on the blue clay. Over the whole are spread, unconformably, layers of gravel and loam. Low hills of marly sand occur along the shores of the North Island, apparently a modern drift; this sand is wholly made up of the frustrules of Diatomacea. Of the fossil remains of birds the present collection contains above five hundred specimens referable to various species of Dinornis and allied genera; and to species of *albatross*, *penguin*, *water-hen*, *nestor*, *apteryx;* with portions of egg-shells of three different types. With the above were associated bones of a species of dog, and of two species of seal. The bones from the North Island, like those previously collected by Mr.

W. Mantell, and now in the British Museum, were from the titaniferous iron-sand near the mouth of the river Waingongoro. Those from *Waikouaiti* in the Middle Island, were imbedded in a morass of small extent, and which is exposed only at low water. This swamp is composed of vegetable fibres, sand and animal matter; it seems to have been originally a morass in which the *Phormium tenax*, or New Zealand flax, grew luxuriantly. The bones are literally tanned; and so well preserved as to appear as fresh as if recent. Among the specimens are crania and mandibles, and bones of the most colossal size. The most extraordinary relics are the entire series of bones (twenty-six in number) of the feet and shanks of the same individual Dinornis robustus, found standing erect, the one about a yard in advance of the other, as if the bird had been mired, and unable to extricate itself had perished on the spot. They were dug up and carefully numbered seriatim, and are now articulated like a recent skeleton. This is the only known instance of the bones of the foot and tarsus in natural connection, and consequently the first certain example of the structure of the feet of the colossal birds of New Zealand. There are no clear indications of this bird having had a hinder toe, as in the smaller species of Palapteryx in which the articulation for a posterior toe is strongly marked. The foot when recent must have been sixteen inches long and eighteen inches wide; the height of the bird to which they belonged, was about ten feet. The author in a highly interesting summary, suggests that these bone deposits, though geologically modern, are of high antiquity in relation to the human inhabitants of New Zealand; and considers it probable that these stupendous birds formerly ranged over a vast continent, now submerged, and of which the islands of the Pacific are the culminating points. Although there seems little doubt that like the Dodo and Solitaire of the Mauritius, and the gigantic elk of Ireland, the last of the Moas was exterminated by human agency, yet it is probable that a change in physical conditions, had prepared for their final annihilation. Of the organic law which determines the extinction of a race of highly organized beings, and whose effects through innumerable ages palæontology has in part disclosed, we are as utterly ignorant as of that which governs the first appearance of the minutest living organisms the powers of the microscope enable us to descry: both are veiled in inscrutable mystery; the results only are within the scope of our finite comprehension.

III. Zoology.

1. *Supplementary Observations on the Structure of the Belemnite and Belemnoteuthis;* by Gideon Algernon Mantell, Esq., LL.D., F.R.S., Vice President of the Geological Society, &c.—(Proc. Royal Society, February 14, 1850.)—In this communication the author describes his recent investigations on the structure of the two genera of fossil Cephalopoda, whose remains occur so abundantly in the Oxford clay of Wiltshire, namely, the Belemnite and Belemnoteuthis, as supplementary to his memoir on the same subject, published in the Phil. Trans., 1848. In that paper evidence was adduced to show the correctness of the opinion of the late Mr. Channing Pierce, as to the generic distinction of these two extinct forms of Cephalopoda.

As however several eminent naturalists have expressed doubts as to some of the opinions advanced by the author in his former memoir, figures and descriptions are given in the present notice, of beautiful and instructive specimens lately discovered in Wiltshire, and which he conceives establish his previous conclusions. Dr. Mantell states as the result of his examination of several hundred examples, that our actual knowledge of the organization of the animal of the Belemnite is at present limited to the following parts, viz.—

(1.) An external *Capsule* or *periostricum* which invested the osselet or sepiostaire, and extending upwards, constituted the external sheath of the receptacle.

(2.) The *Osselet*, characterized by its fibrous radiated structure, terminating distally in a solid rostrum or guard, having an alveolus, or conical hollow, to receive the apical portion of the chambered phragmocone; and expanding proximally, into a thin cup, which became confluent with the capsule, and formed the receptacle for the viscera.

(3.) The *Phragmocone*, or chambered, siphunculated, internal shell; the apex of which occupied the alveolus of the guard, and the upper part constituted a capacious chamber, from the basilar margin of which proceeded two long, flat, testaceous processes. These structures comprise all that are at present known of the animal to which the fossil commonly called " *The Belemnite*," belonged.

Of the *Belemnoteuthis* (the fossil cephalopod which Prof. Owen regards as identical with the Belemnite) many examples of the body with eight uncinated arms, and a pair of long tentacula, having an ink-bag and pallial fins, have been discovered. The osselet of this animal, like that of the Belemnite, *has a fibro-radiated structure*, investing a conical chambered shell; this organ, for reasons fully detailed in the memoir, the author affirms could never have been contained within the alveolus of a Belemnite; the soft parts of the animal of the Belemnite are therefore wholly unknown.

Many beautiful specimens of Belemnites and Belemnoteuthis were exhibited by Dr. Mantell to the Society, in proof of the statements contained in the memoir.

2. *On the Pelorosaurus; an undescribed gigantic terrestrial reptile, whose remains are associated with those of the Iguanodon and other Saurians, in the Strata of Tilgate Forest;* by GIDEON ALGERNON MANTELL, Esq., LL.D., F.R.S., Vice President of the Geological Society, &c. (Ib.)—The author had for a long while entertained the idea, that among the remains of colossal reptiles obtained from the Wealden strata, there were indications of several genera of terrestrial saurians, besides those established by himself and other geologists. The recent discovery of an enormous arm-bone, or humerus, of an undescribed reptile of the crocodilian type, in a quarry of Tilgate Forest in Sussex, where Dr. Mantell had many years since collected numerous teeth and bones of the Iguanodon, Hylæosaurus, &c., and some remarkable vertebræ not referable to known genera, induced him to embody in the present communication the facts which his late researches have brought to light.

The humerus above mentioned was found imbedded in sandstone, by Mr. Peter Fuller of Lewes, at about twenty feet below the surface; it presents the usual mineralized condition of the fossil bones from the arenaceous strata of the Wealden. It is four and a half feet in length, and the circumference of its distal extremity is thirty-two inches! It has a medullary cavity three inches in diameter, which at once separates it from the Cetiosaurus and other supposed marine saurians, while its form and proportions distinguish it from the humerus of the Iguanodon, Hylæosaurus, Megalosaurus. It approaches most nearly to the Crocodilians, but possesses characters distinct from any known fossil genus. Its internal structure is beautifully preserved, the Haversian canals and bone-cells being as distinct as in recent bones. Its size is stupendous, far exceeding that of the corresponding bone even of the gigantic Iguanodon; the name of *Pelorosaurus* (from πελωϱ, monster) is therefore proposed for the genus, with the specific term *Conybeari*, in honor of the palæontological labors of the present Dean of Llandaff, the Rev. W. D. Conybeare.

No bones have been found in such contiguity with this humerus, as to render it certain that they belonged to the same gigantic reptile; but several very large caudal verterbræ of peculiar characters, collected from the same quarry, are probably referable to the Pelorosaurus; these, together with some distal caudals of the same type, are figured and described by the author.

Certain femora and other bones from the oolite of Oxfordshire, in the collection of the Dean of Westminster at Oxford, are mentioned as possessing characters more allied to those of the Pelorosaurus, or to some unknown terrestrial saurian, than to the Cetiosaurus, with which they have been confounded.

As to the magnitude of the animal to which the humerus belonged, Dr. Mantell, while disclaiming the idea of arriving at any certain conclusions from a single bone, stated that in a Gavial eighteen feet long, the humerus is one foot in length; *i. e.* one-eighteenth part of the length of the animal, from the end of the muzzle to the tip of the tail. According to these admeasurements the *Pelorosaurus* would be eighty-one feet long, and its body twenty feet in circumference. Even if we assumed the length and probable number of the vertebræ as the scale, although we should have a reptile of relatively abbreviated proportions, yet in this case, the original creature would surpass in magnitude the most collossal of reptilian forms.

In conclusion, Dr. Mantell comments on the probable physical conditions of the countries inhabited by the terrestrial reptiles of the secondary ages of geology. The highly organized land saurians appear to have occupied the same position in those ancient faunas, as the large mammalia in those of modern times. The trees and plants whose remains are associated with the fossil bones, manifest, by their close affinity to living types, that the islands or continents on which they grew, possessed as pure an atmosphere, as high a temperature, and as unclouded skies, as those of our tropical climes. There are therefore no legitimate grounds for the hypothesis in which some physiologists have indulged, that during the "*Age of Reptiles*" the earth was in the state of a half-finished planet, and its atmosphere too heavy, from an excess of carbon, for the respiration of warm-blooded animals. Such an opinion can only have originated from a partial view of all the phenomena which these problems embrace; for there is as great a discrepancy between the existing faunas of different readings, as in the extinct groups of animals and plants which geological researches have revealed. The memoir was illustrated by numerous drawings, and the gigantic humerus of the Pelorosaurus and other bones were placed before the Society.

3. *On Entophytes;* by Dr. LEIDY, (Proc. Acad. Nat. Sci., Philad., Feb., 1850, v, p. 8.)—Dr Leidy presented to the examination of the Society a colored and several other drawings of what he termed an entophytic forest, taken from a portion of the mucous membrane of the ventriculus of Passalus cornutus. He remarked that at least six species of entophyta were found growing upon the mucous membrane of the ventriculus of P. cornutus, which were often present in great quantity, frequently some thousands, and which from their number, polymorphous appearance of several species, and attachment to various appendages of the mucous membrane, resembled very strikingly a miniature Brazilian forest, which was heightened in some degree by the existence of a nematoid worm, which recalled to mind the idea of one of the serpents of such a forest.

A somewhat similar drawing he exhibited, taken from the small intestine of Julus marginatus.

Other drawings were also presented. Dr. L. stated that among his collection of Julides, he had a number of times observed individuals to become dull in color, and almost motionless, which phenomena were followed by the death of the animal. It occurred to him that, in such a state, there might be exhibited some change in the character of its entophyta, as usually found in the active condition of the animal. Upon removing the intestine of an individual which had just died, he noticed that the entozoa which usually occupied the small intestine, had passed into the rectum, and upon the surface of the mucous membrane of the former, was developed a new plant. This is an oblate spheroidal body, white in color, translucent, embossed upon the surface, and presenting, when viewed by transmitted light, some resemblance to a minute bleached shell of an Echinus; by reflected light, it resembled a minute, white Lycoperdon. This plant was strewed all over the mucous membrane, but grew in greatest quantity along the course of filaments of Enterobrus, which appeared attached to the mucous membrane throughout their length by it. When compressed it opened, and spread into several leaf-like segments, and exuded a clear fluid with faint granules. He thought that probably this plant might be another stage in the existence of Enterobrus, for in the large number of individuals of Julus which he had examined, upward of 130, although he had observed the development of Enterobrus from spore-like bodies, even to the formation of what he supposed to be the sporangia, yet he had never been able to detect the formation of spores, and when he saw this new plant enveloping the Enterobrus filaments, he suspected that there might be a phenomenon here presented analogous to the alternation of generation in certain animals, but had not yet satified himself that such was the case.

He also stated that he had discovered a fourth species of Enterobrus in Polydesmus virginiensis, and another entophyte analogous to Enterobrus growing in Polydesmus granulatus. The latter differs from Enterobrus in having numerous globular cells at the free extremity of the principal cell. He adverted to the several theories of cell formation, and said that in the last mentioned plant, in the development of the globular terminal cells, the division of the permanent cell wall followed the division of the cell contents. In conclusion, he observed, that these matters would be more fully treated of hereafter, in a memoir which he was preparing on the subject.

4. *On Infusoria on the Teeth;* by Dr. H. I. BOWDITCH, (Proc. Amer. Acad. of Arts and Sciences, Boston, Dec., 1849, p. 183.)—Dr. H. I. Bowditch gave the result of the microscopic examination of the accumulations on the teeth of healthy persons, near the gums, in forty-nine individuals, most of whom were very particular in their care of the teeth. Animalcules and vegetable products were found in every instance except two. In those cases the brush was used three times a day, and a thread was passed between the teeth daily. Windsor soap was also used by one of these two persons, with the brush. Dr. Bowditch had tried the effects of various substances in destroying the animalcules, and especially of tobacco, by which they seemed to be in no wise incommoded. Soap-suds and the chlorine tooth-wash invariably destroy them.

IV. ASTRONOMY.

1. *New Comet.*—(Jour. of Com.)—Rev. Mr. JENKINS, of Georgetown College, writes that on his way to Rio Janeiro, Nov. 28, 1849, he saw distinctly a comet to westward, nearly in the track of the sun, and about 14 degrees above the horizon (hour not mentioned); the nucleus being very distinct, and about as large in appearance as Mars, the tail curved and pointing southward, quite bright and nearly a degree in length, as seen by the naked eye.

2. *Expected return of the great Comet of* 1556.—This comet is generally supposed to be identical with that of 1264, and if so, its period must be about 292 years. Leaving out of view any consideration of the effect of planetary action, the return of this comet might have been expected at any time since February, 1848. Although watch has been constantly kept since that period, the comet has not been detected. But its return is not yet to be despaired of. Mr. J. R. Hind, of London, states in a letter to the Editor of the *London Times*, dated March 7, 1850, that Mr. J. T. Barber of Etwell, has computed the effect of the perturbations due chiefly to Jupiter's attraction during the last revolution. Mr. B. finds that " between the years 1556 and 1592, the united attraction of Jupiter and Saturn would diminish the period 263 days, but that between 1592 and 1806, it would be increased by the action of Jupiter alone no less than 751 days, so that a retardation of 488 days must take place. How much longer Saturn, Uranus and Neptune may detain it beyond this time, we do not at present know." Mr. Hind considers it important that search for the comet should be continued until the close of 1851, and that on the supposition that it is within four or five months of its return to perihelion, the region of the heavens about the constellation Hydra should at this time be particularly examined.

V. MISCELLANEOUS INTELLIGENCE.

1. *On the Gradual Production of Luminous Impressions on the Eye, and other phenomena of Vision;* by WILLIAM SWAN, F.R.S.E. (Proc. Roy. Soc. Edinb., 1849, ii, 230.)—The object of this communication was to ascertain the relation between the apparent brightness of a light, and the time during which it acts on the eye. In order to examine the intensity of luminous impressions of short duration, the author made use of discs, having sectors of known angles cut out of their circumferences, which were made to revolve at known velocities between the eye and a luminous object. In this manner, the object is seen at each revolution of the disc for a short interval of time, of which the duration is easily ascertained. An instrument termed a Selaometer (from σελας, *brightness*), to indicate its use as a measure of the intensity of luminous impressions, was devised for the purpose of comparing the brightness of the flashes caused by the revolution of the disc, with a light of known intensity. This instrument consists of two screens, placed so as to face each other, having each a circular aperture of the same diameter, to which is fitted a piece of obscured glass. A disc, having a sector of a known angle, revolves in fornt of one of these screens, so that the aperture in it is visible at each revolution of the disc throughout the sector. The apertures are illuminated by gas flames behind them, which admit of having their distances from the screens varied, so as to increase or diminish the illumination of the apertures. A rectangular prism of glass is placed half way between the apertures, with its faces inclined at angles of 45° to the line joining their centres; so that they are seen in apparent contact by reflection from the faces of the prism, and their relative brightness can thus be compared with great nicety. The light behind the revolving disc is kept at a constant distance from the screen during an experiment; and, before causing the disc to revolve, the apertures are made equally bright by varying the distance of the other light from its screen. When the disc is put in motion, the apparent brightness of the aperture behind it is instantly diminished; and the equality of the apparent brightness of the apertures in the screens is restored, by increasing the distance of the light from the other screen. The ratio of the brightness of the impression produced by the light during the revolution of the disc, to the brightness of its impression, when seen by uninterrupted vision, is that of the squares of the distances of the other light from the aperture in its screen.

The following are the principal results obtained by means of this apparatus :—

(1.) When the eye receives, from a light of common intensity, a succession of flashes of equal duration, which succeed each other so rapidly as to produce a uniform impression, this impression will also have a constant intensity, provided the number of flashes in a given time varies inversely with the duration of each flash.

(2.) The brightness of the impression produced by flashes of light of a given intensity, which succeed each other so rapidly as to produce a uniform impression on the eye, is proportional to the number of flashes in a given time.

(3.) When light of a given intensity acts on the eye for a short space of time, the brightness of the luminous impression on the retina is exactly proportional to the time during which the light continues to act. This law has been proved to be true for impressions lasting from $\frac{1}{18432}$ to $\frac{1}{24}$ of a second. The intensity of the impression produced by light which acts on the eye for $\frac{1}{100}$ of a second, is almost exactly $\frac{1}{10}$ of the brightness of the light when seen by uninterrupted vision; and it is also ascertained that light requires about the tenth part of a second to produce its full effect on the eye.

(4.) It is found that lights of different intensity act on the eye with equal rapidity, so that even the light of the sun produces an impression with no greater rapidity than that of a common gas flame.

(5.) Rays of different refrangibility act on the eye with equal rapidity.

(6.) Since Professor Wheatstone's experiments have proved that the light of the electric spark of high tension continues for less than the millionth part of a second, and it has been shewn that the brightness of the impression, produced by light on the eye, increases in the arithmetical proportion of the time during which it continues to act on the retina, it follows that the apparent brightness of the electric spark is only $\frac{1}{100000}$ of what it would become if the duration of the spark could be prolonged to $\frac{1}{10}$th of a second. From the great apparent brilliancy of the nearly instantaneous electric spark of high tension, when compared with the sensibly continuous light of Voltaic electricity, it is inferred that the brightness of electrical light increases with the tension of the electricity.

2. *Foster's Geological Chart.*—The following announcement has been received for publication in this Journal. It affords us pleasure to know that the Chart alluded to has not the sanction of Prof. Mather's name.

Jackson C. H., Ohio, March 28th, 1850.

To the Editors of the American Journal of Science.

Gentlemen,—I received a few days since the March No. of the Am. Jour. of Science, in which is a notice of Foster's Geological Chart, (vide p. 309, vol ix, new series,) saying "A revised copy, as now ready for publication, having the signatures of Professors E. Emmons and W. W. Mather, has been shown us by the author."

My name on that Chart is a forgery. I have never seen the Chart, have never authorized my name to be put on it, and pronounce the attempt to palm off that production under my signature or recommendation, a base imposition on the public, and a still baser imposition on me.

[Signed] W. W. Mather.

3. *Lefroy on the Application of Photography to the Self-registration of Magnetical and Meteorological Instruments*, (see page 319.)—Mr. Lefroy has sent us the following account of his method of treating his mirrors when tarnished.—The mirror will probably be found in course of time, to get tarnished and to require cleaning, this may be done with soft leather, from which all the dust has been beaten out, and which has been well washed in soap and water, and dried before use. If a turning lathe is at hand, a convex buff, fitting the mirror, and well covered with two or three thicknesses of leather, may be centered on it, and the mirror held against it in a support of some kind, while it is made to revolve, but

the least application of polishing powders, however fine, will endanger an alteration in the form of the mirror, and destroy the sharpness of the focus capable of being produced by it. The greatest care must be taken to keep the leather clean and dry.

4. *On the Cause of the Diurnal Variations of the Magnetic Needle;* by W. H. BARLOW, Esq., M.I.C.E.—(Phil. Mag., [3], xxxiv, 344, from a letter addressed by Mr. Barlow to the Editors of the Phil. Mag.)—In the number of your Journal for April, an extract from a letter from M. de la Rive to M. Arago is published, in which the author attributes the diurnal variations of the magnetic needle and the auroræ boreales to the effect of electric currents at the surface of the earth and in the atmosphere.

In the confirmation of this theory mention is made of a remarkable effect observed by M. Matteucci in the apparatus of the electric telegraph between Ravenna and Pisa during the magnificent aurora on the 17th of last November; and the author concludes by observing that "it would be highly interesting and important to profit by those telegraph wires, which are found to have a direction more or less approaching to that of the declination needle, in order to make with them, when they are not in use for ordinary purposes, some observations which would enable us to demonstrate and to measure the electric currents which probably traverse them."

My object in addressing you is to state, that in the early part of 1847, I was led to undertake extensive observations on this subject, in consequence of the peculiar disturbances occasionally visible on the telegraph instruments of the Midland Railway (on which line the telegraph was erected under my superintendence as the company's engineer).

These disturbances were at first attributed to atmospheric electricity passing to the earth by means of the wires; but from certain effects observed, I was led to infer that they were due to other causes; and in order to explain these effects, it is necessary to state that the Midland system of telegraphs consists of four principal lines centering in Derby, as follows:—

1st. From Derby northwards to Leeds.
2nd. From Derby northeast to Lincoln.
3rd. From Derby southwards to Rugby.
4th. From Derby southwest to Birmingham.

The disturbances on these four telegraphs were observed to occur simultaneously, with rare exceptions; and the direction of the current in the two telegraphs proceeding northerly and northeasterly was always contrary to those proceeding southerly and southwesterly; that is to say, when the deflection was such as to indicate that the current was towards Derby on the first two, it was from Derby on the last two; and when it changed in one, it changed in all. It was also observed that on the 19th of March 1847, there was an unusual degree of disturbance during the presence of auroræ boreales.

As these effects could not be attributed to the transit of ordinary atmospheric electricity along the wires to the earth, I determined to make a set of experiments on the subject.

Having obtained delicate galvanometers, I first ascertained that currents are at all times perceptible in the telegraph wires to a greater or less extent when the galvanometer is applied on a sufficient length of wire, and between two earth connections; but that wires having no earth connection, or only one, exhibited no currents.

I also found by simultaneous observations on two galvanometers, applied one at each extremity of a wire forty-one miles long, that the changes of force and direction of the currents were simultaneous at both ends; the current passing direct from one earth connection to the other.

But the most interesting fact which appeared during these observations, and that which bears immediately on the remarks contained in the letter of M. de la Rive, is that there is a daily movement of the galvanometer needle, similar to that of the horizontal magnetic needle, produced by the electric currents travelling in one direction from about 8 A. M. to 8 P. M., and returning in the opposite direction during the remainder of the twenty-four hours. The times of zero are not regularly maintained and vary from 7 to 10 o'clock both in the morning and evening; but the greatest regularity is observable in the morning, and the mean result of numerous observations is as above stated.

This regular diurnal movement of the galvanometer needle is subject to disturbances of greater or less force and duration, which are found to be of greatest energy during magnetic storms, and when an aurora is visible; and in these cases the currents are so strong as to affect the ordinary telegraph instruments, and sometimes prevent altogether the transmission of messages.

The next experiments were made with a view to ascertain the direction in which these currents alternate; and the result, as determined from numerous observations, denotes it to be from northeast to southwest. The nearer this line is approached, the more decided is the effect on the galvanometer; but between east and south, and between north and west, the effect is smaller; and in approaching northwest and southeast, it becomes indefinite and irregular, but never ceases entirely.

It also appeared that the effect depended, not on the direction of the wire itself, but on the relative directions of the two earth connections; that is, the points where the wire was connected with the earth. I next made simultaneous observations with the galvanometers and a declinometer needle; from which it appeared, taking the mean of numerous observations, that that part of the day in which the currents flow southwards (that is, from 8 or 9 A. M. until the evening), the variation of the declinometer needle is westerly; and that during the night and early part of the morning (at which time the currents travel northwards) the variation is easterly; also, that the large disturbances called magnetic storms are simultaneous on both instruments.

But although there is this resemblance in the general features of the movements of both needles, the paths described are not similar. The movements of the galvanometer needle are more frequent and rapid than the declinometer, and the deflection frequently changes over from right to left without a corresponding movement of the declinometer.

The observations thus briefly recorded formed the subject of a paper which was read at the Royal Society on the 17th of June, 1847; and I have thought it desirable to make this communication to your Journal on reading M. de la Rive's letter, because it rather curiously happens, that the unusual delay which has arisen in the publication of my paper by the Royal Society is attributable to the fact, that I arrived from these experiments at the same conclusion as M. de la Rive, as to the electric origin of the diurnal variation of the magnetic needle, which I considered to be the effect of the alternating electric currents exhibited by the telegraph wires.

The Royal Society were unwilling to give their sanction to this view of the case, and only consented to the publication of the observations above described on my omitting that portion of the paper.

The paper is, however, now in the hands of the printers, and will I hope, be shortly before the public.

I ought to state in conclusion, that my idea of the origin of the currents differs in one respect from the theory of M. de la Rive ; inasmuch as he considers them to rise in the atmosphere, whereas I have attributed them to thermo-electric action in the crust of the earth. I speak of course with great deference on a subject of this kind ; but there is an important fact tending to this conclusion which is now well ascertained, namely, that in the telegraphs which are laid entirely under ground, deflections occur similar to those before described ; while wires suspended in the air exhibit no deflections, unless they are connected with the earth in two places, and then the direction in which the current travels depends on the relative positions of the earth connections, however circuitous may be the route of the wire itself.

Derby, April 12, 1849.

5. *The Ruins of Nineveh*, (London Lit. Gaz., March 9, 1850, from The Times).—A correspondent has favored us with the subjoined extracts from the letter of Mr. Stewart Erskine Rolland, late of the 69th Regiment, who is now at Nimroud with Captain Layard, assisting him in his endeavors to bring to light the hidden antiquarian treasures of Nineveh. The difficulties which the gallant and enterprising discoverer has to contend with, owing to the limited pecuniary resources at his disposal, are dwelt on by our correspondent, who fears that the French antiquarian agent recently despatched will, with his much larger funds (30,000*l*. it is stated), materially encroach on the harvest of antiquities which would fall to the lot of the English nation, were Capt. Layard's exertions backed by more ample means :—

" The first two or three days at Mossul I spent in examining the excavations of Koyunjik, where fresh slabs are being every day brought to light. Two new colossal bulls and two colossal figures were discovered while I was there, at the entrance of the city gates ; and the pavement at the gateway, marked with ruts by the chariot wheels, was also uncovered. I left my wife under Mrs. Rassam's care, and accompanied Layard a day's journey to the villages of Baarshekah and Bamyaneh, and to the mound of Khorsabad. We took greyhounds with us and had a day's hunting, catching seven antelopes. After our return, Mr. Layard, Charlotte, and I, and our servants, embarked on a raft, and floated down the Tigris in seven hours to this little village of Nimroud, close to a large mound, which was the first excavated, sending our baggage and horses by land. We have since been residing in his house here ; it is, in fact, little more than a mud hut ; but he has put in glass windows, a table, and some sofas, and made it as comfortable as circumstances will admit. Layard has placed a party of the workmen under my control, and allowed me to dig where I please. I am sinking wells in all directions, and am not without hopes of discovering subterranean chambers, which I am convinced must exist. In one place considerably below the level of any of the hitherto discovered monuments, a brick arch between two walls of brick has been uncovered: it is a puzzle to us all. Another great discovery is an immense stone wall of most solid masonry inside the brick pyramid. The workmen are laboring to force an entrance into it; but their progress is necessarily very slow, not exceeding a foot or two in a day. But the greatest discovery yet made since the earth was first turned remains to be told. I will give it you in due order.

"*January* 3, 1850.—On the 28th of December, Layard and I, with our attendants and two or three Arab Sheikhs, started off to pay a visit to the 'Tai,' on the other side of the 'Zab.' We were the first Europeans who had ever visited that country. Three hours' galloping from Nimroud brought us to the banks of the stream, which is as rapid and broad as the Tigris, and nearly as deep, but here, being divided into four branches, is fordable. With some difficulty we swam our horses across it, getting of course very wet in the operation. Our visit here has a threefold object—first, to explore the mound of Abou Sheeta, which appears to contain a buried city; secondly, to make friends between two rival chiefs of the Tai; and, thirdly, to promote a reconciliation between them and their implacable enemies, the Jibours, which will much facilitate Layard's future operations. Our first visit was to the camp of the Hawar, who is considered by all the Arabs, even by those of the great African desert, to be the highest born and noblest among them. He is probably the man of most ancient descent in the world, reckoning his genealogy far above the time of Abraham. He is supported in his pretensions to the chieftainship by the noblest of the tribe, while his rival, Feras, is supported by the Turks and the greater number of the Tai. His brother, the handsomest man I have ever seen, came out to meet us with 100 horsemen, most of whom had come to our village to plunder the other day. They galloped madly about the plain, brandishing their long spears, shouting their war cry, and escorted us in great state to the camp of the Sheikh, where he stood to receive us. I never saw so noble or dignified a figure; he is eminently handsome, though advanced in years and suffering from ill-health. In stature he is gigantic—six feet four or five at least, and erect as a pine tree. His tent was a spacious one, a load for three camels, with the women's tents on one side and that of the horses on the other, all under the same covering. Mats and cushions were spread on the floor of the tent, on which the Hawar, Layard and I sat, as did his brother, his uncle, and others of the magnates of the tribe, while the rest stood in a semicircle at the door. A noble hunting hawk stood on his perch in the centre. We partook of spiced coffee, discussed the business on which we came, and dined in the tent on a capital stew of mutton, pumpkins, rice, and sour milk. After we had partaken, the rest of the tribe made their repast, a certain number sitting down together, each man rising when he was satisfied, and a sort of master of the ceremonies calling out the name of the man who was to succeed him. There was no bustle or indecorum. After dinner they all said their prayers. We had set on our tents, which, by the way, got very wet in crossing the river, and we pitched them close to that of the Sheikh. The next day the encampment changed its quarters. I have seldom seen a more picturesque sight. The Sheikh's tent was struck first, and the long procession of laden camels, horsemen, donkeys, and cattle, stretched as far as the eye could reach. I calculated that there were about 2,000 persons with their camels, horses, and cattle. We paid our visit to Feras, the rival Sheikh, taking with us the brother of Hawar. We were well received, though not with the same dignified courtesy. While we were away the workmen had opened a trench, by Layard's direction, to show my wife a certain slab which he had buried; in doing so they uncovered three copper cauldrons of immense size, and some huge dishes of metal. Layard carefully removed the earth from one cauldron, which was partially filled with it, and discovered an immense variety of ivory ornaments, an iron axe-head, and innumerable other articles, which for the present I must forbear to mention, having promised secrecy. Layard removed as many as he could, and covered the rest with earth. It is by far the most important discovery that has yet been made. He has placed them under my charge, and given me the direction of the workmen, as he is obliged to go to Mossul to make preparations for the removal of the two finest colossal lions that have yet been discovered, which will, I trust, be on their way to England in a month or two. After that we shall cross the Zab with our tents, encamp there, and pass our time alternately in hunting and digging in the mound. You can have no idea of the difficulties Layard has had to contend with, or the energy, talent, perseverance, and shrewdness with which he surmounts them, or the exquisite tact and good humor with which he manages the different people he has to deal with. In the first place he has nothing but conjecture to guide him in his researches; it is literally groping in the dark, and all sorts of buried treasures may lie within his reach, while from the very small amount of funds placed at his disposal, he is unable to make anything like a proper search, and contents himself with sinking trenches almost at hazard as it were.

"*Jan.* 6.—Yesterday we removed more than thirty metal vases, bowls and saucers, most beautifully embossed and engraved, some shields and swords, of which the handles alone remain, the iron blades being decomposed, and a small marble vase. The cups and bowls and other ornaments are of some unknown alloy of metals, but they are all so encrusted with decomposed and crystallized copper, and so fragile, that they cannot be handled without great danger, and Mr. Layard is sending them home in the state in which he found them, without attempting to remove the rust. I spent eight hours yesterday in scratching them out of the clay with my hands, as the operation was too delicate to allow even a knife to be used. My wife was employed the whole night in packing them. We may now congratulate the British nation in being possessed of an entirely unique collection, the value of which is inestimable. The ornaments and sculptures on the vases denote a very advanced stage of civilization. Not the least curious of the discoveries are several hundred mother-o'-pearl studs, in form exactly resembling our shirt buttons.

6. *Oak Orchard Acid Spring Water, Alabama, Genesee Co., N. Y.;* by H. Erni, Assistant Chemist of the Yale Laboratory; and by Wm. J. Craw, of the same Laboratory.—This water is clear and transpa-

rent and without smell. It contained always a small sediment of organic matter, and tasted strongly acid, affecting the teeth; spec. grav. as found by Mr. Erni, 1·00482 at 15° C. 1000 pts. of the water yielded—

	Erni.	Craw.
$\dddot{\mathrm{S}}$	3·5706	3·532
$\dot{\mathrm{F}}\mathrm{e}$	0·2065	·2258
$\dddot{\cancel{\mathrm{A}}}\mathrm{l}$	0·1111	·0966
$\dot{\mathrm{C}}\mathrm{a}$	0·4557	·4596
$\dot{\mathrm{M}}\mathrm{g}$	0·1562	·1805
$\dot{\mathrm{K}}$	0·0571	·0444
$\dot{\mathrm{N}}\mathrm{a}$	0·0522	·0412
Na	.....	·0143
Cl	.....	·0220
$\dddot{\mathrm{S}}\mathrm{i}$	0·0656	·0684
Chlorine and organic matters,	*traces*	....
	4·6750	4·6848

Representing the bases as combined with SO_3, we have for the composition of 1000 pts. of water—

	Erni.	Craw.
$\dddot{\mathrm{S}}$	2·0122	2·0070
$\dot{\mathrm{F}}\mathrm{e}\,\dddot{\mathrm{S}}$	0·4356	·4266
$\dddot{\cancel{\mathrm{A}}}\mathrm{l}\,\dddot{\mathrm{S}}^3$	0·3702	·3232
$\dot{\mathrm{C}}\mathrm{a}\,\dddot{\mathrm{S}}$	1·1065	1·1161
$\dot{\mathrm{M}}\mathrm{g}\,\dddot{\mathrm{S}}$	0·4592	·5305
$\dot{\mathrm{K}}\,\dddot{\mathrm{S}}$	0·1061	·0822
$\dot{\mathrm{N}}\mathrm{a}\,\dddot{\mathrm{S}}$	0·1196	·0945
Na Cl	.....	·0363
$\dddot{\mathrm{S}}\mathrm{i}$	0·0656	·0684
Chlorine, organic matter,	*trace*	....
	4·6750	4·6848

Yale Laboratory, April 18, 1850.

7. *On the Cause of Auroræ Boreales;* by AUGUSTE DE LA RIVE, being an extract from a letter to M. Regnault, (Comptes Rendus, Oct. 15, 1849; Phil. Mag., xxxv, Dec., 1849.)—I have just read, in a memoir by M. Morlet on the Auroræ Boreales, inserted in the *Annales de Chimie et de Physique*, 3d series, vol xxvii, the following passage:—

"With regard to the origin of this luminous matter (that of the aurora borealis), it seems natural to attribute it to the electric fluid contained in the atmosphere, and which at great heights where the air is rarefied, must become luminous as under the receiver of the air-pump and in the barometric vacuum: this hypothesis would acquire a great probability if we succeeded in proving by direct experiments, that magnetism exerts an influence on electric light."

This last expression induces me to request you to have the goodness to communicate to the Academy of Sciences an experiment which I mentioned to you on my passage through Paris last June, and which you may perhaps remember; its object was to show, in support of the theory which I had advanced of the aurora borealis, the influence exerted by magnetism upon the light which is produced in ordinary electric discharges. Hitherto this influence has only been shown in the case of the luminous arc which escapes between two conducting points, each communicating with one of the poles of a voltaic battery; which is very different, both as concerns the phenomenon itself, and in what concerns its application to the theory of the aurora borealis. The following is my experiment.

I introduce into a glass globe about thirty centimetres in diameter, by one of the two tubulures with which it was furnished, a cylindrical iron bar, of such length that one of its extremities reaches nearly to the centre of the globe, whilst the other extends from three to four centimetres out of the tubulure. The bar is hermetically sealed in the tubulure, and covered throughout its length, except at its two ends, with an isolating and thick layer of wax. A copper ring surrounds the bar above the isolating layer in its internal part the nearest to the side of the globe; from this ring proceeds a conducting rod, which, carefully isolated, traverses the same tubulure as the iron bar, but without communicating with it, and terminates externally in a knob or hook. When by means of a stop-cock adjusted to the second tubulure of the globe, the air in it is rarefied up to three to five millimetres, the hook is made to communicate with one of the conductors of an electric machine, and the external extremity of the iron bar with the other, so that the two electricities unite in the interior of the globe, forming between the internal extremity of the iron bar and the copper ring which is at its base, a more or less regular fascicle of light. But if the external extremity of the iron bar is placed in contact with one of the poles of a strong electro-magnet, taking good care to preserve the isolation, the electric light takes a very different aspect. Instead of issuing, as before, from the different points of the surface of the terminal part of the iron bar, it is emitted only from the points which form the contour of this part, so as to constitute a continuous luminous ring. This is not all: this ring, and the luminous jets which emanate from it, have a continuous movement of rotation around the magnetized bar; one while in one direction, at other times in another, according to the electric discharges and the direction of the magnetization. Lastly, more brilliant jets appear to issue from this luminous circumference without being confounded with those which terminate on the ring, and form the fascicle. As soon as the magnetization ceases, the luminous phenomenon becomes again what it was previously, and what it is generally in the experiment known by the name of the *electrical egg*. Not having any powerful machine at my disposal, I used for my experiment an Armstrong's hydro-electric machine, the boiler of which I made to communicate with the copper ring, and the isolated conductor which receives the vapor with the iron bar, or *vice versa* when I wished to change the direction of the discharges. The experiment succeeded very well in this manner.

The experiment which I have just described appears to me to account very satisfactorily for what passes in the phenomenon of the aurora borealis; in fact, the light which results from the union of the two electricities in the part of the atmosphere which covers the polar regions, instead of remaining vaguely distributed, is carried by the action of the terrestrial magnetism round the magnetic pole of the globe, whence it seems to rise in a revolving column, of which it is the base. We thus understand why the magnetic pole is always the apparent centre whence issues the light constituting the aurora borealis, or toward which it appears to converge. I shall not recur to the other circumstances which accompany this meteorological phenomenon, the agreement of which I have shown with the explanation I have given in a letter addressed to M. Arago, which was communicated to the Academy, and inserted in the Philosophical Magazine for April, 1849, p. 286.

But, having referred to this letter, in which the question was also raised respecting the explanation of the diurnal variations of the magnetic needle, permit me to add, that I have had occasion to prove, in England, both by my own observations, and still better by the more extensive ones of several physicists,* the existence of electric currents having a direction from the northwest to the southeast on the surface of the earth. The presence of these currents can be easily proved by means of the metallic wires which serve as telegraphic communications: wires which are placed underground and at the same time well isolated, except at their two extremities which dip into the ground, are best suited for this kind of observations. It is very curious to follow the agreement which exists between the variations of intensity of these currents and the variations of magnitude of the deviation of the magnetic needle of declination; a new proof to add to that drawn from their direction, that they are the cause of the diurnal variations.

Colonel Sabine has stated, in opposition to my explanation of the diurnal variations, an objection drawn from the observation on these variations at the Island of St. Helena and at the Cape of Good Hope.† I do not think it well founded, and, without entering into the details which will better find a place elsewhere, I shall limit myself to one single remark. I attribute the origin of the currents which give rise to the aurora borealis and to the diurnal variations, to the rupture of the electric equilibrium occasioned, in each atmospheric column, by the difference of temperature which exists between its base which reposes on the surface of the globe and its upper part which is at the limit of the atmosphere. Each column thus forms a kind of pile charged at its two extremities with contrary electricities, which unite in part by the pile itself, in part by a circuit formed of the upper regions of the atmosphere, of the atmospheric polar regions, and of the surface of the earth. Meteorological circumstances determine the greater or less proportion of the two electricities which unite by one or the other of these ways.

Now, the temperature of the base of the column must vary not only with the season, with the time of the day, and with the latitude of the place where it is observed, but also with the nature of the surface of the globe on which it reposes. When, therefore, this surface is the sea, the hours of maxima and minima of temperature are not the same as when it is *terra firma*, all other circumstances being the same; it results necessarily that the hours of maxima and minima of intensity of the electric currents, and consequently of the diurnal variations to

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* See the observations of W. H. Barlow on this subject, Phil. Mag., vol. xxxiv, p. 344.

† Phil. Mag., vol. xxxiv, p. 466.

which they give rise, must be equally different. Now, St. Helena and the Cape of Good Hope may be considered as places enveloped in atmospheric columns, which have almost their entire base resting on the sea and not on the land; thence the anomalies pointed out by Colonel Sabine are very easily explained, and, in particular, it is easily understood how there is no agreement, in direction, which must in every case be different, between the diurnal variations observed at the Cape of Good Hope and those observed at Algiers, which is equally distant from the equator, but to the north. An excellent paper by M. Aimé on terrestrial magnetism, inserted in the *Annales de Chimie et de Physique*, 3d series, vol. xvii, in which he discusses comparatively the observations made at St. Helena, the Cape, and Algiers, has singularly facilitated the explanation of the anomalies presented as objections by Mr. Sabine.

I, however, do not pretend that there does not exist any anomaly; my explanation is not more free than others from those which result from certain local and exceptional causes. I am not further from admitting that the currents of induction determined on the surface itself of the globe, by its rotation under the influence of its magnetic poles, cannot have any part in the phenomenon of the diurnal variations and aurora borealis, and account for the connection which these variations appear to have with the absolute direction both in declination, and in inclination of the magnetic needle, and with the absolute intensity of the terrestrial magnetism. But this subject would require, for elucidation, to be treated more at length than can be done in a letter; I shall therefore stop, and beg to refer those persons who may be interested in this question to a memoir which I am on the point of completing, and which will be published forthwith.

8. *Charleston Meeting of the American Association for the Advancement of Science.*—The semi-annual session of the American Association was held by appointment in Charleston, South Carolina, in the early part of March, and was attended quite as numerously as could have been expected. The season of the year, and the distance of a majority of members, made it impossible for a large concourse to be gathered. We have failed to procure a full list of the papers read at this meeting, no complete list having at a late date been received from the Secretaries. That the papers were numerous and of importance, we know from the testimony of those who were at the meeting. Dr. A. D. Bache presided at this meeting, and the greatest hospitality, public and private, was enjoyed both from the city and inhabitants. With a most commendable liberality, the City Council assumed all the expenses of the Association in publishing the volume of Reports of proceedings and papers at this meeting. This example so worthy of imitation, will we trust, be a precedent for the future reception of the Association. Such contributions are honorable to those who proffer them, just to the cause of science, and truly encouraging to the working men who sacrifice the hopes of accumulation to the sacred cause of truth for the general good.

The next annual meeting of the Association will be held at New Haven on the 19th of August next. The Local Committee will soon issue their circulars of invitation.

VI. BIBLIOGRAPHY.

1. *Proceedings of the American Association for the Advancement of Science*, second meeting. Held at Cambridge, August, 1849. Boston, 1850. H. Flanders & Co. 8vo, pp. 459.—This volume is composed mainly from the reports made at the time and printed in the Boston Traveler, which have since been corrected by the several authors and are now issued under the sanction of the publishing committee. It is a volume of abstracts rather than one of full papers, although many of the shorter papers are given in full detail. The volume covers a wide range of subjects in all departments of science and evinces a high degree of activity in physical investigation, much greater probably than has existed at any former period of American history. Many of the most important articles it contains have already appeared in this Journal, and others will find their way into it.

2. *The Annual of Scientific Discovery, or Year Book of Facts in Science and Arts, &c.;* edited by DAVID A. WELLS (of the Lawrence Scientific School, Cambridge,) and GEORGE BLISS, Jr. Boston: Gould, Kendall and Lincoln. 1850. 12mo, pp. 392, with a portrait of Prof. Agassiz.—This annual is projected upon a comprehensive plan including the most important discoveries and improvements "in mechanics, useful arts, natural philosophy, chemistry, astronomy, meteorology, zöology, botany, mineralogy, geology, geography, antiquities, together with a list of recent scientific publications, a classified list of patents, obituaries of eminent scientific men, and an index of important papers in scientific journals and reports." This volume is properly a book of selections from the various scientific discoveries of the year past rather than a complete registry of them, and as such it is a work of great merit, and highly useful to the scientific as well as general reader. In a cursory examination of the volume we observe, however, errors and omissions in some departments which more care will in future avoid; and we would especially suggest more attention to American facts and researches, and the propriety of giving a fuller index of the articles in scientific journals and reports. There are numerous original and important memoirs published in the past year, in American publications, to which no allusion is made either in the index of articles or in the body of the work, a deficiency to which we should not allude were not the title so comprehensive as to be calculated to mislead scientific men abroad. We notice also several incorrect statements copied from the daily newspapers, e. g., those regarding the copper mines at Bristol and in Litchfield, in Connecticut. It is our wish to encourage a work in the main so excellent, by suggesting imperfections that may hereafter be avoided. We are glad to learn that a large edition of the book has already been exhausted.

3. *The Physical Atlas of Natural Phenomena;* for the use of Colleges, Academies and Families; by ALEXANDER KEITH JOHNSTON, F.R.G.S., F.G.S., American edition, Lea & Blanchard, Philadelphia, containing 26 maps in 4to, with interleaved text.—This atlas is an encyclopædia of knowledge relating to the physical character and phenomena of our globe, presented in a series of maps, with full descrip-

tions and a vast amount of added detail in the accompanying pages of letter press. The maps have been prepared with the skill and knowledge which none but the most extensive learning could command, and are so displayed by the use of colors and various designs as to speak decisively and intelligibly to the eye. The subject of geology is first presented, and the distribution over the earth of rock formations, including volcanoes, is seen in a general manner on Pl. 1. An elegant geological map of the British Isles is added. Another map or plate shows the distribution of mountain ranges, their exact courses and relations. The accompanying text treats of the mean heights and features of continents, highest peaks and general characters of chains. Another map is devoted to the Andes and Rocky Mountains with the ranges of America. Plate 4, illustrates in a very perfect manner the glacier system of the Alps; plate 5, very minutely and elegantly the distribution of volcanoes of the globe, and volcanoes and earthquakes are the subject of much important information in the text. In the same manner, there are several maps representing the distribution of the waters of the globe, their currents, temperature, tides, usual tracks of vessels, continental waters, river basins; others exhibiting the regions of rains, of deserts, the courses of winds and prevalent hurricanes; others, the vegetation, forest regions, distribution of plants and animals, and of races of men.

4. *Lake Superior, its Physical Character, Vegetation and Animals, compared with those of other and similar Regions;* by LOUIS AGASSIZ, with a narrative of the Tour, by J. ELLIOT CABOT, and contributions by other scientific gentlemen, with appropriate illustrations; pp. 428, 8vo. Boston: Gould, Kendall & Lincoln. 1850.

The narrative occupies 133 pages, and is drawn up with perspicuity, condensation and elegance; interspersed among the pages of the text are scientific remarks by Prof. Agassiz, on the various objects which presented themselves in the progress of the tour which was included between the 15th of June, and the 25th of August, 1848. Railroads and steamboats brought them speedily to and from the scene of action, and the seventy-one days were most industriously and successfully employed by the naturalists and pupils and amateurs in a party of sixteen, acting intelligently and vigorously under their distinguished and accomplished leader.

The most important scientific observations are given separately in an appendix to the narrative, and are included under the following heads.

Lake Superior—Physical character, Vegetation and Animals, compared with those of other and similar regions.

I. The northern vegetation compared with that of the Jura and the Alps.

II. Observations on the vegetation of the northern shores of Lake Superior.

III. Classifications of animals from Embryonic and Palæozoic data.

IV. General remarks upon the Coleoptera of Lake Superior, by Dr. John L. Le Conte.

V. Catalogue of Shells, with descriptions of new species, by Dr. A. A. Gould.

VI. Fishes of Lake Superior compared with those of the other great Canadian Lakes.

VII. Description of some new species of Reptiles from the region of Lake Superior.

VIII. Report on the Birds collected and observed at Lake Superior, by J. E. Cabot.

IX. Description of some species of Lepidoptera from the northern shores of Lake Superior, by Dr. Thaddeus William Harris.

X. The Erratic Phenomena about Lake Superior.

XI. The outlines of Lake Superior.

XII. Geological relations of the various Copper deposits of Lake Superior.

5. *A natural Scale of Heights by the application of which the Measures of different countries are reduced to a common measure known to all Geographers*, constructed by Miss Colthurst.—Presented to the Royal Geographical Society, by G. B. Greenough, V. P., [and by him forwarded to us.]—The standard is an equatorial, geographical mile, a fixed quantity universally known and derived from the figure of the earth =6086·78 English feet. Five of these miles being divided each into 100 parts or degrees, give a scale of 500 degrees each of which is equal to 60⅞ English feet.

The measures of different countries are arranged separately in parallel vertical columns, each with its own caption; and adjoining each on the left, is the scale derived from the centesimal division of the geographical miles, and the corresponding numbers or lines denote the values of the different measures.

6. *The East; Sketches of Travel in Egypt and the Holy Land;* by the Rev. J. A. Spencer, M.A. *With illustrations from original drawings.* G. P. Putnam, New York. pp. 503, 8vo, in cloth, gilt. 1850.—As the physical features of these countries form a prominent topic in this agreeable and instructive volume of travels, it may be properly mentioned in this Journal. It follows with advantage after the more elaborate works from which it quotes and sometimes dissents. Its moral tendency is excellent, although its amiable author in his winding up has often viewed objects through a colored medium, and his numerous apologies seem to us uncalled for. We have derived both pleasure and useful information from the perusal, and can cordially commend it.

7. *Man Primeval, or the Constitution and Primitive condition of the human being, &c.;* by John Harris, D.D., President of Cheshunt College, England. Reprint by Gould, Kendall and Lincoln, Boston, pp. 480, cloth. 1850.—Although this new work of Dr. Harris is a contribution to theological science, it has like its predecessor, "The Pre-adamite Earth," by the same author, such intimate relations to geology, and like that work, it presents such enlarged and just views of science, that it is entitled to respectful mention in this Journal.

8. *A Systematic Treatise, Historical, Etiological and Practical, on the Principal diseases of the Interior valley of North America; as they appear in the Caucasian, African, Indian and Esquimaux varieties of its Population;* by Daniel Drake, M.D. 878 pp. 8vo: Cincinnati, Ohio, 1850. Winthrop B. Smith & Co., Publishers, Philadelphia.—This very elaborate work treats first, of General Etiology, pp. 701; and secondly, of the Febrile diseases of the region, pp. 703–863. In Book I,

there are chapters on the topography, hydrography, and geological outline of the great western valley; on the hydrographical basin of the Gulf of Mexico, its currents, tides, temperature, &c.; on the special medical topography of places along the coasts of the Gulf of Mexico; the delta of the Mississippi, and river above, with the regions east and west of the river, and the basin of the Ohio, Alleghany and other tributary streams, the basins of the St. Lawrence and Great Lakes, and the Hudson and Arctic hydrographical basins. Next the author treats at length of the temperature of the different basins, barometrical character, winds, rain, electrical phenomena, and whatever can have a bearing upon health. He then passes to the subject of population, its distribution and character, modes of life, diet, use of alcohol and tobacco, clothing, occupations or pursuits. Book second contains full descriptions of the various diseases, as to their many forms and symptoms and modes of treatment.

Dr. Drake is undoubtedly the most able man in America for so difficult a task. It is well known, he has for many years investigated the subject with characteristic ardor, and in the research has personally visited all parts of the West and South, making at many places anxious and laborious observations—medical, statistical and physical.

9. *Transactions of the Society of Arts for* 1846–7 *and* 1847–8. 1847, 1849.—The Society of Arts commenced in 1847, a new series of their publications, and have issued Parts 1 and 2 of the first volume. These transactions are elegant in style of typography and illustration, abounding in colored plates of great interest and beauty, and the memoirs are valuable contributions to the Arts. They treat of carving, cameo making, steam boilers and locomotives, atmospheric electricity, of beauty, artificial lava for ornaments, ancient Greek vases, steam navigation, lighthouses and beacons, lithography, ancient and modern bookbinding, photography, cotton of Honduras, and various other subjects of general interest.

10. *A Universal Formulary, containing the method of preparing and administering officinal and other Medicines, the whole adapted to Physicians and Pharmaceutists;* by R. EGGLESFELD GRIFFITH, M.D., 568 pp., 8vo, Philadelphia. Lea & Blanchard.—The Universal Formulary of Prof. Griffith has the completeness which its title implies, and is exceedingly convenient in arrangement. The body of the work is preceded by a long introduction containing comparative tables of weights and measures, United States and foreign, explanations of abbreviations and terms in use, with observations on the management of the sick room, and rules for the administration of medicines. The formulary is arranged alphabetically, according to the pharmaceutic names adopted in the United States pharmacopeia; the English appellations of articles are used, and the quantities are expressed in words instead of pharmaceutical signs. Copious indexes are added not only of the formulas, but of the diseases for which they are advised.

T. A. CONRAD: Descriptions of one new Cretaceous and seven new Eocene Fossils from Georgia.—By T. A. Conrad, from the Journal of the Acad. Nat. Sci., Philad., [2], ii, part 1, p. 39. March, 1850. 7 species are Echinoderms and the rest Mollusca.

C. B. Adams: Monograph of Vitrinella, a new genus of Turbinidæ, with new species; by C. B. Adams. 10 pp. 8vo. Amherst, Mass. [Generic description, "Testa, turbiniformi, minimâ, vitreâ; aperturâ maximâ, orbiculari, subtus valde indentatâ vel umbilicata."—Distinguished by the vitreous texture of the shell, and the rapid enlargement of the whorls, producing a large aperture. Species from Jamaica.]

C. B. Adams: Contributions to Conchology, Nos. 5 and 6. 32 pp. 8vo. Amherst. —No. 5 contains new marine and terrestrial shells from Jamaica. No. 6, a memoir on the origin of the terrestrial molluscs of Jamaica; together with a description of a new genus of Helicidæ, *Spiraxis;* and notes on certain species of the land shells of Jamaica and descriptions of supposed new species.—[Genus Spiraxis is described as follows: "G. t. parvâ, turritâ; columellâ medio in laminam spiralem productâ: aperturâ ovali, medio partim divisâ: labro simplice." The *Achatina aberrans* of Pfeiffer is supposed to be identical with the author's Spiraxis aberrans.]

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Proceedings of the American Philosophical Society, v, No. 44. Oct., March, 1850.—p. 108. Observations on the radiation of heat by air; *Henry.*—p. 117. On the alleged influence of the moon on the weather; *T. Gilpin.*—p. 125. Remarks on a memoir by Delgado on the disc of the Emperor Theodosius, presented to the Society by the Royal Academy of Madrid; *Trego.*—p. 127. On the original purchase of land in Pennsylvania and the celebrated "Indian Walk;" *Trego.*—p. 139. Observations on the occultation of Jupiter and his Satellites, Feb. 26, 1850; *Kendall.*

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ERRATUM.

P. 419, bottom line, for 'soda, or the,' read 'soda, and the.'

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